STATE COMMITTEE OF WATER ECONOMY (SCWE)
MINISTRY OF AGRICULTURE (MOA)
THE REPUBLIC OF ARMENIA

PREPARATORY SURVEY FOR YEGHVARD IRRIGATION SYSTEM IMPROVEMENT PROJECT

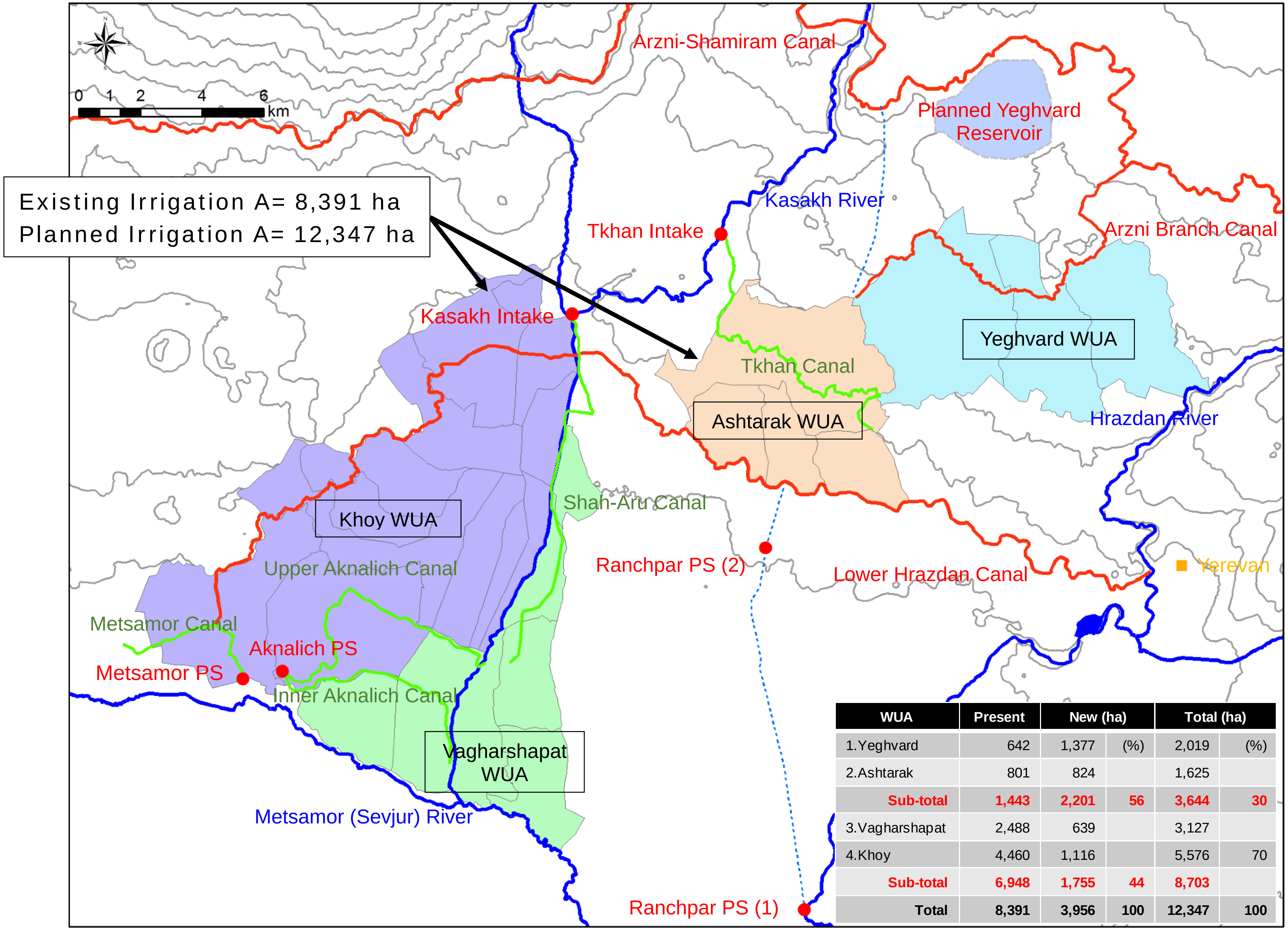
DRAFT FINAL REPORT
(DFR)

SEPTEMBER 2016

SANYU CONSULTANTS INC. (SCI)
ORIENTAL CONSULTANTS GLOBAL CO., LTD. (OCG)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

LOCATION MAP



WUA	Present	New (ha)		Total (ha)	
1.Yeghvard	642	1,377	(%)	2,019	(%)
2.Ashtarak	801	824		1,625	
Sub-total	1,443	2,201	56	3,644	30
3.Vagharshapat	2,488	639		3,127	
4.Khoy	4,460	1,116		5,576	70
Sub-total	6,948	1,755	44	8,703	
Total	8,391	3,956	100	12,347	100

SUMMARY

OUTLINE OF THE PROJECT

1. Objectives
   1) To distribute stable irrigation water to the Project area,
   2) To improve agricultural productivity in the Project area by the stable irrigation water,
   3) To fulfill the national policies such as; a) conservation of Lake Sevan and b) shifting pump-based to gravity-based irrigation system.

2. Project area and beneficially
   1) Irrigation area: 12,347 ha of agricultural land
   2) 27 communities in Kotayk, Aragatsotn and Armavir Marzes
   3) Number of farm households: 13,574 HHs (Approx. 61,000 persons) as of 2014

3. Main construction facilities

Reservoir			Irrigation System				
1	Capacity	94 MCM	1	Feeder canal 1	Approach canal	L=1,160m	Q=1.11 - 9.0 m^3/s
					Pipeline	φ=1.60m, L=1,600m φ=1.72m, L=1,940m	
2	Dam height	H=25.55m	2	Feeder canal 2	Concrete open canal	W=ave 4.0m, L=330m	Q=2.20 - 13.0 m^3/s
3	Full Water Level	EL.1,305m	3	Outlet canal 1	Pipeline	φ=1.20m, L=730m	Q=0.22 - 2.33 m^3/s
4	Low water level	EL.1,290m	4	Outlet canal 2	Pipeline	φ=1.72m, L=4,700m	Q=0.16 - 12.82 m^3/s (Maximum 13.7m^3/s)
					Dissipater	L=500m	
5	Reservoir area	8.08 km^2	5	Other canals	Rehabilitation	Approx. 65km	-

4. Project cost and schedule (provisional)
   1) Project cost: 226.9 million USD (including VAT)
   2) EIRR: 3.68% (*5.72 % in case including conservation of Lake Sevan)
   3) Implementation; Detailed design: 2017 to 2018, Construction: 2019 to 2022 (4 years)

5. Indicators (Year 2027: 5 years after completion of the construction)
   1) Irrigable area; 8,391ha →→ 12,347ha,
   2) Agricultural production increase (Wheat, Alfalfa, Potato, Grape),
   3) Energy saving by “shifting pump-based to gravity-based irrigation system”, and
   4) Water conveyance from Lake Sevan; 50MCM →→ 0 MCM.

6. Rationale
   - ✓ Government of Armenia places this Project as one of the important projects to fulfill the national policies which are; 1) conservation of Lake Sevan and 2) shifting pump-based to gravity-based irrigation system.
   - ✓ While one-third (1/3) of population in Armenia is living in the capital city of Yerevan, taking accessibility and marketing into considerations, agricultural activities in the Yeghvard directly connect not to only farmers’ income generation, also food security for inhabitants of the capital.
   - ✓ Since Armenian agricultural development strategy towards promoting; 1) cooperated and competitive market-oriented and 2) export-oriented productions for international trading by shaping favorable conditions, farmers concerned in Yeghvard have much advantage to involve in opportunities obtaining agricultural training/information, extension/machinery services, credit and techniques through research institutes available in Yerevan.
   - ✓ While irrigation projects; Kaps and Vedi are under the process of detailed design and tendering stages prior to construction, government will concur in developing infrastructural projects in relation to water resource on agriculture/irrigation sectors.

1. INRODUCTION

Background of the Survey

After a request for Official Development Assistance (ODA) Loan to the government of Japan was made by the Government of the Republic of Armenia (hereinafter referred to as “Armenia”) in June 2012, JICA had executed to gather information related to the construction of Yeghvard reservoir by sending the contact missions as well as sending questionnaire in order to formulate the Project.

In June 2014, JICA dispatched a consultant team for a preliminary feasibility study (Pre-F/S). Since the consultant team conducted a field survey including data/information collection and had a series of discussions with related agencies in Armenia from June through August 2014 and analyzed the collected information prior to prepare a draft final report (DFR) for the Pre-F/S, JICA sent a mission to Armenia in November 2014 for the purpose of explanatory discussion on the DFR. In March 2015, JICA, consequently, sent an official letter decided to dispatch a consultant team for the Full-scaled F/S of Yeghvard Irrigation System Improvement Project (hereinafter referred to as “the Project”). Then, the consultant team (hereinafter referred to as “the Survey Team”) have started a preparatory survey for the Project (hereinafter referred to as “the Survey”).

Project Area

Project area is located in the surrounding area of Yerevan within 20km from the capital city, with 22,754 ha of land area of which 12,200 ha or 53.6 % of the land area is registered as a farmland in cadaster. The Project area expands to 27 communities in three (3) Marzes (regions), i.e. Kotayk, Aragatsotn and Armavir. While the whole territory of 22 communities belongs to the Project area, a part of the territory belongs to the area in other 5 communities. Consequently, 91.2 % of total land area in the 27 communities is included in the Project area.

In terms of WUA category, the Project area is divided into 4 (four) WUA command areas, namely; Yeghvard, Ashtarak, Vagarshapat and Khoy. Potential farmland area for irrigation in the Project area is estimated at 12,347 ha by the Survey Team. The area is larger than the registered farmland area in cadaster as actual cultivated area has extended to non-registered farmland area in many communities in Vagarshapat and Khoy command areas.

2. BACKGROUND OF THE PROJECT

Background of the Project

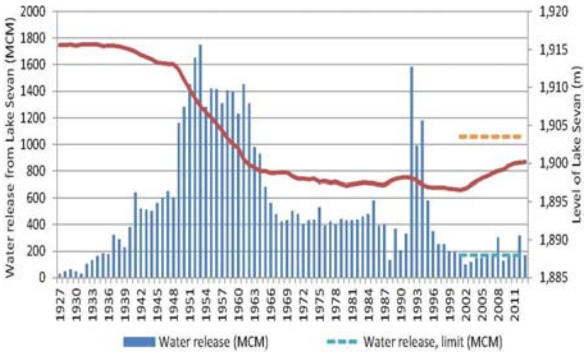
Water volume stored in Lake Sevan measured 58,000 MCM in late 1940s was reduced to 33,000 MCM in early 1970s due to the heavy water use by domestic/industrial sectors as well as irrigation, as a result water level in the Lake dropped by as much as 19 m. As the conservation measures for Lake Sevan suffering from heavy drawdown of water level, the Government of Armenia constructed a water tunnel for diverting water from other watershed areas during the period 1960s to 1980s and it also implemented the policy of limiting annual water use for irrigation. However, during the period of energy crisis in 1990s, the lake water was again overused, lowering water level.

Yeghvard reservoir project was planned during 1970s as one of the conservation measures for Lake Sevan. Later in 1980s, the work with a scale of 228 MCM had been started, but it was later interrupted due to difficulty in fund supply. Later in 1990s, coping with second recession of water level, reservoir construction plans were studied at 16 sites throughout the country from water conservation point of view. Yeghvard reservoir project was included as one of these countermeasure-plans. The scale of this reservoir was reviewed by the country and reduced to around 90 MCM.

Policy on Water Resources

The Water Code is the principal document adopted by the National Assembly. The main purpose of this Code is the conservation of the national water reserve, the satisfaction of water needs of citizens and economy through effective management of useable water resources, securing ecological sustainability of the environment. And the National Water Policy pursues aim to provide accessibility for sufficient quantity, regime and quality of water resources to maintain basic human well-being for present and future generations, socio-economic system development, and to meet economic and ecological needs. Agricultural water usage priority is higher than the energy and industrial production uses.

Furthermore, in 2001, Armenia launched an environmental improvement strategy for Lake Sevan with the target of elevating its water level by 6m (up to 1,903.5m) by 2030 as shown in Figure 2-1. Additionally, the country has not only determined the upper limit of annual releasing (intake) water volume from Lake Sevan to an irrigation network at 170MCM, but it also decided to operate hydropower stations located along the Hrazdan River only during the period of distributing irrigation water.



Source) World Bank (2014),Towards Integrated Water Resources Management : Revisited

Figure 2-1 Change in Water Level in Lake Sevan

Policy on Agricultural Development

The Armenian people focused their economic activity back to the agricultural sector in order to make utmost efforts to accommodate themselves to the economic crisis after the independence. As a result, the sector was headed for recovery and GDP ratio of the sector grew to 46.3% in 1993. Currently, however, GDP ratio is reduced to lower than half of that of 1993. The current state of agriculture in the country shows that the sector has surpassed the stage of self-subsistence and has entered the next stage of commercialized agriculture that includes vegetables, fruits, industrial crops and livestock, as seen in the USSR era. It is reported that approx. 80% of domestic agricultural production was from irrigated land. Irrigation is a significant infrastructure supporting the country’s agriculture.

The government launched its SADS covering the period 2010-2020 as the national policy in order to respond to the commercial-oriented agriculture. SADS aims to enhance productivity and value of agricultural products; to improve food security for the population by distributing products appropriately both to domestic and international markets, and to promote its export (targeting 3.5 times increase in the current export volume). More details of SADS are described as follows;

Sustainable Agricultural Development Strategy (SADS)

Vision (in 2020)

- ✓ Sustainability and competitiveness agriculture,
- ✓ Cooperated and highly competitive, market-oriented production,
- ✓ Sustainable provision of food to the population and meeting the demands of the processing industry,
- ✓ Increase in gross farm produce though increasing labor productivity,
- ✓ Development in SMEs in rural communities,
- ✓ Positive change of intrans sectoral structure of plant and livestock production,
- ✓ Utilization of agricultural potential, especially land resources, and
- ✓ Improvement of food security for the population.

Strategy goal

- ✓ Promotion of industrialization of agriculture (value-addition),

- ✓ Increase in the food security, and
- ✓ Shaping favorable conditions for promoting export-oriented productions.

Production goals of major crops

SADS attempts to increase production of all major crops from the level of 2007, with special focus on increasing production of fruits and grapes, industrial crops, sheep and poultry. Fruits, grapes, industrial crops and sheep are expected to be the driving force of value-addition and exporting of agricultural products. On the other hand, poultry is seen as an import substitute. In addition, SADS aims to increase cultivating areas of forage crops rapidly, as a response to high demand in forage crops from livestock sub-sector.

Agricultural Development Strategy in the Project Area

The SADS specifies agricultural strategies in respective Marzes where beneficial communities of the Project belong to Table 2-1 shows the development strategies of three (3) Marzes, i.e. Aragatsotn, Armavir, and Kotayk

Table 2-1 Agricultural Development Strategy of Concerned Marzes

Marz	Current Situation	Prospective Situation
Aragatsotn	Dairy-and-meat cattle breeding; potato and fruits production; and cereals farms	Dairy-and-meat cattle breeding; fruits and potato production; sheep breeding; and fodder production
Armavir	Vegetable production; cereal farms; grapes production; meat-and-dairy cattle breeding; potato and fruits production	Production of grapes, vegetables and fruits; dairy cattle breeding: early ripe potato production
Kotayk	Meat-and-dairy cattle breeding; vegetable and potato production; and cereals farms and fruits production	Meat-and-dairy cattle breeding; poultry farming: fruits production; cereals farms; vegetable production; and fodder production

Source) 2010-2020 Sustainable Agricultural Development Strategy, RA

Recent Situations of International River Treaty

Water distribution of the Hrazdan River is managed by the Sevan-Hrazdanyan Jrar (“Jrar” means intake) Closed Joint Stock Company (CJSC) under the SCWE, and Water Resource Management Agency (WRMA) under the MNP. The Hrazdan River flows within the Armenian territory, therefore, the Hrazdan River is regarded as an in-country river in Armenia and there is no international treaty on utilization of water of the Hrazdan River.

3. CURRENT CONDITIONS AND ISSUES ON IRRIGATION/AGRICULTURE SECTORS IN ARMENIA

Status of the Project to the National Development Plans

Irrigation sector

With regards to irrigation policies, the government aggressively deploys the policy of converting irrigation methods from pump to gravity-based system. There lies a background behind the strategy of “breakaway from energy intensive agriculture”, and an issue of decreasing the groundwater level which causes the difficulty for pumping up irrigation water. In particular, the groundwater level has been drawing down in the Ararat Plain.

Agriculture sector

The government recognizes that the Project area is a strategic area to achieve the goals of SADS, which is the highest level of agricultural development policy in Armenia, by the following reasons;

- ✓ The area belongs to a production center of vegetables, fruits and grapes which are expected to be main products for promoting industrialization of agriculture and export-oriented productions declared in SADS.

- ✓ The area is located on the suburbs of Yerevan city, where many agro-industries are developed and is the main market of the products.

Table 3-1 implies that crop production, especially vegetables/melons and grapes, in the Project area contributes much to the national production, though the total land area is only 0.8% of the national land area.

Table 3-1 Production of Major Crops in Armenia and in the Project Area in 2014

Crop	Armenia (A)		Project Area (B)		(B)/(A)	
	Area (x1000 ha)	Production (x1000 ton)	Area (x1000 ha)	Production (x1000 ton)	Area (%)	Production (%)
Grains	188.7	590.6	1.8	6.9	1.0	1.2
Potatoes	31.6	733.2	0.7	29.1	2.2	4.0
Vegetables/Melons	32.2	1,200.4	2.9	91.6	9.0	7.6
Fruits	40.1	291.0	0.9	6.3	2.2	2.2
Grapes	17.2	261.3	1.3	17.5	7.6	6.7
Total land area	2,974.3	-	22.8	-	0.8	-

Source) Statistical Yearbook of Armenia, 2015
27 communities concerned (Crop Area and Production in Project Area 2014)

Food Security

Armenian recent trend of self-sufficiency ratio reveals polarized tendency. Basic foods such as cereals, edible oils and pork meats are at a lower level. In contrast, other foods like vegetables and fruits/grapes show a high rate. The SADS emphasizes that a rise in cereals production and promotion of animal husbandry with an increase in forage crops should be the main strategy of domestic food security. Actually, the self-sufficiency ratio of cereals, especially wheat shows a trend toward the improvement in recent years. Nevertheless, since major cereals and forage crops are internationally commercialized, it is inevitable to rely on cheap imported products in order to pursue economic efficiency. It is crucial to keep a careful balance between the improvement of food self-sufficiency ratio and economic efficiency.

International Trade of Agricultural Products

Since Armenia’s independence, the government has promoted agricultural sector with some successes. However, the production of many crops cannot meet domestic demands; the country still depends on substantial amount of imported products. Regarding major exporting crops, both the variety of exporting commodities; mainly vegetables, fruits and alcoholic beverages, and the volume are limited. Alcoholic beverages are the highest exported item which is mainly composed of brandy made from grapes. Export destinations are dominated by Russia and other CIS countries, mainly because of the strength of the Armenian brand established during the USSR era, which remains in high demand.

Marketing of Agricultural Products

Farm products are classified into two (2) categories as for personal consumption (including gift and barter exchange) and for market sales. Cereals, potatoes, eggs and sheep wool are mainly consumed by producers themselves. On the other hand, comparatively high percentage of vegetables (including melon), fruits, grapes and meats are marketed. These commodities are recognized as important cash income sources of farmers. Many farmers sell their products to the middlemen at the farm-gate. Organized cooperatives or group marketing by farmers are not common. Although all farmers recognize the difficulties for securing advantaged selling channels and favorable selling prices of their products, no one can figure out the certain images or ideas of solution for the problems.

Agricultural Processing

According to the Ministry of Agriculture (MOA), there are about 1,500 agricultural processing companies in Armenia as of 2014, if unrecognized tiny companies are also counted. Alcoholic & non-alcoholic beverage, meats & dairy products and preserved foods are the priority commodities in the government policy. Rehabilitation of Armenian agricultural processing industries is still only at the halfway mark despite of vigorous supportive policies of the government.

The Department of Agro-Processing Development recognizes the following problems on the development of agricultural processing industries.

1) Limited market (the industries have over processing capacity)
2) High production-cost structure (raw materials, energy, management, etc.)
3) Inconvenient loan condition (financial institutions reluctant to provide a long-term loan)
4) Limited transportation routes due to geopolitical constraint

Agricultural Inputs

Fertilizers

The government of Armenia is importing fertilizers in order to provide cheaper fertilizers to farmers under the subsidy system. Most of farmers heavily depend on the subsidized fertilizers for their crop farming, and a limited volume of miscellaneous compound fertilizers mainly used for vegetables and flowers are distributed through the private channel. According to the MOA, the subsidized fertilizers cover more than 95% of the annual domestic demand. Farmers are demanding mainly on nitrogen fertilizers, and the demands of other fertilizers are quite limited. Farmers tend to input more volume of nitrogen fertilizers, probably due to its immediate effect on their crop productivity.

Agricultural chemicals

All agrochemicals are imported from foreign countries, as same as fertilizers, in Armenia. In contrast to fertilizers, agrochemicals are marketed only through the private channel, as the government are not subsidizing for them. The government has imposed a registration system of agrochemicals which prohibits importation and distribution of unregistered agrochemicals in Armenia. A division in charge of agrochemicals under the MOA inspects agrochemical shops periodically in order to control unregistered or obsolete agrochemicals.

Agricultural machinery

Most of current workable agricultural machinery in Armenia was procured in the former USSR era. There have been about 11,000-12,000 workable tractors since 2005 and there was no drastic change of those figures in the last decade. The government has played a significant role in the import of agricultural machinery, though there are several private dealers importing agricultural machinery. Actual market demand for the agricultural machinery on commercial basis is still limited, mainly due to weak paying capacity of each individual farmer, despite the high potential demand.

Agricultural research and extension

According to the MOA, there are three (3) agricultural research institutions; 1) Scientific Centre for Agriculture, 2) Scientific Centre of Vegetables and 3) Industrial Crops and Experimental Centre for Technical Crops, under the Ministry. In Armenia, agricultural extension services are implemented by specialized agencies; the ASRC (Agricultural Support Republic Centre) and ASMCs (Agricultural Support Marz Centres). ASRC is placed at the central level and one ASMC is established in each Marz at the regional level. ASMCs are responsible for agricultural extension services to individual farmers in respective Marzes, and 130 agricultural extension agents are allocated to ASMCs in total. According to the results of survey against farmers, most of the farmers recognized that they’ve never had any opportunities of agricultural extension or supporting services.

4. CURRENT CONDITIONS OF YEGHVARD IRRIGATION PROJECT SITE

4-1 Meteorological and Hydrological Conditions

Meteorological data

Data of the average annual rainfall in Hrazdan and Yeghvard stations are 742 and 439mm, respectively. The maximum average temperature is observed around July to August. The average temperature from December to February is negative in all the meteorological stations. Monthly rainfall is in maximum on April and May and decreases to August. Evaporation is in maximum on June as shown in Figure 4-1. Around latest ten (10) years , annual rainfall in 2008, 2012 and 2013 are less than the average at the Hrazdan station and in 2004, 2012 and 2013 at Yeghvard station is less than average as well

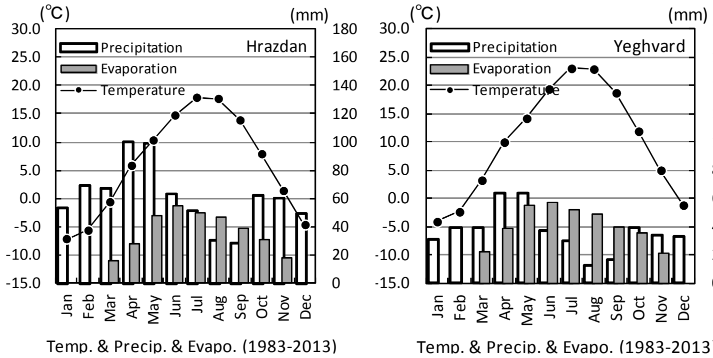


Figure 4-1 Meteorological Data at Hrazdan and Yeghvard Station

For the evaluation of rainfall trend at Hrazdan station, probability of annual rainfall is calculate. One is long-term from 1983 to 2013, and the other one is latest 10 years from 2004 to 2013. The reason to evaluate by the Hrazdan station's data is that Yeghvard reservoir will be filled by the river flow from Hrazdan River's watershed area, so Hrazdan station's data will be presumed that it has relationship between rainfall and river flow. Year of 2008 is extremely low amount of rainfall, especially in the latest 10 years.

Hydrological data

Monthly river flow at Hrazdan and Lusakert stations along Hrazdan River and Ashtarak station along Kasakh River from 1983 to 2013 was collected. Discharge of river flow rise up from March and maximum on April or May. Runoff ratio at Hrazdan station along Hrazdan River and Ashtarak staion along Kasakh River is respectively 43% and 25%.

Probability of Hrazdan River flow is evaluated through 2004 to 2013, and the target of evaluation month's data are sum-up the river flow discharge from March to October. Probability of 75% is 2009 based on the calculation, and this result shows that 2008 and 2012 are the relatively dry year.

4-2 Current Water Utilization Conditions

Lake Sevan

Outline

In the Project area, the main water sources of main canals are Hrazdan and Kasakh Rivers. When the water is short to the demand, water is supplemented from Lake Sevan through Sevan-Hrazdan Hydropower Plants Cascade. The release water from Lake Sevan for irrigation has been limited to 170 MCM/year for the preservation of Lake Sevan since 2001. In addition, the hydropower generation along Hrazdan River is allowed to operate only during the irrigation period.

These limitations are aimed to restore water level of Lake Sevan, which is planned to increase to EL.1903.5 m by 2030. The water level has successfully been raised from 1896.32 m on January 1st, 2002 to 1900.13m on January 1st, 2015 and 3.4m remains to reach to the target level. However, the limitation of the usage of lake water for irrigation would not be applied in case of drought year. Most use of the lake water is released to Sevan-Hrazdan Hydropower Plants Cascade and the released water is used for power generation and irrigation. Around 100 to 170 MCM has been used in each year except the drought ones - 2008, 2012 and 2014.

Prospects of water balance and water level in future

The Llake water level rose by approx. 3.7m in ten years until 2011 under the circumstances that sufficient water comes from Arpa-Sevan conduit and the release to Sevan-Hrazdan HPPs Cascade is limited basically to 170 MCM/year. The required water level rise to the target is 3.4m at present, so that if the circumstances are the same, the water level probably reaches the target level within next 10 years.

That is, if the released amount of water can be controlled under 170 MCM/year for a non-drought year after completion of rehabilitation work of Arpa-Vorotan tunnel, the release exceeding 170 MCM in a drought year probably doesn't affect the restoration plan of the lake water level as far as many drought years do not repeat successively.

Hrazdan and Kasakh Rivers

Water Resource Management Agency (WRMA) is the responsible organization to permit the water right regarding irrigation, hydropower, drinking water, fish breeding and industries. WRMA has been reported summary report of water use permits every year. The major water user along Hrazdan River is irrigation and hydropower plant, and the major user along Kasakh River is irrigation. Water source for drinking water is ground water and the discharge volume of utilization for industries is very few compare to irrigation use. Thus, irrigation and hydropower plant is considered as major water user along Hrazdan and Kasakh Rivers.

The water user along Hrazdan and Kasakh Rivers is Sevan-Hrazdanyan Jrar CJSC. The water right for this CJSC has been already permitted by WRMA, and there is no conflict among hydro power plants. The agricultural water usage has higher priority than the energy and industrial production use.

Yeghvard Irrigation Project Site

From the evaluation of the ratio of supplied water source for current Yeghvard Irrigation Project Site, current Yeghvard area depends on more than fifty percent of pump-based irrigation water. The 26% of supplied water comes from pump stations and 25% of it comes from small pumps and deep wells. Shift from pump-based to gravity-based irrigation has an important role in this area.

Aknalich Lake's water comes from ground water. Aknalich pump station is taking irrigation water from this lake. It is cleared that the discharged volume has been decreasing year by year. Energy reduction by shifting to gravity-based irrigation from pump-based irrigation is the important policy in agriculture sector. In addition, from the view point of ground water resources, abolishment of pump facilities contributes not only energy reduction but also conservation of ground water resources in the Project site.

4-3 Current Situation of Planned Reservoir

Outline of Geological, Hydrogeological and Soil Investigations

Major purposes of the initial investigation works were 1) reconfirming the ex-USSR's geological/hydrogeological investigation results, followed by 2) checking the permeability and its anisotropy, and 3) Revealing the groundwater condition in dam site, so that the investigations were distributed widely but rather shallow in and around the reservoir. Through the consideration on the initial investigation, both Recent Alluvium (called; ① layer in Stratigraphy) and Pleistocene Alluvium (called; ⑥ layer) were regarded as an aquiclude. Based on these facts and their significances, the additional geological/hydrogeological investigation works were conducted.

The investigation works were separated into four (4) categories of; 1) Initial geological boring, 2) Monitoring well drilling, 3) Geophysical prospecting and soil investigation boring and 4) Additional geological boring. Work volumes actually conducted were as follows;

1) Initial geological boring;
   a) All-core boring: 10 holes (depth 30 – 50m, total 320m)
   b) In-situ tests:
      - Standard Penetration Test (SPT) (every 1.0m)
      - Permeability Test <Horizontal test> (3.0 – 5.0m span)
      - Permeability Test <Vertical test> (every 5.0m)
      - Natural γ-ray Logging (every hole)

2) Geophysical prospecting and soil investigation boring;
   c) Geophysical prospecting: 53 points (VES, 120m analyses)
   d) All-core boring: 5 holes (depth 17 – 30m, total 137m)
   e) In-situ tests:
      - Standard Penetration Test (SPT) (every 1.0m)
      - Permeability Test <Horizontal test> (3.0 – 5.0m span)
      - Permeability Test <Vertical test> (every 5.0m)

3) Additional geological boring;
   f) All-core boring: 6 holes (depth 60 – 100m, total 480m)
   g) In-situ tests:
      - Standard Penetration Test (SPT) (every 1.0 – 2.0 m)
      - Permeability Test <Horizontal test> (3.0 – 5.0m span)
      - Permeability Test <Vertical test> (every 5.0m)

4) Monitoring well drilling;
   h) Deep well drilling: 5 wells (depth 120 – 150m, total 660m)
   i) In-situ tests:
      - Natural γ -ray Logging (every well)
      -Resistivity Logging with SP log (3 wells but partially)
   j) Completion to monitoring Wells: 5 wells
   k) Installation of Automatic Water Level Recorder (AWLR): 5 wells

Results of Geological/Hydrogeological Investigation

Initial geological boring

Major works conducted under this category were 10 holes of all-core boring together with in-situ tests of; Standard Penetration Tests (SPT), Permeability Test (PT), and Gamma-Ray Logging (GRL). Two (2) kinds of PT were tried to know a horizontal (HPT) and a vertical permeability (VPT). Results of core-boring were arranged into boring log, several geological cross-sections and profiles which were provided to understand the geological condition of dam site.

The geological investigation boring revealed a distribution and properties of major geological formations such as many volcanogenic layers, mainly fluvial sand and gravels (pebbles and cobbles), and rather impervious loamy soil layers. Anisotropy of permeability of these formations was clarified.

Geophysical prospecting and soil investigation boring

Under the category of “Soil investigation boring”, total 53 points of geophysical prospecting were conducted, and based on their results, total five all-core boring with in-situ tests were drilled as Soil Investigation Boring. In these boring, soil samples taken by SPT were sent to a laboratory to make 3 kinds of soil tests (1.Moisture contents, 2.Specific Gravity and 3.Grain-size Distribution Analysis).

Geophysical prospecting was carried out as Vertical Electric Sounding (VES). Results of VES revealed the wide and deep distribution of very thick low apparent resistivity zone ($\rho\ \alpha < 25\ \Omega$m), which can be considered as almost impervious clayey layer in the central portion of planned reservoir.

Soil investigation boring (total 5 holes) were drilled, consequently, to the depth of 30m as a rule. They found out deep loamy layers showing rather low permeability of both VP and HP.

Additional geological boring
Major targets of additional geological boring are Alluvial deposits of Holocene (① layers in Figure 4-2) and Pleistocene (⑥). The work contents were 6 holes of all-core boring up to maximum 100m, VPT and HPT, SPT, and soil laboratory analysis by SPT samples.

Additional boring made clear the distribution of thick clayey layer with very low permeability (VP: 1.28×10^{-6} cm/sec, average) in the central and west central parts, and distribution of sand-and-gravelly ❼ layer in the central east part of the reservoir. Through the additional boring, the distribution of these mostly impervious loamy layers (① and ⑥) was more clearly distinguished, and then, enough permeability coefficients on ① and ⑥ layers were obtained.

Based on the results of additional geological boring, most of geological cross-sections and profiles were modified. Both VP and HP of ①, ⑥ and ❼ layers were rearranged. All boring and in-situ tests results are arranged into boring log.

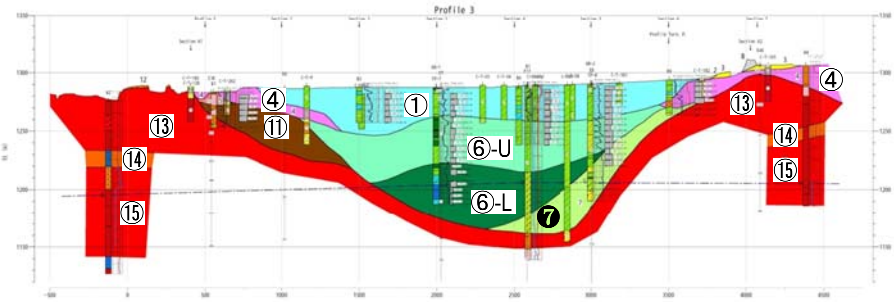


Figure 4-2 Sample of Modefied Geological Profile

Monitoring well drilling
Five (5) monitoring wells were drilled in and surrounding the reservoir area. Well depths were 120 – 150m. Monitoring W1 was drilled at the center of the reservoir to check the groundwater table in the reservoir center, then the other wells were drilled at N, S, E and W of the outside of dam-site, which remained and controlled as monitoring wells after the dam construction completed (except W1 well).

Wells were drilled by 244mm drilling bit, and steel casing/slotted screen with 114mm dia. were installed. After the well development, γ-Ray Logging throughout the well depth was carried out. Groundwater table was detected in the all monitoring wells but depths were varying from around 80 to 131m, mainly because of the differences of the ground elevations. Results of these deep well drilling were rearranged into “Well Log” together with all γ-ray and resistivity logging results.

In the all monitoring wells, an Automatic Water Level Reorder (AWLR) was installed. AWLR measure the groundwater depth at every two (2) hours. However, the groundwater depth must be calibrated comparing manual measurement whenever the recorded data were read up.

Geological/Hydrogeological Conditions of Dam-site

Geological/Hydrogeological conditions
Partially referring to USSR’s results, the Survey Team built up the stratigraphy based on the field reconnaissance and newly obtained geological/hydrogeological information(see Table 4-1). Major differences from Rusian stratigraphy were as follows: Lowest Pliocene Gravel formation (old⑫) was changed to Pyroclastic flow consisting the base of Volcanic Breccia (⑪) and merged into Volcanic Breccia (new ⓫), then, Lower Quaternary sediments series (⑦ to ⑧) are combined into new ❼. Holocene Proluvial-alluvial sediments (②) is renamed as Moraine deposit (new ❸), and

Eluvial-diluvial sediments of the same age is renamed from Gravel to as Surface Gravels (②).

Practical geologic basement of the Yeghvard reservoir area is a sedimentary rock formation belonging to Miocene, consisted of Sandstones, Clays and Marls (⑱). This formation forms impervious basement in this area. On a significant scale, the surface of Miocene was dissected and heavily covered by many volcanic formations erupted from the Aragats and Alairer Volcanos in Pleistocene.

These volcanic activities were quite active throughout the Pliocene and continued to the almost end of the Pleistocene. The oldest volcanic formation in this area is Dacites (⑰) in late Miocene, covering the Miocene sediments (Hrazdan Suite) but dissected strongly so as merely cropping out on some gentle hill tops.

Covering the oldest Dacites, several volcanogenic formations together with a few sedimentary formations, were accumulated in the Yeghvard Highland in early Pliocene. At first, amphibole Andesite (⑮) filled after the Dacites lava, and a little later, andesite-basalt slags (pyroclastic flow (⑭) covered them. Then, Olivine-basaltic Andesites in middle Pliocene (⑬) emerged in large scale and formed the framework of southern and western banks of dam-site. Covering the olivine-basaltic andesite lava, Andesites slags (⓫) were deposited.

Table 4-1 General Stratigraphy of Yeghvard Dam Site

Age			Genetic Classification	Symbol	No.	Main Facies	New No.	Main Facies
Quaternary	Holocene		Aeolian-Diluvial-Proluvial Formation	$_{Vdp}Q_{IV}$	①~1a	Sandy Loam and Loam	①	Sandy Loam and Loam
			Eluvial and Deluvial Sediments	$_{ed}Q_{IV}$	2^a	Gravel	②	Surface Gravel
			Proluvial-Alluvial Sediments	$_{pa}Q_{IV}$	②	Gravel	❸	Moraine Deposits
	Pleistocene	Upper	Volcanogenic Formations	$_{\beta}Q_{III}$	④	Welded Tuff	④	Welded Tuff
		Middle	Volcanogenic Formations	$_{\beta}Q_{II}$	⑤	Lava	⑤	Lava (North bank)
		Lower middle	Lacustrine-alluvial-proluvial Sediments	$_{lap}Q_{I-II}$	⑥	Loamy Sand and Loam	⑥	Loamy Sand and Loam
		Lower	Alluvial-proluvial Sediments	$_{ap}Q_{I}$	⑦-7^a	Sand - Loamy Sand	❼	Sandy Loam to Loamy Sand
			Lacustrine-alluvial-proluvial Sediments	$_{lap}Q_{I}$	⑧	Loamy Sand and Loam		
			Volcanogenic Formations	$_{\beta}Q$	⑨	Lithoidal Pumices	⑨	Lithoidal Pumices
			Volcanogenic Formations	$_{\beta}Q_{I}$	⑩	Welded Tuff	⑩	Welded Tuff
Tertiary	Pliocene		Volcanogenic Formations	$_{\alpha}N_{II}$	⑪	Volcanic Breccia (Scoria)	⓫	Volcanic Breccia (Scoria)
			Alluvia deposits		⑫	Gravel		Pyroclasic flow deposits
			Volcanogenic Scoria Formation	$_{\alpha+\beta}N_{II}$	⑬	Lava	⑬	Lava (South bank)
			Volcanogenic Formations		⑭	Volcanic Breccia	⑭	Volcanic Breccia
			Volcanogenic Formations	$_{\alpha}N_{II}$	⑮	Lava	⑮	Lava
	Mio-cene		Volcanogenic Formations	$_{\alpha}N_{I}$	⑰	Dacites	⑰	Dacites
			Sarmation Sediments (Hrazdan Suite)		⑱	Sandstone, Clay, Marls	⑱	Sandstone, Clay, Marls

In the early Quaternary (lower Pleistocene), volcanic activities were still continued and some volcanogenic formations, such as Welded Tuff (⑩) and Welded (or Lithoidal) Pumices (⑨) were formed. After this, there was a rather long rest of volcanic activities, and in this period, a thick alluvial, diluvial and proluvial deposits accumulated thickly, filling up the deep valley dissected on the andesite lava (⑥ and ❼). The base of these layers (❼) is mostly sandy to gravelly sediments with rather high permeability. Covering these Pleistocene alluvium to diluvium, more younger Olivine-basaltic Andesites in middle Quaternary (⑤) flowed down as lavas formed the main body of the northern bank of reservoir area. And, directly covering the Andesite lava, characteristic brick red color Scoria (or Welded Tuffs) is distributing (④). Notably, the tuffs show quite high gamma-ray radiation. The formation changes its facies from hard rock to rather soft scoria, and pyroclastic flow deposits looking like sand-and-gravels.

The low-land of planned reservoir was an enormous dissected valley in lower Quaternary and buried several volcanogenic and alluvial deposits through upper Pleistocene to Holocene. At the end of Pleistocene, huge volume of moraine deposits were left in northwest bank of the reservoir area (❸). The deposits were consisted of huge basalt blocks, boulders, cobles, pebble, sand and gravels, without selection. Moraine deposits are now covered by recent eluvial and diluvial sediments (② or ① sometime) thinly.

Recent Aeolian diluvial-proluvial formations (①) cover almost all of the central portion of the reservoir area, represented by gray Sandy Loam with comparatively impervious property. Thin sand or clay layers are intercalated everywhere. Thickness of the formation is said from 35 to 40m in the central portion but the total thickness of relatively impervious layers including Lower to Lower-middle Pleistocene Lacustrine-alluvial deposits (series ⑥) shall be beyond 120m in the central portion.

Permeability and its anisotropy of reservoir basin

The Survey Team made a special attention to the anisotropic permeability of the all formations, because dam water shall flow to vertical direction, not horizontal. In accordance with a refernce, there are two methods to evaluate the permeability in the test hole: a piezometer method and a tube method. The piezometer method indicates horizontal permeability and the tube method showed vertical permeability, mainly.

The anisotropic of permeability was clearly detected, mostly the VP were lower than the HP around 1/4 to more than one order. There were some exceptions that VP was higher than HP, mainly in volcanogenic formations and moraine deposits. HP of moraine deposits (❸), young volcanogenic formations (④,⑤), and surface gravels (②) were rather high. However, VP of relatively impervious formations such as Holocene Sandy Loam (①) or Lower middle Pleistocene Sediments (⑥) indicated low VP: the former showed 8.3×10^{-6} and the later showed 6.2×10^{-6} cm/sec in an average. Especially, the lower clay in ⑥ layer (called as ⑥-Low) showed very low VP as 1.28×10^{-6} cm/sec on the average.

In accordance with AWLR measuring results, the maximum fluctuation was only 56.7cm (in W5) for around a half year. Besides that, small fluctuations in each hydrograph are daily tidal fluctuations, and a long span movements of groundwater level are large scale areal groundwater movements, and partly getting an influence of leaking water flow from the Arzuni-Shamiram canal.

Measured groundwater depth suggested that the groundwater table is almost flat but slightly tilted from north to south and east to west. Groundwater movement near the dam-site flows from north to south totally, however, the maximum inclination is less than 14m for around 4km of distance.

From the prepared hydrogeological cross sections in Yeghvard basin, it’s clear the groundwater table in the reservoir area is very flat and deep. These aspects and the groundwater hydrograph indicate that a) groundwater table in the reservoir area is very deep (more than 80m), b) permeability of the Yeghvard highland in between Kasakh and Hrazdan Rivers are very high as a total, and 3) rainfall and snowmelt in the reservoir area give almost no influence to the groundwater table.

Investigation on Dam Body Materials

Investigation on impervious materials

The ground of the reservoir area is widely covered by the thick soil layer so called "loamy sand or sandy loam" which was investigated and planned as the impervious materials for the dam body in the USSR era. The excavation of ten (10) test-pits were planned this time in the reservoir area and also the drilling of 10 hand-augers in the area, defined as the spare borrow area, outside of the reservoir. The location map of the survey points is shown in Figure 4-3. In these test-pits, the field permeability tests by the pit method and by the cylinder method were carried out to grasp the differential between the horizontal permeability coefficient and the vertical one. The former, for the horizontal permeability, was the test done in the excavated pit where seepage through the pit wall is predominant; the latter, for the vertical permeability, was done to the soil column sculptured in the ground where seepage was forced to occur from the top of the column to its foot.

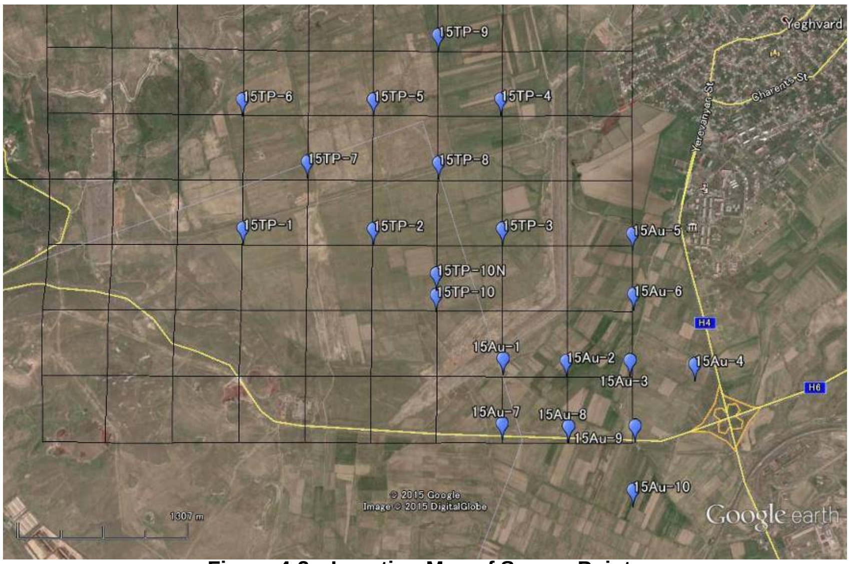


Figure 4-3 Location Map of Survey Points

Laboratory Soil Test

Tests to impervious materials (sandy loam)

[Moisture content]

Most of the soils have the field moisture content lower than the optimum moisture content by 5% to 12% except for the some exceptional ones with the field moisture content higher than the optimum moisture content by 1% to 2% as shown in Figure 4-4, so that to conduct the compaction work to the soils with optimum moisture content condition, a large amount of water shall be needed for moisture content adjustment.

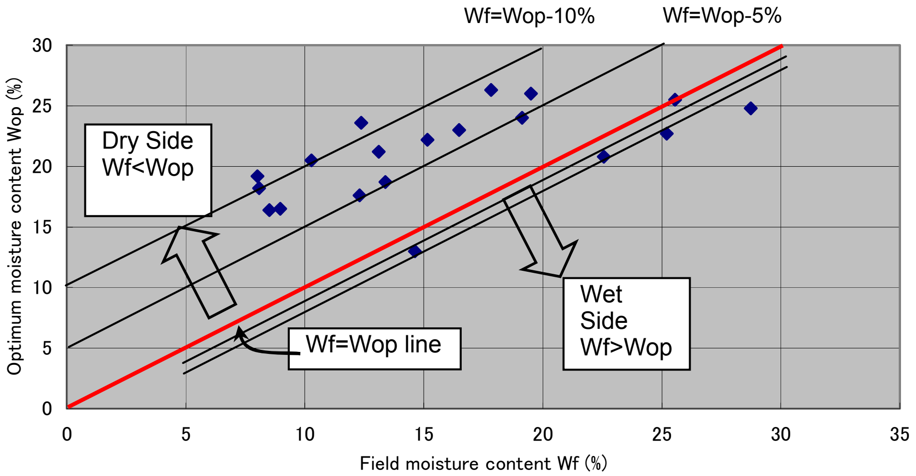


Figure 4-4 Relationship between Field Moisture Content and Optimum Moisture Content

[Grain size distribution test]

The results of the grain size distribution test are shown in Figure 4-5. Most of the samples contain fine particles more than 50%, but it ranges wide from 50% to 95%.

[Standard compaction test]

The coarser soils with a wide range of particle size generally form sharp curves and tend to indicate higher maximum dry densities and lower optimum moisture contents. On the other hand, the finer soils with a narrow range of particle size form flat curves and tend to indicate lower maximum dry densities and high optimum moisture contents as shown in Figure 4-6.

[Direct shear test and tri-axial compression U-U ／C-Ubar test]

Shear strength of the sandy loam is evaluated to be medium class, not good but not so bad as shown in Figure 4-7. It should be noted that a relatively definite differential between the UU strength and the CU strength.

[Permeability test]

The sandy loam (G-1, G-2, G-3) is highly impervious showing the permeability coefficient to be in the order of 10^{-7} cm/sec; on the other hand the loamy sand (G-4, G-5) shows the higher value to be in the order of 10^{-6} cm/sec as shown in Figure 4-8. Once saturation degree of the compacted soil in both cases being a little bit low, the permeability coefficient becomes to be in the order of 10^{-5} cm/sec; therefore, compaction under high compaction energy by a heavy compactor shall be needed.

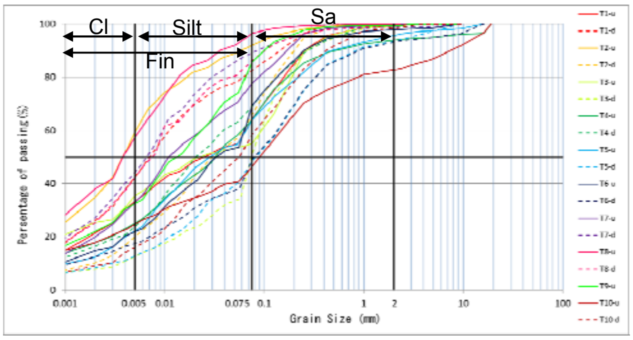


Figure 4-5 Grain Size Distribution Curve of Sandy Loam

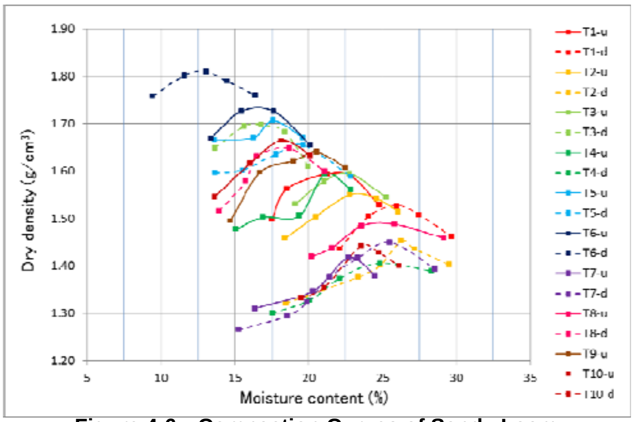


Figure 4-6 Compaction Curves of Sandy Loam

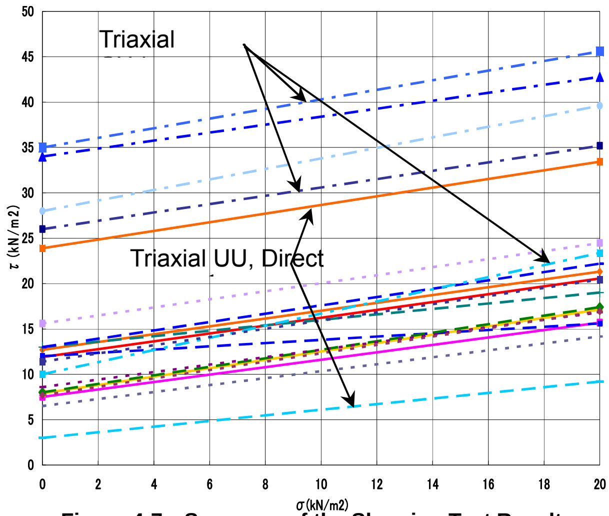


Figure 4-7 Summary of the Shearing Test Results

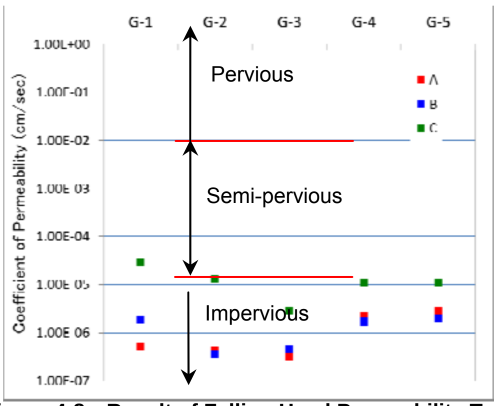


Figure 4-8 Result of Falling Head Permeability Test

Test results of bentonite soil mixture

Contrary to our expectation of the bentonite-soil mixture being improved to show the permeability coefficient in the order of 10^{-8} cm/sec, the lowest value was the one in the order of 10^{-7} cm/sec. When recognizing that the mechanism of gravelly soils' permeability being improved by bentonite mixing depends on the swelling of bentonite powder that fills up the voids among gravelly soils' particle, it is assumed that the reason why bentonite mixing cannot function is the voids among sandy loam's particle are too small for bentonite powder to intrude and swell. Room to pursue the permeability improvement by arranging the gradational conditions of sand-and-gravel is left but at this stage it has not yet been succeeded.

Test results of soil-cement

[Improvement degree in permeability by mixing with cement]
Satisfactory results showing permeability coefficients of k=7.7 x 10^{-7} cm/sec- 3.9 x 10^{-8} cm/sec were obtained.

[Materials to be mixed with cement]
From the view point of stable test values in imperviousness and definitely larger unconfined compression strength, the material “sand-and-gravel coarse” is superior to others.

[Mixing ratio of cement]
As a safety side decision, 10% of mixing ratio shall be adopted.

[Importance of curing]
The influence of specimens being cured or not being cured appears as the differential of two orders, i.e. from 10^{-8} cm/sec order to 10^{-6} cm/sec order in the permeability coefficient, so that curing is very important at the construction stage.

[Durability of soil-cement]

The permeability coefficient becomes larger by half an order, i.e. 5 times, as the influence of freezing/thawing; the unconfined compression strength is not influenced by freezing/thawing. Based on the test results of Slaking Test and Sodium Sulfate Soundness Test, soil-cement made of materials “sand-and-gravel fine” and “sand-and-gravel coarse” shall be estimated to have as stable enough quality as the coarse aggregate for concrete, so that soil-cement is available not only for the anti-infiltration work but also for the slope protection work (Refer to Figure 4-9).

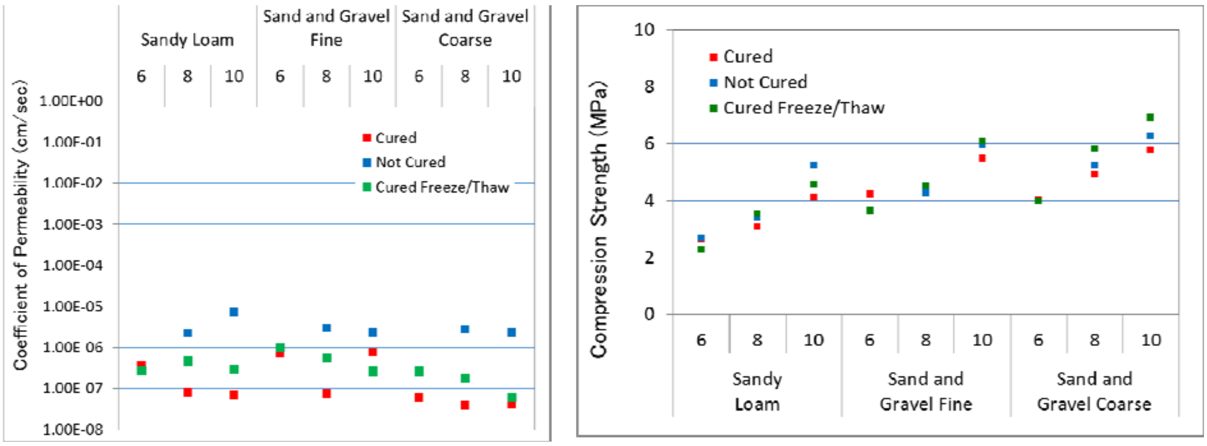


Figure 4-9 Results of falling head permeability (left) and Unconfined Compression Tests (right) to Soil-cement

Investigation for the Anti-infiltration Works to the Reservoir Basin

Field survey of the existing range of sandy loam
This survey was conducted to confirm visually the existing range/condition of sandy loam based on the geological plane map obtained from the investigation results in USSR era. As the survey result, it was confirmed that the area of low terraces extending north-eastern side of the reservoir would have the basement of sand-and-gravel and that at the south side of the reservoir, the edge of the existing range of sandy loam corresponded to the changing point of gradient between the reservoir bottom and the slope.

Field survey to confirm the layer conditions in terms of piping phenomenon

In case of a soil layer receiving water pressure and its basement having cracks or voids, there is a possibility that piping phenomenon occurs. This survey was done to confirm the basement conditions. The results are as follows;

1) There is no possibility of the piping phenomenon arising into the sand-and-gravel layers because of its half-consolidated condition by the gypsum-like materials or the predominance of silty sand that makes the gravels to be compared to the balls floating in the ocean of silty sand.
2) There is a high possibility of the piping phenomenon arising into the volcanic rock layers which are rich with cracks in case of lava or voids in case of pyroclastic flow.

Field survey of ground water seeping out of the slope surface

When the ground surface of the reservoir is covered by an anti-infiltration works, there suspected breaking of this works by the back pressure pushing up from behind due to the light weight of the works. This survey was done to grasp the possibility of ground water acting as the back pressure against an unti-infiltration works. The result is shown as follows.

1) Ground water which maintains two ponds on the reservoir bottom just upstream side of the Dam No.1 might function as a back pressure against as anti-infiltration works.
2) It should be considered that the geological formation in the northern slope of the reservoir with an alternation of gravel layers and silty sand layers might cause the back pressure when seeping out surface is closed by an anti-infiltration work.
3) The surface gravel layer on the south slope seems to be pervious. When an anti-infiltration work covers this layer and the welded tuff layer lying below is impervious, the back pressure would arise against this works.

Snow melting condition survey

Snow melting water is one of the origins that cause the back pressure. This survey was done to grasp the snow melting condition around the reservoir during the snowmelt season in 2016. The result is shown as follows;

The northern catchment area of the reservoir composed of the two main watersheds, one is 18 km^2 and the other 7.2 km^2, is 30 km^2 approximately; waters from these watersheds are concentrated into two valleys over which Arzni-Shamiram canal goes across by the water-way bridge. According to the field observation, small stream appears only in the valley from the 18 km^2 watershed only at the peak of the snowmelt season; and the stream disappeared in the downstream meadow but created groundwater in the sand-and-gravel layer on north-eastern slopes of the reservoir.

Wind velocity survey

8 records of mean wind velocity for ten minutes and 8 records of the instantaneous maximum wind velocity during ten minutes observed in 2014 at Yeghvard Weather Station were obtained. The study result is summarized as follows;

1) Occurrence of high wind velocity, mean and instantaneous, becomes more frequent in June, July and August.
2) In terms of the instantaneous maximum wind velocity, the peak of occurrence frequency is the velocity around 5 to 6 m/sec all through a year.
3) Even under the breeze conditions, a gusting wind with velocity of 10 m/sec or more blows down all through a year.

Conditions of Existing Dam Bodies

[Test-pit excavation]

Five (5) test-pits were excavated on the crest of Dam No.1 and No.2. Findings are as follows;

1) The maximum grain size of cobbles is about 40 cm.
2) The rock sort of cobbles and gravels is basalt.
3) The quality of cobbles is hard and not weathered so that the metallic sound is emitted from them by the hit of the geologist hammer.
4) The compacted layers are rich with fine particles composed of sand and silt that fills up almost completely and densely voids among gravels and cobbles.

[Field density test]
The field density tests by the water-replacement method were carried out on the bottom surface of the test-pits. The values obtained range from 1.88 g/cm^3 to 2.13 g/cm^3 in dry density.

[Field permeability test]
The field permeability tests by pit-method were carried out on the bottom surface of the test-pits. The values obtained range from 5.8 x 10^{-3} cm/sec to 1.9 x 10^{-4} cm/sec.

[Repose angle of sand-and-gravel materials]
Repose angles were measured on the natural slope caused by the backhoe's dumping work of excavated materials. The values obtained range from 33° to 41.2° .

[Laboratory test]

Table 4-2 Summary of the Laboratory Tests to Sand-and-gravels from the Existing Dam Bodies

pit No.	Field moisture	Spe. gravity	Spe. Gravity/absorption		praticle size distribution			Compaction test	
	Wf (%)	(-37mm)	Bulk density	absorption (%)	fine (%)	sand (%)	gravel (%)	D_{max}(t/m3)	W_{opt}(%)
TP-1	5.97	2.69	2.34	1.87	5.00	23.26	71.74	1.95	11.0
TP-4	7.04	2.57	2.34	1.67	7.88	22.78	69.34	1.73	14.6
TP-14	9.50	2.59	2.25	2.52	10.20	24.98	64.82	1.77	16.0
TP-15	11.48	2.53	2.17	1.91	11.50	23.38	65.13	1.65	17.2
TP-16	7.81	2.64	2.35	1.68	6.87	23.99	69.14	1.95	12.7

[Evaluation of the compaction degree]
Compaction tests were carried out to the samples of which grain size was smaller than 37 mm. The relative density is evaluated as the ratio of "the density of the portion of which grain size is smaller than 37 mm in the dam boy" to "the maximum dry density in compaction test". Evaluated values range from 91.6 to 93.7%, which shall be expressed to be "not loose but not so dense".

4-4 Current Conditions of Irrigation Network System with Related Structures

Overview of Current Irrigation System

Current irrigation system distributes water to 8,391 ha through Arzni-Shamiram canal, Lower Hrazdan canal and Ranchpar pump station, divided to two (2) parts. First part is the east side of Kasakh river before Arzni-Shamiram canal crossing Kasakh river, which area irrigated by Arzni-Shamiram canal. And the second part is the west side of Kasakh river after Lower Hrazdan canal passing the Kasakh river, which are irrigated by Lower Hrazdan canal.

The Ranchpar pump station consists of two (2) pumps; i.e. No.1 in Ararat Marz and No.2 in Armavir Marz. The station No.1 lift up the collected drain water near lower part of Hrazdan river to pump station No.2, and lifted water distributes to Lower Hrazdan canal through the No.2. These pump stations are operated by Water Supply Agency (WSA).

Most of the area is irrigated by furrow irrigation method. However, the area lower part of Lower Hrazdan canal has issues about water shortage. It is caused by difficulty of pump's water distribution due to deficit of ground water, conveyance water loss and so on. The current situation of ground water level and amount of collected water volume by drain canal for irrigation use becomes worse year by year, especially in Akanalich and Metsamor pump stations, which located in Ararat Plain.

As a countermeasure to the water shortage, especially in Khoy and Vagharshapat WUAs, those WUAs install a lot of wells and tackle with water shortage issues by themselves. Consequently, WUAs strongly hope to shift from pump-based irrigation to gravity system.

Current Conditions of Irrigation Network System

Irrigation areas targeted by the Yeghvard irrigation system are divided into two (2) areas, those are;

1) The area is composed of Yeghvard and Ashtarak WUAs which are located at east of Kasakh river and are irrigated by a) Arzni-Branch canal and b) Takahan canal through Kasakh river.
2) The other area is composed of Vagharshapat and Khoy WUAs which are located at west of the Kasakh river and are irrigated by c) Shah-Aru and d) Lower Hrazdan canals through Kasakh intake and Ranchpar pump station No.1 and No.2. These area, also, are irrigated by e) Upper Akhnalich, f) Inner Aknalich and g) Metsamor canals sourced by two (2) pump stations (Aknalich and Metsamor PSs).

The aim of the irrigation facility survey to understand current irrigation situation for the targeted areas including the above seven (7) canals, "a)" to "g)", by field surveys as well as to interviews to related WUAs and organizations.

Current Operation and Maintenance on the Irrigation Network System

One is WSA belonging to SCWC, the other one is WUA. Under WSA, two (2) of the organizations of the Sevan-Hrazdanyan Jrar CJSC and Akhuryan-Araks Jrar CJSC are related to collecting irrigation fee.

Operation and maintenance in the Project area has been carried out by the Sevan-Hrazdanyan Jrar CJSC. This WSA has been carrying out the operation and maintenance (O/M) for Arzni-Shamiram canal, Lower Hrazdan canal, Ranchpar and Aknalich pump stations. One of the major activities of the WSA is proper water distribution for irrigation system. WSA is a responsible organization for distributing irrigation water from main canal to secondary canal.

WUA has a responsible for appropriate water distribution for farmers, and O/M along the secondary and tertiary canals. WUA also collect the water fee from farmers. There are Yeghvard, Ashtarak, Vagharshapat and Khoy WUAs in the Project area.

Administrative responsibility demarcation point between WSA and WUA is an intake gate facility where the irrigation water is distributed from the main canal to branch canal. At the gates of the secondary canal' intakes, the operation and management are carried out by the WSA. This is the reason that WSA is the only organization to distribute irrigation water equally along the main canal. WUA has been operated and maintained the gates and canals after the secondary canal's intake gate.

Water supply method

WUA has a responsible of water distribution technical support for farmers, maintenance of irrigation facilities, safety operation, discharge measurement by measuring-record equipment and others. WUA collects the water fee based on the cropped contracted area. Regarding the water fee for irrigation, WSA sells the gravity-based irrigation water by 1.01 AMD/m^3 and the pump-based irrigation water by 11.52 AMD/m^3 to WUA.

On the other hand, WUA sells water to users by 11.00 AMD/m^3 for both gravity-based and pump-based irrigation water. The cost of pump-based irrigation water is differed according to the location by location. However, WSA sells the constant price of pump-based water fee to every WUA in Armenia. Based on the interviewing to PIU, the water fee by pump-based irrigation costs around 50 AMD/m^3 in actual maximum cases. Therefore, the difference cost between the actual cost and the selling price from WSA to WUA has been paid by Armenian government as subsidy.

Maintenance with monitoring (inspection) method
Water level is monitored at the major points along the main canal. These monitored data are observed twice a day by WSA's remote staff and are reported to the WSA's head office. The staff of WSA observes the water level at boundary point between each WUA, and inspects so that irrigation water is diverted to each WUA appropriately. There are six (6) monitoring points along Arzni-Shamiram canal and four (4) monitoring points along Lower Hrazdan canal, respectively. The observed data are converted to the discharge and the 10 day's average data have been recorded and stored.

Maintenance cost
While maintenance cost is different from the size of irrigation area and irrigation facilities, 40% to 50% of total maintenance cost spends for canal cleaning, and remaining percentage used for the rehabilitation works for canals, pumps and deep wells. Vagharshapat WUA spends a lot for maintenance in comparison with other WUAs.

Current Issues on Irrigation Network System

Current situation and issues on target canals are observed by irrigation facility survey. In the basis of results of irrigation facility survey, findings on current situations and issues are summarized below;

1) Deteriorated/damaged due to cracks and exfoliated concrete panels on canals at a number of sections,
2) Lack of cross-section area to convey the design discharge at a number of sections,
3) Sections of open canal replaced by pipeline system due to changing WUA administrative boundary,
4) Areas where substitution new canals are required in the case that existing pumping stations (such as Aknalich PS and Metsamor PS) is abolished due to the policy of the Project, and
5) Some areas irrigated by unclear water source.

4-5 Agricultural Production and Farm Management

Agricultural Surveys Carried Out

The survey team carried out the following surveys in order to collect necessary information for the agricultural planning.

1) Farm household survey
2) WUA workshops
3) Data/information collection (MOA, Marz Agricultural Support Centers, Community Offices, marketing & processing agents, inputs sellers & dealers, etc.)

Number of Farm Households and Family Size

Number of households in the Project area is increasing in recent years, even slightly. The number in agrarian sector, however, stays constant. Total number of households and the number of farm households in the Project area is 16,849 and 13,574, respectively in 2014. The average size is stable in recent years at approx. 4.5 person/family. The percentage of farm households is about 80% in the Project area.

Farmland

Table 4-3 Farmland in the Project Area

Land Category		Yeghvard		Ashtarak		Vagharshapat		Khoy		**Total**	
		Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	**Area (ha)**	**(%)**
1. Registered Farmland in Cadaster (Crop field & backyard)		2,427.9	53.8	1,738.9	48.2	2,797.1	63.1	5,236.9	51.4	**12,200.8**	**53.6**
(1)	Irrigated land (WUA contract 2013)	1,050.6	23.3	915.0	25.4	2,161.0	48.7	5,093.0	49.9	**9,219.6**	**40.5**
(2)	Non-irrigated land	1,377.3	30.5	823.9	22.8	636.1	14.3	143.9	1.4	**2,981.2**	**13.1**
2. Non-farmland		2,084.6	46.2	1,869.6	51.8	1,637.9	36.9	4,961.1	48.6	**10,553.2**	**46.4**
Total Project Area		4,512.5	100.0	3,608.5	100.0	4,435.0	100.0	10,198.0	100.0	**22,754.0**	**100.0**

Source) PIU

<u>Farmland use</u>

The Survey team made an estimation average farmland size per farm household in the Project area with available information. It is estimated that the average farmland size is about 0.97 ha.

Crop farming mostly concentrates on irrigated farmland, and majority of farmland are used for growing annual crops in the Project area. Only a few annual crops, maybe cereals in plateau areas, are grown in non-irrigated farmland. While home garden is generally used for growing vegetables, herbs and some fruits mainly for home consumption, substantial number of farm households generates a certain amount of cash income from surplus production from their home gardens.

Farmers in Vagharshapat and Khoy WUAs are more active in renting in farmland than farmers in Yeghvard and Ashtarak WUAs.

Profile of Farmers and Farm Household Economy

<u>Profile of sample farmers of farm household survey</u>

The average age of head of the sample farm households is 55.8 years old. As regard to farming experience, the average is 25.9 years. It shows that many farmers have a certain long experience in farming. Majority of head of the sample farm households are well educated. Most of them completed their secondary school education, and the percentage of university graduates or more accounts 21%.

The average number of family members of the sample farm households is 5.81 persons/family. Out of 5.81 persons, about 4 persons are categorized into the working active age (15-64 years old). It is interesting that an ordinary farm household may have at least 1 person of permanent employee, including self-employment. It implies that many farm households depend on not a small income from non-farming activities.

<u>Income and expenditure</u>

Average annual income in 2014 declared by sample households is AMD 5,979.1, while the average expenditure is AMD 4,103.3. The highest average income WUA is Vagharshapat and the lowest average WUA is Yeghvard and Ashtarak.

<u>Income source</u>

Naturally, income from farming, especially from crop sales, is the most important income source. It is interesting that salary or wages from non-agriculture sector is the second important income source, while salary or wages from agriculture sector is a very minor source for the farm households. It implies that many farm households in the Project area have family members who have off-farm side-jobs or have main jobs in non-agricultural sector.

<u>Expenditure items</u>

The first priority expenditure item is “agricultural inputs and management”. After it, “food and beverage” and “housing, home-consumables and public services” are second priority items. In

Yeghvard & Ashtarak WUA, the priority for "food and beverage" is very high, maybe, due to high % of low income families.

Strategy to increase living standards of family

There are many farm households who maintain good motivation to continue crop farming, while majority of them has a negative vision for livestock farming. Simultaneously, a substantial number of households look for a good job opportunity in local area. Many farm households also consider that education for children is important for increasing living standards of family, because education brings a good job opportunity. Such conditions imply that a movement to abandon farming is slowly progressing among farm households in the Project area.

Agricultural Production

Various kinds of crops are grown in about 8,500-9,000 ha in total every year in the 27 communities, while the annual average is 8,713ha during 2010-2014. In terms of planted area, wheat is the largest crop, while vegetables and fruits including grapes are also widely grown. Considering a price advantage of vegetables and fruits over cereals, many farmers in the 27 communities generate agricultural profit mainly from vegetables and fruits. The Project area is characterized as a leading area of vegetables and fruits production in the country. Higher productivity of many crops in the 27 communities comparing the national average proves that the Project area is a leading crop farming area in the country.

Out of 13,574 farm households in the communities, only 4,749 farm households or 35% of total farm households are growing some sort of livestock in 2014. In general, livestock farming is not popular among farmers in the 27 communities.

Cropping Calendar

Cropping season of most crops begins in April and May, as rainfall increases when spring season starts in the Project area. The cropping ends in September and October before cold winter season comes. Wheat is an exception since it is widely sowed in autumn, when a certain rainfall is expected. In any case, the farming system in the Project area is designed based on timing with appropriate climate. Irrigation is required for growing all crops in Ararat plain where the Project area is located due to small amount of rainfall and high temperature.

Use of Farm Inputs

Inputs Use

According to the result of farm household survey, 82% and 61% of sampled farmers use fertilizers and herbicides respectively for their crop production, and those percentages are relatively higher compare to other inputs. While fertilizers are commonly used for almost all crops, herbicides are not much used for cereals and sweet pepper. Other farm inputs such as compost, pesticides and commercial seeds are used only by 20-35% of sampled farmers. As regard to fertilizers, there might be growing concern about an excessive use of nitrogen fertilizers in Armenia. A result of the survey implies that many respondents use only nitrogen fertilizers and overuse them to their crops.

Many farmers has recognized that pests and diseases are serious problem for their crop production when the Survey team interviewed about their problems, but pesticides and fungicides are still not popular among them. They are still used selectively by limited farmers to limited crops.

As for commercial seeds and seedlings, those of cereals, potato, tomato, cucumber, cabbage and watermelon are often procured from market. It is noted that many growers of tomato and cucumber under greenhouse depend much on commercial seedlings.

Number of Farm Machinery

Many farmers in the Project area expressed serious shortages of farm machinery during an interview survey with them. Though there are agricultural machinery services by service providers in the Project area, shortages of farm machinery and improper timings of the services are serious issue for appropriate crop management works as planned. In Armenia, many over aged farm machinery such as tractors are still used at field, even from the Soviet time continuously. Present farm machinery services cannot properly cope with requirements for managing a large number of fragmented farmlands owned by individual farmers.

Procurement Sources

Private market is the major source of farm inputs for farmers. Besides, government program is another major source of chemical fertilizers, as there is a government subsidy system of fertilizers to encourage farmers in their intensive farming.

Greenhouse

Almost 95 % of total greenhouse areas in Armenia are concentrated in Ararat Marz and Armavir Marz which are located in Ararat plain. Vagharshapat WUA and Khoy WUA areas, located in Armavir Marz, are the center of greenhouse crop production in the Project area. According to interviewed farmers and the Greenhouse Association, RA, tomato and cucumber are the most popular crops for greenhouse cultivation.

Marketing of Agricultural Products

The Project area has an advantage location for marketing agricultural products to Yerevan city which is the biggest consuming place of agricultural products in the country. Middleman is the most major buyers for farmers in the Project area. Middleman is playing the role of filter to collect up enough volume of products from farmers for retailer’s demand. Middleman are generally selling the purchased products from farmers to other buyers with 20~30 % higher price. The seasonal farm-gate prices show that there are huge gaps between minimum price and maximum price in every crop. The prices of vegetables and fruits are staying at the bottom due to the saturated situation in the market during in the peak harvesting season.

Agricultural Cooperatives

According to the result of the farm household survey, agricultural cooperatives are not active in the Project area. Agricultural cooperatives are not yet became ingrained in farmers not only in the Project area but also in Armenia.

Agricultural Credit

Since April 2011, the government has been implementing an agricultural finance supporting program which compensates the interest rate of agricultural credit. The subsidized agricultural credit is provided through three private banks. According to the result of interviews to farmers in the target area, nearly 40% of interviewed farmers regard access to credit is a considerable issue of farm management. There are subsidized agricultural credit systems in Armenia but many surveyed farmers presumed that those credit systems are not applicable due to its repayment conditions.

Difficulties Confronting Farmers

The Survey team collected information about farming issues through farm household survey WUA workshops and direct interviews with farmers. Major issues pointed out by farmers are shown as follows in the order of seriousness.

1) Marketing issues
2) Pests & diseases issues
3) High cost issues
4) Machinery issues and Irrigation issues

Figure 4-10 shows an image of current circumstance of farmers in the Project area by compiling the issues.

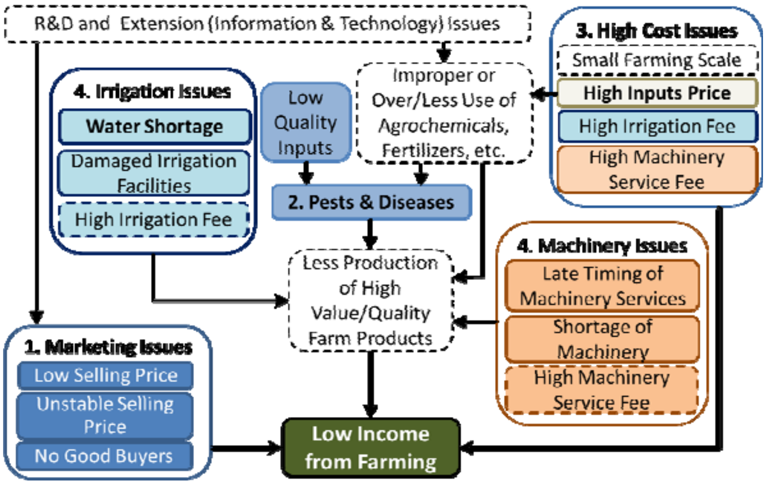


Figure 4-10 Constrains of Farmers in the Project Area

4-6 Information on Cost Estimate and Procurement

Conditions of Cost Estimate

Preconditions for estimating of the project cost are decided as follows;

Table 4-4 Condition of Cost Estimate

No.	Expense and cost	percentage	Source
1	Overhead expenses	13.3 %	Armenian Construction Law
2	Contractor's profit	11.0 %	
3	Expenses on temporary building and Climate impact	4.1 %	
4	Consultant services	6.0 %	Estimation
5	Price contingency	10.24 %	Calculation from price escalation
6	Physical contingency	5.0 %	General rule
7	Exchange rate (1 US dollar = 486.99 AMD		Armenian central bank
8	Exchange rate (1 US dollar = 113.65 JPY		Bank of Tokyou-Mitsubishi UFJ

Procurement of the Construction Machinery

Several construction machinery manufacturers in Japan and Europe have agents in Armenia and general construction machineries are distributed in the market. These machineries are used under lease mainly. These agents have workshops for maintenance of machineries and provides the service of repairing. Only soil-cement mixing machine is import through a machinery agent in Armenia.

Procurement of the Construction Materials

Bentonite

Bentonite mine is located in Ijevan, north east part of Armenia. Mined bentonite includes montmorillonite over 80% and has enough quality for using anti-infiltration works. Capacity of produce is 2,000 ton/month but this volume is to be increased up to 20,000 ton/month by future investment in equipment and facilities. However, even enhanced product from Ijevan is not enough considering the necessary volume of the reservoir construction. Georgia also exports good quality bentonite which contains montmorillonite over 85%. Bentonite is mined in Mitispri, western part of Georgia. Estimated amount of deposit is 50,000,000 ton and annual product is 400,000 ton. This amount is enough for the consumption in the construction in Yeghvard reservoir. Also part of produced bentonite is transported to Belarus and manufactured to bentonite sheet. This bentonite sheet is imported and available in construction market in Armenia.

Cement and aggregate
Raw materials of concrete such as cement, fine aggregate and coarse aggregate are produced in Armenia. Product of these materials is enough for demand of the construction in the Project.

Pipe, gate and valve
Pipes can be procured in Armenia. Some factories have a laboratories for quality control and tensile test, water pressure test and compression test are conducted. Gate and valve are exported from Europe, Russia and China so that products made in Russia and China are inferior in quality, European product are installed for significant facilities in Armenia. Some European valve companies had their factories in Slovenia and valves distributed in Armenia widely.

5. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5-1 Environmental and Social Considerations

Institutional and Legislative Framework for Environmental Consideration

In Armenia, the "Law on Environmental Impact Assessment and Expertise was formulated in 2014. Based on the Law, the Project is classified into "Category A", which requires preparation of an Environmental and Social Assessment (ESIA) Report, and it is needed to get a positive conclusion from the Ministry of Nature Protection (MNP). There are some gaps between Armenian laws and the JICA Guidelines for Environmental and Social Considerations (the JICA Guideline).. Specific standard for irrigation water quality, water/soil quality standard for agrichemical have not been prepared, and international standards such as FAO standards are applied for those matters.

Examination of Alternatives

Some alternatives of the Project in terms of water resources, construction site, scale and anti-infiltration works are examined. As a conclusion, the current location of the Reservoir basin is the most suitable to store a large amount of water, and utilization of free water from the Hrazdan River is the most sustainable as water resource. Concerning reservoir scale, around 800ha reservoir area is selected, since the existing dikes can be used and the cost is lower than that of 600ha. As anti-infiltration works, in terms of reliability and cost, "Soil-Cement with a sandwiched bentonite sheet" is proposed as the best option.

Scoping and TOR for Environmental Examination

Considering the conditions around the construction sites and proposed components, some environmental negative impacts, namely, pollutions during construction works, increase of agrichemicals & fertilizers, impacts on ecosystem and so on in construction stage are expected and they are judged as "B-". Moreover, some parameters, namely, possibility of the conflict between the beneficiaries and affected persons, impacts on groundwater, cultural assets & heritages and so on are unknown and they are judged as "C". Those environmental parameters have to be studied in detail, and based on the scoping result, Terms of Reference for the environmental studies is proposed.

Results of Environmental Examination

Impacts before construction
Before construction, land acquisition will be caused by the Project, and in total, 819.36ha will be influenced by the Project and most of the area is communal land. Compensation policy for land loss, crop loss and so on is established, and it is needed to compensate for the impacts based on the policy.

Impacts during construction

During construction works, air pollution, mud water, noise, road closure, waste generation and so on will be caused in and around the construction sites by the Project. It is necessary to take some countermeasures to minimize the impacts. However, they are temporary and the scale will be relatively small. As a whole, the expected impacts are not very significant.

Impacts during operation

Due to the expansion of irrigation area, application of chemical fertilizer and agrichemical will be increased, and pollution of groundwater and soil can be caused. It is important to promote awareness of suitable agrichemical and fertilizer application methods through the MOA staff. Especially, control of illegal agrichemical is essential.

In and around the Reservoir basin, some endangered species (birds and a snake) are identified, however, they can move to outside of the Reservoir basin by themselves, and there are similar places around the Reservoir. Therefore, it is not difficult for them to survive after the Project, and no severe impacts on fauna and flora by the Project is expected. On the contrary, after the Project, the Reservoir will be attractive for migratory water birds, which can contribute to biodiversity of the area.

The Project will divert 103 MCM from the Hrazdan River, however, it will not cause severe hydrological change, since the River has already been utilized for irrigation and power generation. Even in the downstream, the peak discharge in spring will be kept after the Project. In case of Kasakh River, discharge will be increased, however, the section is very short, only 14km, and significant impact is not expected. Regarding the Lake Sevan, the Project can contribute to save the water of the lake, however, and estimated water level increase by the Project is limited to only 4cm per year.

Concerning impacts on fish in the Hrazdan River, it is possible to category 1) upstream, 2) middle stream and 3) downstream. Fish in the upstream will not be damaged, since the upstream section is located on upper of the water intake point of the Arzni-Shamiram Canal. In the middle stream, natural river and canal flow in parallel, most of the water is taken to canal for irrigation and power generation at present, and the conditions will not be changed after the Project. In the downstream, there is no weir and no canal. The most important season for fish is spawning, namely, spring. In general, spawning triggers of fresh water fish are water temperature change and discharge peak, and sufficient water depth is also necessary. As mentioned before, discharge peak will be kept after the Project and water temperature will be increased as ever. At the Masis Observatory in the downstream, the lowest depth through the year is around 3m, which is enough for fish spawning. Thus, the Project will not give a damage to fish in the downstream neither. Therefore, the damage to the ichthyological system Hrazdan River by the Project will be small.

At the Reservoir, some fish can be flushed away from the Hrazdan River and they can mix to fish in the Kasakh River through the planned Outlet Canal-2. However, there are some common fish between the Hrazdan and Kasakh Rivers, therefore, significant impacts on ichthyological system in the Kasakh River is not expected.

Hrazdan River is mainly used for irrigation and power generation, and even though the Project will take 103 MCM for the Reservoir, the impact will be small, considering that water discharge for hydro power generation in 2013 was 1,875 MCM. In Hrazdan River, around 500 million kWh is generated on average per year, while total power generation in Armenia is around 7,800 million kWh annually. The influenced power generation by the Project will be 27million kWh, which accounts for only 0.35% of total national power generation. Therefore, the impact by the Project on the power generation will be very limited.

Evaluation

During construction period, air pollution, water pollution, noise & vibration, impacts on ecosystem within the Reservoir and waste will be generated, while groundwater pollution, soil contamination and impacts on ichthyological system in the Hrazdan River are concerns during the operation stage. However, these impacts are not significant and irreversible. It is possible to manage to some extent by implementation mitigation measures. Therefore, it can be judged that the impact by the Project will not cause severe environment and social impacts.

Mitigation Measure

Before construction, the compensation measurement should be established and it is to be implemented properly. During construction period, the construction contractor should take measures to minimize the expected impacts. PIU/SCWE will supervise the mitigation measures taken by the contractor in collaboration with the technical consultant. During operation period, MOA, WUA and WSA will be key organizations to mitigate the impacts. MOA is requested to control the proper farming management, while WUA and WSA are recommended to comply with regulation for water use. During operation period, the MNP will be responsible for supervision.

Monitoring Plan

In the process of implementation of EMP, regular monitoring is to be practiced by the responsible organizations. The monitoring results will be complied as a monitoring report by using proposed monitoring indicators and formats. In addition, it is important to record how the implementation agency takes measures against any problems in the process. The report should be submitted to the supervising agency regularly.

Stakeholder Meeting

According to the Law on Environmental Impact Assessment and Expertise, public hearing shall be organized at two stages, namely, initial stage and draft ESIA report preparation stage. At the initial stage, the project outline and environmental expected impacts are to be presented. The second Public Hearing would be organized to share the ESIA Report and gain comments from the participants, when the draft of ESIA Report is ready.

5-2 Involuntary Resettlement and Land Acquisition

Necessity of Resettlement and Land Acquisition

Physical relocation will not be caused by the Project, while the land acquisition will be caused by construction of Yeghvard reservoir and related irrigation canals. Especially, the permanent land acquisition is needed for construction of the Reservoir and planned Feeder Canal 2 which is planned to be an open canal. On the other hand, expected impacts by other proposed canals are limited to the construction period, since they will be constructed as pipelines.

Legal and Administrative Framework

There are some gaps to be mitigated between the Armenian laws and JICA Guidelines/WB OP.4.12. It is not needed to prepare Resettlement Action Plans (RAP) in Armenia, while it is necessary to prepare RAP according to the JICA Guidelines. The main gaps between Armenian laws and JICA Guidelines/WB OP.4.12 are followings;

- ✓ There is no grievance redress system except for complaint about property evaluation result in Armenian laws;
- ✓ There is no provision for cut-off date, and implementation of socioeconomic survey. Cut-off

date cannot be set at F/S stage. However, it can be set at D/D stage after concluding Loan Agreement;

- ✓ In the Armenian legislation, only legal property owners are eligible for compensation.

Scope of Resettlement

The population survey, assets and lands survey, and socioeconomic survey were carried out from March to April 2016. As shown in Table 5-1, there are 75 Project Affected Households (PAHs) with 418 Project Affected Persons (PAPs) in the Project Affected area.

Table 5-1 Numbers of PAHs and PAPs

Type of loss	No. of PAHs			No. of PAPs		
	Legal	Illegal	Total	Legal	Illegal	Total
1. Required for physical relocation						
1-1. HH (Structure owner on Gov. land)	Nil	Nil	Nil	Nil	Nil	Nil
1-2. HH (Structure owner on Private land)	Nil	Nil	Nil	Nil	Nil	Nil
1-3. HH (Tenants)	Nil	Nil	Nil	Nil	Nil	Nil
1-4. CBEs (Structure owner on Gov. land)	Nil	Nil	Nil	Nil	Nil	Nil
1-5. CBEs (Structure owner on Private land)	Nil	Nil	Nil	Nil	Nil	Nil
1-6. CBEs (Tenants)	Nil	Nil	Nil	Nil	Nil	Nil
1-7. Community owned structures including physical cultural resources	Nil	Nil	Nil	Nil	Nil	Nil
Sub-total (1)	Nil	Nil	Nil	Nil	Nil	Nil
2. Not required for physical relocation						
2-1. State or Community owned land[1]	-	60	60	-	340	340
1) Canal area	-	7	7	-	44	44
2) Reservoir area	-	53	53	-	296	296
2-2. Private owned land	15	-	15	78	-	78
1) Canal area	12	-	12	64	-	64
2) Reservoir area	3	-	3	14	-	14
2-3. Labor*	-	-	-	-	-	-
Sub-total (2)	15	60	75	78	340	418
Total (Sub-total 1~2)	15	60	75	78	340	418

Source) JICA Survey Team, March-April of 2016

Remarks) In the Project, farming labors are not included to PAPs.

As shown in Table 5-2, total Project affected area is 819.36 ha, including all three categories, namely, a) State Lands, b) Communal Lands, and c) Private Lands.

Table 5-2 Project Affected Area by Land Ownerships

Category	Plots	Affected Area (ha)
1. State	2	54.49
2. Community	77	738.94
3. Private	25	25.93
Total	104	**819.36**

Source) JICA Survey Team, March-April of 2016

Accordingly, the result of socioeconomic survey is analyzed by three groups of cultivators, namely, 1) cultivators in only Reservoir basin, 2) cultivators in only area along the proposed canal, and 3) cultivators in both Reservoir basin and area along the proposed canal. The lowest income is “1. Cultivators in only reservoir basin.” However, it is also unveiled that they have much higher income from cultivation in non-affected area.

Compensation Measures

By considering the gap between Armenian law and JICA Guidelines/WB OP.4.12 and results of census, assets and lands, and socioeconomic surveys, entitlement matrix was established as shown in Table 5-3.

[1] If the illegal users have cultivated one plot, there would be 53 illegal land users in maximum. Hence, the number of affected households are assumed as 53 households. In addition, according to the socioeconomic survey, the average number of family members in the Project affected area is 5.59 person. Then, the number of PAPs of illegal land users within the Reservoir area is assumed approximately 296 persons.

Table 5-3 Summary of Entitlement Matrix

	Legal land owners	Illegal land users
1. Land loss	Cash compensation at the market price (or official rate, higher of them) +15 %	-
2. Crop loss	Perennial Crop compensation for expected harvest in cash at market rate	-
3. Tree loss	Cash compensation at market rate based on type, age and productive value of the trees	
4. Loss of livelihood means	-	Employment priority in project-related jobs
5. Vulnerable people	1. Allowance equivalent to 6 months of minimum salary 2. Employment priority in project-related jobs	
6. Temporary land loss	1. For land; Cash compensation at the market price (or official rate, higher of them) + 15% 2. For crop; Crop compensation for expected harvest in cash at market rate. 3. For tree; Cash compensation at market rate based on type, age and productive value of the trees	-

Grievance Redress Mechanism

It is recommended to use existing grievance redress system in Armenia for the Project implementation process. Three (3) patterns for grievance redress system, namely, 1) directly applying to the court, 2) directly applying to PIU, and 3) applying to local government or WUA, can be proposed. PAPs can choose the most convenient and accessible way for them to lodge grievance.

Implementation Structure

PIU/SCWE is the Implementation Agency in charge of implementation of the proposed RAP. PIU is requested to cover the final RAP preparation, implementation of the RAP, coordination with concerned organizations. Based on the proposed cost for compensation and support to the PAPs, PIU will apply the necessary budget allocation to the Government. The social expert of PIU is responsible for the general management of the planning and implementation of the RAP. In the process of the monitoring, private consultants will be employed separately, for internal and external monitoring. The main activities of the consultants for internal monitoring are providing technical support to the PIU for RAP implementation. And the external monitoring consultant is required to confirm the progress of compensation payment, living conditions of PAPs.

Implementation Schedule

At the D/D stage, it will take about 14 months to facility design. After the determination of the affected area in the period, the final census survey will be started and it will take two months for the survey. Then, the Cut-off date of the Project will be established as the first day of final census survey.

Before construction, compensation and land acquisition should be done. It is required to discuss on the amount to be paid and to make a compensation agreement between the Government of Armenia and PAPs before compensation implementation. In addition, the monitoring will be started during payment period and it will be continuously done during the construction stage.

Cost and Financial Resources

The total compensation cost for the Project, excluding compensation to state and communal lands, is estimated at 437,720,390 AMD, which is equivalent to 898,828 USD. If the state and communal lands is compensated, the compensation cost can be 5,668,306,790 AMD, which is equivalent to 11,639,473 USD.

Monitoring Structure and Monitoring Form

It is required the internal and external monitoring by different organizations for the RAP implementation. Internal monitoring will be carried out by PIU and private consultants. In the internal monitoring process, following indicators could be proposed;

- ✓ Number of people raising grievances in relation to the Project and number of unresolved grievances;
- ✓ Progress of compensation payment;
- ✓ Whether the payment is properly done; and
- ✓ Change of the living conditions of PAPs.

External monitoring will be carried out by private consultants hired by the PIU/SCWE, who are independent from internal monitoring to confirm whether the compensation progress, considerations to the vulnerable people, grievance redress and so on are properly implemented in accordance with the RAP. The monitoring form is proposed based on the JICA Guidelines.

Public Consultation

The series of stakeholder meetings on ESIA and RAP were organized altogether. Based on the Armenian law on Environmental Impact Assessment and Expertise, public consultation shall be organized at two stages. The first Public Hearing was held on 20th October 2015 in Yeghvard city office. There was no objection against the Project. The participation of the residents at the meeting was relatively small, the seminar to explain the Project outline was also organized in Nor-Yerznka village on 5th November 2015. The people were also interested in the environmental impacts and transportation of soil within the Reservoir. Some of have concern about safety of the Reservoir. On 23rd December 2015, based on the Law, the MNP organized the public consultation at Yeghvard city to confirm the situation. So far, no person who is against the Project has been identified.

Regarding explanation of ESIA Report and proposed compensation policy on the Project, a series of public consultations was organized from the end of May 2016 to the beginning of June 2016. The participants are interested in anti-infiltration works, compensation measure for land loss, scale of the Reservoir and irrigation canals, and so on. In general, negative opinion for the Project was not presented at the public consultations. It is noted that communities concerned have a request that the State will implement some small scale project for the communities, since the communities have to provide their lands for the Project.

5-3 Climate Changes

Armenia has cooperated with international climate change frameworks for a long time. The government ratified the United Nations Framework Convention on Climate Change (UNFCCC) in May 1993 as Non-Annex I party and the Kyoto Protocol in December 2002. MNP has been appointed as the Designated National Authority (DNA) for the Clean Development Mechanism (CDM) of the Kyoto Protocol by a decree of Government of Armenia. One of the main functions is to approve the compliance Kyoto Protocol, as well as to ensure effective participation of Armenia in international CDM processes. In 2010, the Republic of Armenia submitted a statement to the Convention Secretariat for association with the Copenhagen Accords. This statement presents the position of the Republic of Armenia on the continuation of the Kyoto Protocol and the limitation of greenhouse gas (GHG) emissions. In September 2015, the RA approved the Intended Nationally Determined Contribution (INDC) under the UNFCCC. According to this, the climate change mitigation actions should not reverse the social and economic trends, but contribute to the socioeconomic development of the RA.

Agriculture sector is one of the most climate sensitive sectors in the economy. Even in the current conditions, the sector is affected by adverse weather phenomena such as drought, hail, early frost, spring floods, and landslides. In recent decades, extreme weather events have been becoming more frequent and lasting longer. Agriculture accounts for about 20% of the country's total GDP, and the sector has a role of ensuring food security, targeting 75-80% of self-produced basic foods. Therefore, the TNC notes that the strategy for this sector should be aimed at enhancing competitiveness and sustainable development, and at implementing preventive adaptation measures.

Mitigation Strategy

After the project, it is expected that existing deep wells and pump stations will be converted to gravity irrigation systems. The abolishment of them may reduce GHG emission through saving in energy use. The estimated GHG emission reduction of the project is 16,575.02 t-CO2/year.

Adaptation Strategy

Water loss due to wasting of water resource has not been observed in the Project area so far, however, deterioration of the existing irrigation facilities cause water loss, e.g. water leaking from the canals. It is necessary to rehabilitate those facilities and the proposed project components include the rehabilitation works. In the future, it is possible to introduce water saving irrigation system such as drip irrigation and sprinkler irrigation. During the Project implementation, a pilot project to verify the water saving irrigation system can be implemented in collaboration with the MOA.

6. PLAN OF YEGHVARD IRRIGATION SYSTEM IMPROVEMENT PROJECT

6-1 Agricultural Plan

Cropping Area

Table 6-1 Cropping Plan in the Project Area in 2023

WUA	Crop groups (unit: ha)							
	Wheat	Alfalfa	Other food & forage	Potatoes	Vegetables /Melons	Fruits	Grapes	Total
Yeghvard	156	491	64	18	51	758	481	2,019
Ashtarak	77	137	85	8	165	302	851	1,625
Vagarshapat	724	274	160	88	1,701	32	148	3,127
Khoy	944	550	292	737	1,725	527	801	5,576
Project Area Total	**1,901**	**1,452**	**601**	**851**	**3,642**	**1,619**	**2,281**	**12,347**

Crop Productivity

Table 6-2 Crop Productivity

No.	Crop	Yield (ton/ha)		
		Without project	With project	Difference (increase)
1	Wheat	3.6	3.8	0.2
2	Barley	2.7	3.0	0.3
3	Maize (grain)	2.4	2.4	0.0
4	Alfalfa	11.3	11.3	0.0
5	Potato	36.3	40.0	3.7
6	Tomato, open	47.7	48.3	0.6
7	Tomato, green-house	100.0	100.0	0.0
8	Cucumber, open	38.4	40.0	1.6
9	Cucumber, green-house	80.0	80.0	0.0
10	Eggplant	49.8	53.1	3.3
11	Sweet pepper	38.9	40.1	1.2
12	Cabbage	29.7	30.6	0.9
13	Water melon	42.7	44.4	1.7
14	Grape	11.2	12.2	1.0
15	Apricot	7.1	7.5	0.4
16	Apple	7.7	8.9	1.2

Recommended Agricultural Plans Supporting the Project

Summary of Issues Confronting Farmers and Policy Direction is shown in Table 6-3.

Table 6-3 Policy Direction Addressing Farmers' Issues

Farmers' Issues	Policy Direction
1 Difficulty in accessing reliable information on farming technology	To encourage research activity to address the technical issues at farmer level, i.e. fertilization, pest-control, farm-mechanization, water management & saving, etc.
	To enhance agricultural extension activity to be more friendly to individual farmers
2 Lack of promising crop-varieties to meet the market demand	To encourage research activity to develop or introduce new varieties
	To promote seed/seedling growing and importing business
3 High cost of agricultural inputs and farm machinery services & Shortage of farm machinery and spare-parts	To exempt or reduce import duties
	To ease regulations in order to accelerate the private sector entering the business
	To promote a competitive business environment by fostering private business operators and by phasing out of the government intervention from actual business transactions
	To promote a farm mechanization service managed by the private sector/cooperatives
	To introduce affordable credit-schemes to farmers and business operators including cooperatives
4 Low quality inputs are in the market & Banned agrochemicals are used	To educate business operators and farmers (regulations, good practice in handling & storage)
	To create a competitive business environment by increasing the number of business operators
	To practice periodical monitoring and inspection at market and field levels
5 Improper use (overuse or less use) of fertilizers and agrochemicals	To encourage research activity to define an appropriate dosage of fertilizers and agro-chemicals
	To educate farmers how to use fertilizers and agrochemicals properly
6 Shortage of irrigation water	To rehabilitate irrigation canals and networks
	To regulate grand water use
	To develop and introduce water saving technology acceptable to farmers
	To educate farmers the water saving technology
7 Low and unstable selling price of crops	To encourage research activity to develop or introduce new varieties with high market demand
	To develop and introduce forcing or inhibiting cultivation technology of crops
	To educate farmers how to adjust themselves to the present free-market economy system
	To disseminate updated market information to farmers including price information
	To promote a group marketing/processing among farmers by changing their negative mindset against cooperatives
	To interface farmers/cooperatives with private traders to develop a partnership in marketing and processing
	To encourage the development of agricultural marketing and processing industries in rural area
	To disseminate an international-competitive hygiene technology in marketing and processing industries
	To develop a cold chain system in the distribution of agricultural products

Recommended Projects

Followings projects are drafted as priority agricultural projects supporting the Yeghvard Irrigation Project based on the discussion with MOA staffs.

(1) Pilot Agricultural Cooperatives Development
(2) Enhancement of Agricultural Credit System
(3) Establishment of Monitoring and Inspection System of Pesticide Residue
(4) Enhancement of Agricultural Research to Promote a Market Oriented Agriculture
(5) Vitalization of Agricultural Extension

6-2 Irrigation Plan

Water Resources Utilization Plan

Hrazdan is a major river in Armenia. There are hydro power generation systems along Hrazdan river. Most of other countries in the world, irrigation and hydro power generation always have conflict because of mismatching period of demand needs between irrigation and hydro power generation respectively. However in Armenia, the hydro power generation is allowed its operation during irrigation period only, therefore it is no conflict between irrigation and hydro power generation.

The canal parallel to Hrazdan river is used for the Hydro Power Cascade System. The water is distributed from Lake Sevan for irrigation purposes prior to hydro power generation. During the water flow from Lake Sevan to Lake Yerevan, irrigation system take the water for irrigation and remaining water generate the hydro power at each power station.

Irrigation Area and Water Requirement

The total area of Yeghvard Irrigation Improvement Project is 12,347 ha. The target area can be characterized into two (2) areas, one is higher altitude land located around 1,000-1,300m, and the other one is lower altitude land located around 800-1,300m. Altitude of 1,000m is the boundary of higher and lower altitude land. Yeghvard and Ashtarak WUAs are located in higher altitude land belong to Kotayk and Aragatsotn Marzes. Vagharshapat and Khoy WUAs are located lower altitude land belong to Armavir Marz. This lower altitude land is well known as a major agricultural production area, which is called as Ararat plain.

Crop water requirement is calculated by the Irrigation Norm in Armenia, the Institute of Water Problems and Hydraulic Engineering, Yerevan, which was published from Ministry of Agriculture in 2007. In the irrigation norm, crop water requirement is mentioned in consideration of rainfall probability for 50% and 75%. The probability of 75% was used as criteria for management of irrigation schedule as well as for designing of the Yeghvard irrigation system. Water demand for 12,347 ha is equivalent to 154.2 MCM with 46.8% of canal conveyance efficiency factor into the calculation.

Water Balance Calculation

The concept of water distribution from Hrazdan river through Arzni-Shamiram canal is to store the snow melted river flow water to Yeghvard reservoir during March to May. The difference between available water and demand is the maximum water volume which can be diverted to Yeghvard reservoir. However, the maximum discharge to Yeghvard reservoir is calculated with the limited maximum condition of 22.0m^3/s according to the 80% of current canal cross section.

The water balance is calculated combining with hydro-meteorological data, water demand of Yeghvard Improvement Project area and other irrigation systems along Hrazdan river. Year of 2013 is decided as a reference year for definition of the capacity of Yeghvard reservoir. 2013 is matched to the criteria of 75% probability from the view point of rainfall and river flow.

Based on the result of calculation for reference year, the capacity of Yeghvard reservoir is defined as 94MCM. On the reference year, total area of 12,347ha could be irrigated by Yeghvard reservoir. The distributed water from Arzni-Shamiram canal to Yeghvard reservoir is diverted start from 1st decade of March to 2nd decade of May. And from the result of water distribution plan for four targeted WUA, Yeghvard reservoir starts to irrigate from 3rd decade of May and end to 2nd decade of October.

Improvement Plan of Irrigation Network System

Improvement plan of irrigation network system is planned as shown in Tables 6-4 and 6-5.

Table 6-4 Plan of Irrigation Facilities around Yeghvard Reservoir

Name of Facilities		Purpose	Type	Specification				Target Discharge
Feeder Canals	Feeder Canal 1	Inflow to Reservoir	Pipeline	Diameter	φ=	1.60(1.6km), 1.72(1.94km))	m	1.11 *- 9.00 m³/s *) Except Arzni-branch 0.39m³/s
				Length	L=	4.70=1.16(approach canal)+ 3.54(pipe)	km	
	Feeder Canal 2	Inflow to Reservoir	Open Canal	Width	B=	ave. 4.00	m	2.20 - 13.00 m³/s
				Length	L=	0.33	km	
Outlet Canals	Outlet Canal 1	Outflow to Yeghvard WUA	Pipeline	Diameter	φ=	1.20	m	0.22 - 2.33 m³/s
				Length	L=	0.73	km	
	Outlet Canal 2	Outflow to Kasakh River	Pipeline and canal	Diameter	φ=	1.72	m	0.16 - 12.82 m³/s (for irrigation purpose) Maximum 13.7m³/s (in case of emergency)
				Length	L=	4.70(pipe)+0.5(dissipater)	km	

Table 6-5 Plan of Rehabilitation Facilities in Irrigation Field

Facilities and structures	Rehabilitation outline	Responsibility Organization
Arzni-Shmiram canal	・Section between approx. PK14 and PK17, PK28 and PK32, PK64 and PK69, PK85 and PK93, PK94 and PK96. PK96 and PK97, PK101 and PK105 (L=2.7km) ・Remove concrete panel and line with concrete	WSA
Lower Hrazdan canal part2, BP. to PK219	・Section between PK10 and PK188 (L=17.8km) ・Add the concrete for raising to the sidewall ・Installation of 2 pipes that connect Upper Aknalich canal (ϕ400mm) at PK10 and Inner Aknalich canal (ϕ1,000mm) at PK13 with Lower Hrazdan canal at PK188 .	
Aknalich PS	・Abolish	
Metsamor PS	・Abolish	
Ranchaper PS 1	・Abolish	
Ranchaper PS 2	・Abolish	
Arzni-Branch canal, BP. to PK120	・Section between BP and PK23 (L=2.3km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 1 gate	Yeghvard WUA
Arzni-Branch canal, PK120 to EP.	・Section between PK123 and PK234. (L=12.1km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 22 gates, 1 water measurement facility and 2 aqueduct bridges	Ashtarak WUA
Takahan canal, BP. to PK130	・Section between PK69 and PK126 (L=5.4km(except pipeline 0.3km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replacement 17 gate and 2 aqueduct bridges	
Shah-Aru canal, BP. to PK118	・Section between BP. and PK31 PK62 and PK70, PK82 and PK112 (L=6.9km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 16 gates	Vagharshapat WUA
Inner Aknalich canal	・No rehabilitation in the Project	
Upper Aknalich canal BP to PK104	・Section between PK6 and PK104 (L=9.8km) ・Install the precast concrete canal in existing canals ・Replacement 39 gates and 2 aqueduct bridges	Khoy WUA
Metsamor canal	・No rehabilitation in the Project ・Facilities and structures were rehabilitated under the assistance of the World Bank.	

6-3 Reservoir Plan

Comparative Study of the Reservoir Scale

<u>Facility layout around private orchard area</u>

There is a private orchard area at the west edge of northern slope and a part of this area will be submerged after impounding. Since this area has high permeability, an anti-infiltration measure is required against this area to reduce leakage volume.

The following two (2) plans can be considered as anti-infiltration measure and Plan-A is selected due to economical advantage.

Plan-A: A part of orchard area is covered by slope protection with anti-infiltration capacity and some land compensation is requires.

Plan-B: Dam structure is constructed along the toe of slope and no land compensation is required.

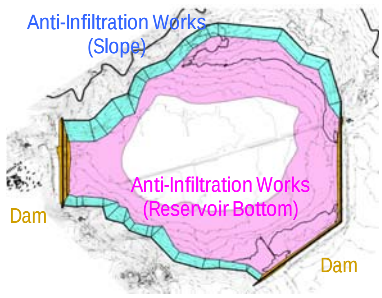
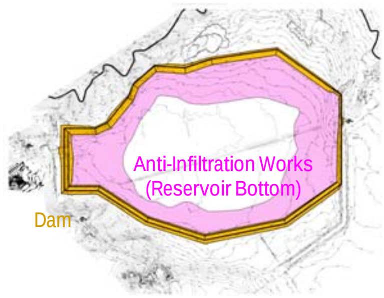
Facility layout to reduce total construction cost

Anti-infiltration works on reservoir bottom, north slope and south slope to reduce leakage volume account high ratio of total construction cost. While dam along the toe of slopes instead of anti-infiltration works can be considered as leakage control structure. Therefore the following two (2) plans can be considered and Plan-A is selected due to economical advantage (Refer to Table 6-6).

Plan-A: Reservoir bottom, north slope and south slope are covered by anti-infiltration works.

Plan-B: Reservoir bottom is covered by anti-infiltration works and dam is constructed along the toe of north and south slope as leakage control structure.

Table 6-6 Results of Comparison Study to Minimize Anti-Infiltration Area

			Plan A	Plan B
			900ha	600ha
Outline				
Reservoir Properties	Reservoir Capacity		94 MCM	Same as on the left
	LWL		EL. 1290m	Same as on the left
	FWL		EL. 1305m	EL. 1307m
	Dam Height		25.55m	27.55m
	Reservoir Area		7.96km^2	5.42km^2
Direct Construction Cost	Total	(USD)	87,768,086	89,853,972
		(Million USD)	87.8	89.9

Estimation of Leakage Rate from Reservoir

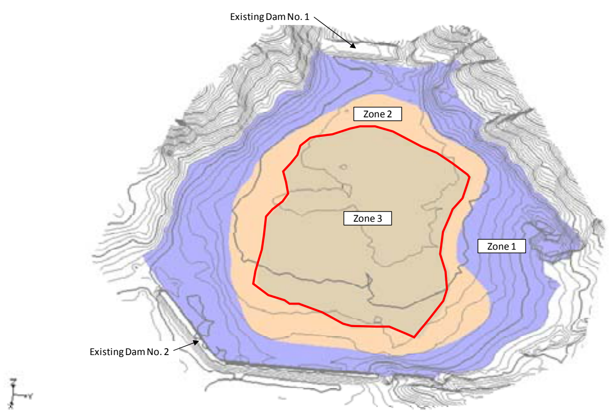
1) In order to grasp the efficiency of the anti-infiltration layer with which the reservoir must be covered to reduce leakage, the leakage rate was estimated for alternative cases of reservoir layout and covering extents of the anti-infiltration layer.
2) Two (2) methods are applied for the estimation: the "2-D Simple Method" and the "3-D FEM Method". The 2-D method is basically the same as used in the past D/D in 1985, but the zoning for the calculation is finer. The calculation for all cases was carried out with the 2-D method. The 3-D method was applied only for the main cases to infer the three-dimensional flow condition.
3) The coefficient of permeability obtained by in-situ test in the present and past investigations were all collected and analyzed. The geometric mean was used for the representative value of each geologic layer.
4) There are two geologic layers which mainly consist of sandy loam or loam and possibly work as the natural anti-infiltration layer. Their representative coefficient of vertical permeability and thickness in the central area of reservoir are as follows;

Layer 1 $k_v = 8.3 \times 10^{-6}$ cm/s, t_1= 15 m ~ 40 m (Upper 10 m : $k_v = 4.3 \times 10^{-4}$ cm/s)
Layer 6 $k_v = 7.5 \times 10^{-6}$ cm/s, t_6= 15 m ~ 90 m (t_1+t_6 = 30 m ~ 110 m)

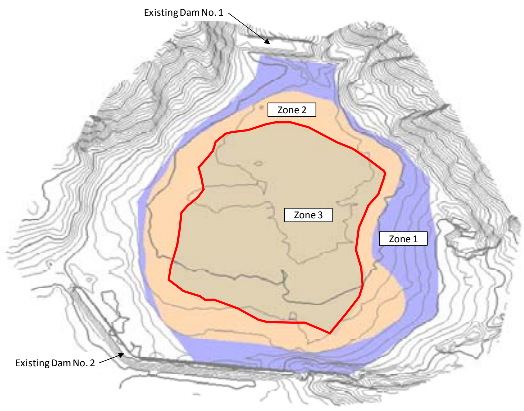
5) Table 6-7 shows the estimation cases and their estimated leakage rates. The rate is larger in the 900 ha plan than the 600 ha plan, but the difference is small. The leakage rate itself is a little large, but probably does not affect the reservoir function significantly, because the ratio to the full reservoir capacity; 94 MCM is near or smaller than 0.05%/day which is the Japanese guideline for reservoir construction. Difference is not so large between the whole and partial coverage cases of anti-infiltration layer. Therefore the central part of the reservoir may not be covered with the layer considering the cost efficiencies.

Table 6-7 Estimated Leakage Rate from Reservoir

Reservoir Layout Plan	Anti-infiltration Layer Coverage	Infiltration Rate at 94MCM			Average Infiltraion rate in Irrigation Period of Standard Year		
		Amount (m^3/day)	Ratio	Ratio to 94 MCM (%/day)	Amount (m^3/day)	Ratio	Ratio to 94 MCM (%/day)
900 ha	Whole	45,900	100%	0.049	29,599	100%	0.031
	Partial	52,196	114%	0.056	34,614	117%	0.037
600 ha	Whole	43,190	94%	0.046	28,809	97%	0.031
	Partial	49,712	108%	0.053	33,908	115%	0.036



900 ha Plan



600 ha Plan

Note) Layer 1 exposes on the ground in zone 2 and 3. The partial coverage case doesn't cover the zone 3 (263 ha).

Outline of the Reservoir Plan

Natural and structural conditions

Meteorological conditions to be considered in the reservoir planning are minus (-) monthly mean temperature in December, January and February, small amount of precipitation shown as 445 mm/year of the average annual precipitation for 30 years (1983~2012), and strong wind accompanied by gusts with 10 m/sec or more of wind velocity. Topographically the reservoir area expanding 3 km long from north to south and 3 km wide from east to west is composed of the wide central plane and gentle slopes at both northern and southern side with the inclination of 1 to 100 or so in average. Geologically and physically, the central plane is composed of thick sandy loam which has low permeability coefficient totally; and the north and south slopes of the reservoir are composed of volcanic products which are pervious totally.

Topic items to be considered in the Reservoir planning

Consideration/study shall be needed to slope protection works against wave actions and against the freezing-thawing effect, anti-infiltration works to the reservoir slopes/bottom, and shape-arrangement to the existing dams and the anti-infiltration works to them.

Comparative Study on the Anti-infiltration Works to the Reservoir

Candidates of the anti-infiltration works

As candidates, seven methods are reckoned up such as 1) earth blanket coverage method, 2) watertight asphalt concrete coating method, 3) polyethylene sheet (rubber sheet) coating, 4) bentonite sheet coating, 5) Soil-cement coverage, 6) Blanket coverage by the compacted layer of bentonite-soil mixture, and 7) soil-cement with a sandwiched bentonite sheet; but these 7 methods are confined into the latter four methods from 4) to 7) because of obvious disadvantages in cost and construction conditions.

Allowable leakage quantity and required permeability coefficient/thickness of anti-infiltration works

Allowable leakage quantity is decided empirically considering the efficiency as a reservoir and the capability or the limit of improvement of the treatment works. In Japan's case, the target of this allowable quantity is '0.05 % of the total reservoir capacity a day'. This target value shall be applied to this reservoir. Then, allowable leakage quantity to 94MCM of the reservoir total capacity is 47,000 m^3/day and the required permeability coefficient/thickness of the anti-infiltration works to two reservoir plans of average depth 10 m and 15m are as follows.

Table 6-8 Quantity and Thickness Required for Anti-infiltration work

Reservoir model	Allowable Q (m3/day/m2)	H (m)	A (m2)	k (cm/sec)	k (m/day)	L (cm)
A=9,400,000 m2 Av. Depth=10m	0.005	10.0	1.0	5.E-05	4.E-02	8640.0
	0.005	10.0	1.0	5.E-06	4.E-03	864.0
	0.005	10.0	1.0	5.E-07	4.E-04	86.4
	0.005	10.0	1.0	5.E-08	4.E-05	8.6
	0.005	10.0	1.0	5.E-09	4.E-06	0.9
A=6,267,000 m2 Av. Depth=15m	0.0075	15.0	1.0	5.E-05	4.E-02	8640.0
	0.0075	15.0	1.0	5.E-06	4.E-03	864.0
	0.0075	15.0	1.0	5.E-07	4.E-04	86.4
	0.0075	15.0	1.0	5.E-08	4.E-05	8.6
	0.0075	15.0	1.0	5.E-09	4.E-06	0.9

Permeability coefficient confirmed through information collection or laboratory tests

Table 6-9 Permeability Coefficient Obtained/Confirmed through Information Collection and/or Laboratory Tests

Candidate	Permeability coefficient (cm/sec)	Source
Bentonite sheet	5×10^{-9}	Producer's catalog
Soil-cement	7.7×10^{-7} - 3.9×10^{-8}, Sufficiency/insufficiency of curing influences the permeability.	Laboratory test
Bentonite-soil mixture	7.0×10^{-6} - 4.6×10^{-7}, Possibility to improve the imperviousness is left.	Laboratory test

Thickness of the anti-infiltration works and its total structural formation

Table 6-10 Thickness of Anti-infiltration works

Candidate	Required thickness/ permeability coefficient (cm/sec)	Adopted
Bentonite sheet	9 mm / 5×10^{-9}	Two-layer application (6 mm×2)
Soil-cement	86.4 cm / 5×10^{-7}	90 cm
Bentonite soil mixture	86.4 cm / 5×10^{-7}	90 cm
Soil-cement with a sandwiched bentonite sheet	Soil-cement; 45 cm, bentonite sheet; one sheet Soil-cement; 5×10-7cm/sec, t=45cm⇒5×10-7cm/sec, t=45cm Bentonite sheet; 5×10-9cm/sec, t=0.6cm⇒5×10-7cm/sec, t=60cm Total; 105 cm>86.4 cm	

Comparison of anti-infiltration workss

In case of bentonite sheet and bentonite-soil mixture, a bed layer work as the filter against piping phenomenon and the slope protection work against wave action and freezing/thawing phenomenon must be considered. The differential in construction cost from the reservoir bottom to the south slope comes from necessity /non-necessity and the sort of these works.

Table 6-11 Comparison of Anti-infiltration Works

Method \ Item	Design (k: cm/sec)	A. Construction cost: item	A. Construction cost: cost	B. Construction work	C. Reliability	Judgment	A	B	C	Total
Bentonite sheet	k=5×10−9 t=6 mm	Bottom	12.6 $/m2	Frequent interruptions by strong wind	Low because of easiness of connection works done hurriedly in the strong wind condition	Bottom	10	5	3	18
		North	22.4 $/m2			North	5	5	3	13
		South	24.1 $/m2			South	5	5	3	13
Bentonite-soil mixture	k=5×10−7 t=90 cm	Bottom	18.3 $/m2	No problem	Complete enclosure is needed; if not, compscted body of bentonite- soil mixture loses its component.	Bottom	5	10	7	22
		North	28.1 $/m2			North	3	10	7	20
		South	30.4 $/m2			South	3	10	7	20
Soil-cement	k=5×10−7 t=90 cm	Bottom	15.3 $/m2	No problem	Lack of curing brings the compacted body incomplete imperviousness.	Bottom	8	10	7	25
		North	15.3 $/m2			North	9	10	7	26
		South	15.3 $/m2			South	9	10	7	26
Soil-cement with a sandwiched bentonite sheet	k=5×10−7 t=45 cm Bentonite sheet 1	Bottom	14.5 $/m2	The additional work of fixing the sheet by driving concrete nails Fewer occurrence of wind interruptions	Mistake in connection works of bentonite sheets can be covered by the continuous layer of soil-cement. Incomplete imperviousness of soil-cement can be covered by the low permeability of bentonite sheet.	Bottom	9	8	10	27
		North	14.5 $/m2			North	10	8	10	28
		South	14.5 $/m2			South	10	8	10	28
						adopted due to economy and reliability				

As the result of comparison study, soil-cement with a sandwiched bentonite sheet is adopted. However there will still remain some risks of leakage more than design value. To mitigate the hazards of risks, trial construction shall be carried out.

Anti-infiltration Works to the Dam Body

The anti-infiltration works to the dam body shall be given as the usual 'core zone' made of compacted sandy loam considering the sustainability against damages caused by earthquake and lack of experience of soil-cement being used as the anti-infiltration works of the dam in earthquake countries.

Basic Design of the Dams and the Reservoir

Slope protection

[Estimation of wind velocity/direction]
Based on the interview to the villagers, the field reconnaissance in and around the reservoir, and the observation record at Yeghvard Weather Station, twenty meter per second (20 m/sec) of the maximum mean wind velocity shall be adopted; as for the wind direction, deflection to from the north or the north-eastern shall be taken into account in the reservoir planning.

[Estimation of the wave height]
The height of the significant wave is estimated by S.M.B. method based on the wind velocity and the blow-over distance. The wind velocity 20m/sec and the blow-over distance 3.7 km (from the north-eastern end to the south-western end of the reservoir) give the point of wave height 0.85 m.

[Estimation of the rock's weight as the slope protection work]
By the Hudson's formula, the rock's weight to the wave height H1/3=0.85 m and the damage percentage 0 - 1 % (KD=3.2) is calculated to be 0.057 tf/m^3 and the grain diameter is about 40 cm when reckoning the rock to be sphere.

[Protection thickness against the freezing/thawing effect]
According to the Armenian construction standard for pipe lines, Construction Norms Ⅳ -10.01.01-2006, the required thickness of cover layer to protect the pipe from being frozen is 79 cm in Yeghvard area. The thickness of 80 cm shall be applied to the protection coverage over the compacted soil layer on the slopes of the reservoir and the dam body.

[Candidate of the slope protection works]

Rock rip rap ; this protection work shall be composed of lava rocks with the grain size of the passing percentage 50% larger than 40 cm and shall have the layer thickness of 80 cm. And moreover, the rock rip rap shall be bedded by the 50 cm thick sand-and-gravel layer, i.e. 30 cm from 80 cm in total of the rock rip rap is assumed to be effective against freezing/thawing effect, as the anti-freezing buffer in case of the slope being provided with the soil layer of anti-infiltration works.

Soil-cement protection; the performance of the US Bureau of Reclamation (USBR) soil-cement test section in the Bonny reservoir built in 1951 provides a positive example of the one exposed long to the wave action and an average of 140 freeze-thaw cycles per year. And the test results of freezing/thawing test, slaking test and sodium sulfate soundness test conducted in this preparatory survey stage indicate high durability of soil-cement against weathering.

Cobble-gravel rip rap; an advantage of this work is that the layer can function not only as the protection against wave actions but also as the coverage against the freezing/thawing effect. But this type of protection work is applicable only to the north and the east slopes where wave actions are little because the grain size/weight of cobbles is not enough to stand wave actions on the slopes on the lee.

[Selection of slope protection works and their application plan]

Table 6-12 Selection of Slope Protection and their Application Plan

Slope / Protection work	Dam No.1		Dam No.2		North slope		South slope	
	Wave action hard	Freezing-thawing	Wave action not hard	Freezing-thawing	Wave action not hard	Freezing-thawing	Wave action hard	Freezing-thawing
Rock rip rap	work	not work	work	not work	work	not work	work	not work
Cobble-gravel rip rap	not work	work	work	work	work	work	not work	work
Soil-cement	work	work	work	work	work	work	work	work
Adoption	Soil-cement		Cobble-gravel rip rap (due to economy)		Cobble-gravel rip rap (due to economy)		Soil-cement	

Dam crest protection

In Armenia, in the area around Yerevan, roofs of residential houses are made of concrete with a 25 cm thick heat-insulating layer of coarse Scoria between the outer slab and the inner slab. According to this manner, a 25 cm thick Scoria layer shall be provided to the crest as the protection against the freezing and thawing effect. Over this Scoria layer, 30 cm thick sand-and-gravel layer shall be provided as the protection against the vehicles' wheels. This sand-and-gravel layer shall have the supplemental effect to the heat-insulating function of the Scoria layer.

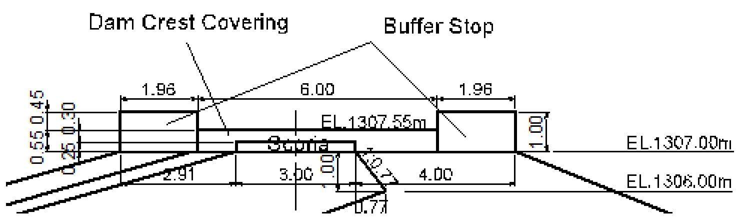


Figure 6-1 Illustration of the Dam Crest Protection

Freeboard elevation of the dam body

Considering the height of wave run-up estimated by the calculation formula shown by Van der Meer and Janssen and the earthquake wave height estimated by Sato's formula, the freeboard elevation of the dam body is adopted to be E.L.1,307.00 m.

Dam crest elevation

The dam crest elevation can be given by adding the dam crest protection thickness to the freeboard elevation of the dam body. Then, Dam crest elevation = Freeboard elevation + Crest protection thickness.

= E.L. 1,307.0 + 0.55 = EL. 1,307.55

Typical cross-section of dams

Inclined core type is selected as dam type for both Dam No.1 and Dam No.2. Those typical cross section is decided as shown in the Figure 6-2 by stability analysis and utilizing physical properties decided according to the results of laboratory and field test.

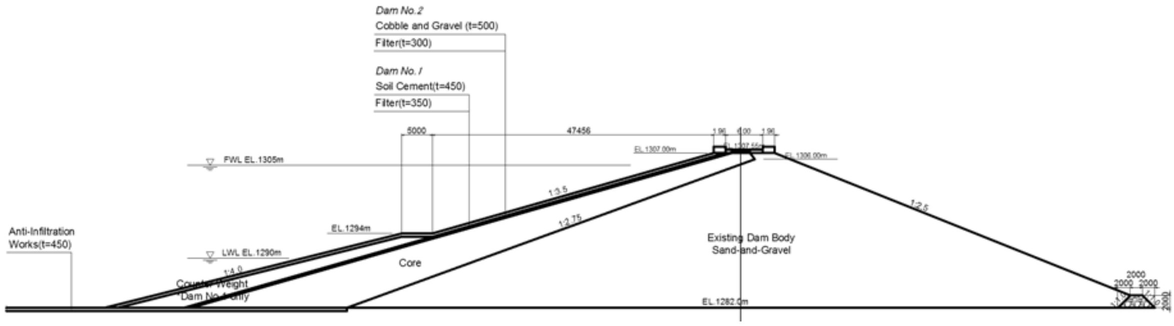


Figure 6-2 Typical Cross Section

Basic Design of Related Facilities (Emergency Discharge Structure)

Emergency discharge facility is designed taking into account the specific conditions of Yeghvard reservoir below;

1) Facilities along Kasakh river will suffer from flood damage in case huge volume of water is discharged from Yeghvard reservoir and,
2) For Nor Yerznka village, water level shall be lowered as fast as possible (emergency discharge volume shall be as much as possible) to mitigate risk of dam collapse and damage in case dam collapse.

Here sets two (2) kinds of emergency situations shown as below and discharge volume is set for each condition.

Low Emergency (Low possibility of dam collapse)

✓ Some observed parameters indicate mild abnormal tendency such as increasing of leakage volume or decreasing of water pressure regardless of the fluctuation of water level.

Total volume of discharge from Yeghvard reservoir and flow from upstream side shall be less than flow capacity of Kasakh river, 13.7m^3/s. Under this condition, discharge volume can be discharged from Yeghvard reservoir varies according to the season as shown in the Figure 6-3 and relation of those and water level of Yeghvard reservoir are shown in the Figure 6-4. Discharge facility is designed to be able to discharge at least volume at each water level shown in the Figure 6-4.

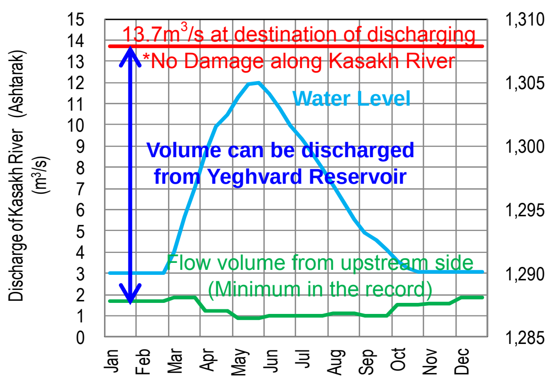


Figure 6-3 Discharge volume from Yeghvard Reservoir

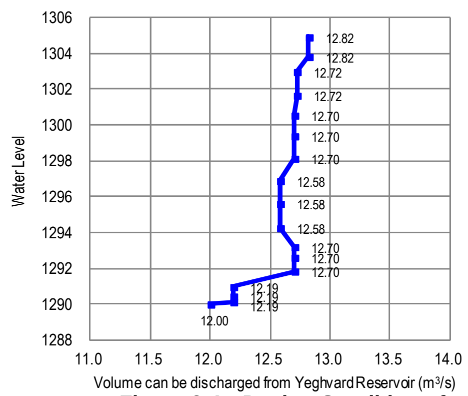
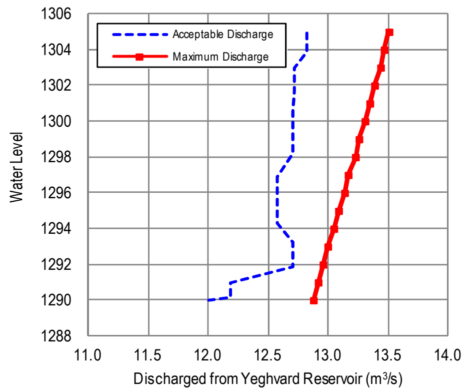


Figure 6-4 Design Condition of Emergency Discharge Facility

<u>High Emergency (High possibility of dam collapse)</u>

- ✓ Some observed parameters indicate serious abnormal tendency such as sudden increasing of leakage volume or sudden decreasing of water pressure regardless of the fluctuation of water level.
- ✓ Some deformations which indicate sliding failure of dam body such as faulting at upper area or swelling at lower area.

Discharge control valve is fully opened and maximum volume of water is discharged. The maximum discharge volume of each water level is shown in the Figure 6-5. Alarming system to Nor Yerznka Village and along Kasakh river is required because there is a possibility of flood caused by dam collapse and by discharge from Yeghvard reservoir.



<u>Figure 6-5 Discharge volume under High Emergency Condition (=Maximum discharge volume)</u>

6-4 Project Cost Estimate

Project Cost

Estimated Project costs of 4 construction method are shown in Table 6-13. Among the 4 method, the method of "Soil-cement with a sandwiched bentonite sheet" is cheapest.

<u>Table 6-13 Project Cost</u>

Contents (Unit: Million USD)		1. Bentonite sheet (2 layers)		2. Soil-Cement coverage		3. Bentonite-soil mixture		Soil-Cement with a Sandwiched Bentonite sheet: 4. Total		5. Excepted irrigation system		6. Irrigation system only	
		Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%
R. Bottom Anti-Infiltration		80.6	66.8	111.8	73.6	83.3	67.6	78.3	66.2	78.3	75.1	0	0.0
Exisiting Dam (No.1, No.2)		6.8	5.6	6.8	4.5	6.8	5.5	6.8	5.7	6.8	6.5	0	0.0
Feerder canal, Outlet canal		17.6	14.6	17.6	11.6	17.6	14.3	17.6	14.9	17.6	16.9	0	0.0
Irrigation system, other works		15.6	12.9	15.6	10.3	15.6	12.7	15.6	13.2	1.6	1.5	14.0	100.0
Direct Construction Cost		120.6	100	151.8	100	123.3	100	118.3	100	104.3	100	14.0	100.0
Overhead expenses	13.3%	16		20.2		16.4		15.7		13.9		1.9	
	sub-total	136.6		172.0		139.7		134.0		118.2		15.9	
Contractor profit	11.0%	15.0		18.9		15.4		14.7		13.0		1.7	
	sub-total	151.6		190.9		155.1		148.7		131.2		17.6	
Expenses on Temporary buildings & Climate impact	4.1%	6.2		7.8		6.4		6.1		5.4		0.7	
	Indirect expenses	37.2		46.9		38.2		36.5		32.3		4.3	
	Construction Cost	157.8		198.7		161.5		154.8		136.6		18.3	
Consultant Service	6.0%	9.5		11.9		9.7		9.3		8.2		1.1	
	sub-total	167.3		210.6		171.2		164.1		144.8		19.4	
Price Contingency	10.24%	17.1		21.6		17.5		16.8		14.8		2.0	
Physical Contingency	5.0%	8.4		10.5		8.6		8.2		7.2		1.0	
	Sub-total	25.5		32.1		26.1		25.0		22.0		3.0	
	Grand Total	192.8		242.7		197.3		189.1		166.8		22.4	
VAT	20%	38.6		48.5		39.5		37.8		33.4		4.5	
	Grand Total with VAT	231.4		291.2		236.8		226.9		200.2		26.9	

Construction Schedule

The Project will start from 2-year Detail Design and tender of construction after the Feasibility study. Then start 4-years construction which calculated necessary construction vehicle. After completion of the reservoir and irrigation facilities, initial impoundment is plan to conduct taking 1 year. Total project period is estimated 7-years as shown in Figure 6-3.

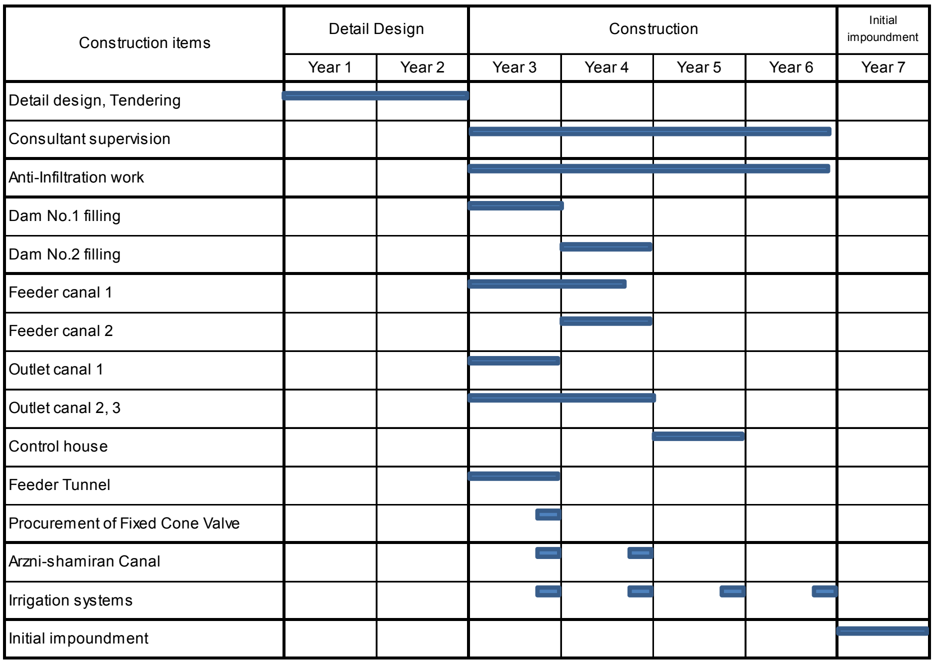


Figure 6-6 Construction Schedule

6-8 Operation and Maintenance (O&M) Plan

O&M Plan of the Reservoir

Yeghvard reservoir will be administration of the Sevan-Hrazdanyan Water Supply Agency CJSC. It should be responsible for the operation and arrangement of staff for Yeghvard reservoir. While, two of Feeder canals and three of Outlet canals should be demarcated to WSA and WUAs in the view of operation. However, the maintenance for the related facilities of reservoir shall be conducted by WSA because the integrated maintenance by single organization could be smooth and effective to interactive relation in each facility of reservoir. **WSA shall be recommended to be main responsible agency for reservoir and related facilities.** The suggested demarcation for operation is shown in Table 6-14.

Table 6-14 Operation Demarcation of Reservoir and Related Facilities around Yeghvard Reservoir

Facility	Conveyance	Maintenance	Operation				
				WUAs			
		WSA	WSA	Yeghvard	Ashtarak	Vagars hapat	Khoy
1. Gate of F.C. 1	Pipeline	●	●				
2. Switching valve box of F.C.1 and O.C.1	Pipeline	●	●				
3. Operation valve house of F.C.1 and O.C.1	Pipeline	●	●				
4. Gate of F.C. 2	OP. canal	●	●				
5. Operation valve box of O.C.1	Pipeline	●		●			
6. Operation valve box of O.C.2 at Dike 1	Pipeline	●					
7. Operation valve house of O.C.2 at connection	Pipeline	●			●		
8. Operation valve house of O.C.2 at Kasakh	Pipeline	●				●	●
9. Main control house of Yeghvard Reservoir		●	●				
Reservoir body		●	●	-			

Yeghvard reservoir as large irrigation facility could seriously affects to social environment, if an unexpected accident may arise. To avoid these damages and serious situation, necessary persons shall be stationed at reservoir facilities to regular observation and report, in addition, unexpected situation shall be taken measure and/or secured safety by these assigned experts. Especially, in case of consultation on engineering matters for reservoir, PIU should be supported and assist the operation unit.

Maintenance of reservoir

To secure the safety situation of reservoir, following items should be observed by visual and or equipment. All data regarding reservoir observation and maintenance records in digital should be documented as evidence of safe operation and maintenance. In addition, design construction document shall be stored in main control house in order to use as required.

1. Leakage water volume at dike and foundation
2. Deformation at dike and foundation
3. Pore water pressure at dike and foundation
4. Water level in reservoir
5. Water level in deep well around reservoir
6. Reaction of dike and foundation for earthquake
7. Visual observation for pipeline

In unusual situation, all of facilities in relation with reservoir shall be inspected by eligible and experienced engineer. Especially, the inspection should be performed not only analyze the seismometer and/or measurement equipment but also visual investigation.

Operation of each Canal at reservoir

To convey the irrigation water to irrigation filed, five of canals connected reservoir should be dully operated to in-flow and out-flow. These canals have the different discharge and have to be operated in accordance with following water allocation. In addition, special attention has to be shortly after the earthquake and similar situation. To prevent the dangerous situation for reservoir, the emergency operation shall be executed.

Table 6-15 Water Allocation of Feeder and Outlet Canals (m^3/s)

	Jan.			Feb.			Mar.			Apr.			May			Jun.		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Arzni-Shami. note1)	0.00	0.00	0.00	0.00	0.00	0.00	7.00	15.5	14.4	22.0	19.2	11.2	18.5	15.4	5.50	7.00	5.00	6.00
Arzni-Branch note2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.16	1.33	1.00	0.39	0.00	0.00	0.00
Feeder C. 1	0.00	0.00	0.00	0.00	0.00	0.00	7.00	9.00	9.00	9.00	8.72	7.84	7.67	8.00	1.11	0.00	0.00	0.00
Feeder C. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	5.40	13.00	10.20	2.20	5.90	3.40	0.00	0.00	0.00	0.00
total inflow	0.00	0.00	0.00	0.00	0.00	0.00	7.00	15.5	14.4	22.0	18.92	10.04	13.57	11.40	1.11	0.00	0.00	0.00
Outlet C. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.66	2.10
Outlet C. 2 for Ashtarak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.28	0.32	0.24	0.09	0.12	0.40	0.51
Outlet C. 2 for Kasakh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.66	0.75	0.56	0.22	6.48	8.24	8.99
total outflow											0.23	0.94	1.07	0.80	0.31	7.10	10.30	11.60
Operation	no-operation						Inflow to Reservoir											
											Outflow from Reservoir							

	Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Arzni-Shami. note1)	6.00	7.00	13.0	13.0	13.0	13.0	8.00	8.00	8.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
Arzni-Branch note2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feeder C. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feeder C. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 1	2.33	2.27	2.22	2.22	2.11	1.83	1.72	0.33	0.22	0.22	1.05	0.44	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 2 for Ashtarak	0.56	0.55	0.54	0.54	0.51	0.44	0.42	0.08	0.05	0.05	0.25	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 2 for Kasakh	6.61	6.88	6.74	5.94	5.68	5.13	3.36	2.39	3.33	3.03	0.59	0.25	0.00	0.00	0.00	0.00	0.00	0.00
total outflow	9.50	9.70	9.50	8.70	8.30	7.40	5.50	2.80	3.60	3.30	1.90	0.80	0.00	0.00	0.00	0.00	0.00	0.00
Operation	Outflow from Reservoir												no-operation					

Note1) Arzni-Shamiram convey water to only Part2 section from 1st period June to3rd period October. Other area is irrigated by Reservoir water

Note2) Arzni-Branch of intake is available from 2nd period April to3rd period May to Yeghvard WUA.

O&M Plan of the Facilities in Irrigation Filed

In the target area, open canal, pipeline and distribution gates compose the irrigation system. Regular inspection and maintenance of these structures and facilities should be conducted. In the Project, some structures will be rehabilitated and reconstructed, but the works do not install new function and unseen structure. Most of structures succeed to the original function and structural form. An irrigation engineers has been assigned at each WUAs, and those engineers can fix irrigation facilities when the facilities are damaged. In addition, all of WUA have established their own internal rules related to operation and maintenance of irrigation facilities. Therefore, present inspection and maintenance will be continuously implemented by WUAs.

7. PROJECT IMPLEMENTATION ASPECTS

7-1 Project Implementation Structure

Related Agencies to the Project Implementation

State Committee of Water Economy (SCWE)
While SCWE is the state agency to take responsibility for the planning, implementation and operation of the large scale of water infrastructures including reservoir, irrigation system and water supply/sanitation investments, the SCWE is placed as implementing body of this F/S of the Project and recognized as the undertaker on ESIA towards the Project implementation. Budget of SCWE in recent last 4 years is steady with a level of 70 million USD annually.

Water Sector Project Implementation Unit (PIU)
PIU was created by the SCWE in 1994 supported by WB to manage the implementation of irrigation improvement projects mainly with dam/reservoir construction funded by international agencies, such as Kaps by KfW, Vedi by AFD, Mastara by EDB and other donors. Out of total number of 36 PIU staff currently, 12 specialists are engaged with financed by AFD loan, and 5 specialists and other staff are engaged their works with burden of Armenian national budget.

Main tasks of PIU are; a) preparation of preliminary project schedule and cost estimate, b) assessment of planning and facility design, c) preparation of tender documents, tendering and its evaluation, d) construction supervision / monitoring of project implementation, e) quality control of construction works, f) assistance to ESIA and RAP assessment, g) assistance to applications for loan and grant projects, h) clarification for contents of loan agreement, etc.

Ministry of Agriculture (MOA)
MOA is a superstructure to agencies of SCWE and PIU. It is suggested that the MOA should conduct following five (5) agricultural supporting projects by national fund or other sources, through “Agricultural Projects Implementation Unit” in accordance with the progress of implementation in order to be the Project sustainable and effective. It is, therefore, recommended to allocate budget in appropriate timing for conducting agricultural supporting projects;

1) Pilot agricultural cooperatives development,
2) Enhancement of agricultural credit system,
3) Establishment of monitoring and inspection system of pesticide residue,
4) Enhancement of agricultural research to promote market oriented, and
5) Vitalization of agricultural extension.

Proposed Implementation Structure and Procedure

Project implementation agency as well as undertaker on ESIA will be SCWE in cooperation with

PIU which will supervise international consultant to be selected by International Competitive Bidding (ICB). Since PIU has enough specialists within their office with experience of international funded projects, a new organization body is not required to mobilize for the Project implementation.

Concerned ministries to the Project implementation, those are; MOF, MFA and MOA will assist to SCWE in coordination with MIEIR after the Loan Agreement signed by and between MOF and JICA which will be financial agency to disburse Japanese ODA Loan.

Contents of D/D including design, drawing, cost estimate, construction schedule and so on to be prepared by the selected consultant, will be applied for their approval by WRMA/MNP and Ministry of Urban Development (MUD). Also, ESIA and RAP reports to be prepared by the international consultants will be applied for their approval by SNCO/MNP.

Tender documents for the selection of construction contractors for both international and national will be prepared by the international consultant through the consultation of PIU. And tendering will be carried out by PIU assisted by the international consultant so that contractors will be selected through ICB and National Competitive Bidding (NCB). It is recommended that Yeghvard reservoir and related facilities around would be under the ICB and rehabilitation of Arzni-Shamiram canal including other main/secondary canals under the NCB respectively.

In C/S stage, Environmental Management Plan which prepared by international consultant and approved by SNCO/MNP and RAP will be monitored by MNP, MOA MES and Yeghvard City.

Cost Burden of the Armenian Government

Since most of consultant fee, cost of civil works will be eligible for Japanese ODA Loan sponsored by JICA during D/D and C/S stages, 1) technical supervisor fees of EMP/RAP monitoring, 2) general administration expenses of Armenian staff, 3) Tax and duties including VAT, 4) compensation for resettlement/crops are non-eligible portions under the JICA guideline. Also, it is recommended that costs of; 1) agricultural supporting projects and 2) on farm level irrigation system improvement are burden of Armenian government which would be 38 to 49 million USD.

8. PROJECT EVALUATION

Project evaluation is carried out in order to determine the economic viability of the Project. The analysis compares the situations "without" and "with" Project, and is carried out on the point of view of the national economy. As indicators of project efficiency, Economic Internal Rate of Return (EIRR), net present value (NPV), and benefit-cost ratio (B/C) have been calculated.

There are another important indicator; FIRR, which is an indicator evaluating projects on the point of view of private companies, however, the Project does not profit-oriented. In fact, the main proposed beneficiaries are farmers, on the other hand, Armenian government is planning to be fully responsible for initial investment, and WSA will be in charge of O&M of the reservoir and other main facilities. It means that the beneficiary is not consistent with the burdens. In this respect, the Project cannot be evaluated in terms of financial costs and returns, therefore, FIRR is out of analysis in this evaluation.

Estimated Project Costs

Economic cost consists of base cost and physical contingency. Appling appropriate specific conversion factors, the economic costs are derived as shown in Table 8-1.

Table 8-1 Summary of Project Costs

Type of Costs	Options			
	1. Bentonite Sheet (2 layers)	2. Soil-Cement Coverage	3. Bentonite-Soil mixture	4. Soil-cement with a Sandwiched Bentonite Sheet
Grand Total with VAT (Million USD)	231.4	291.2	236.8	226.9
Economic Cost (million USD)	164.3	206.9	168.1	161.3

Source) The Survey Team

Expected Project Benefits

In the base analysis, three (3) major benefits are considered; a) benefit from yield and area increase in crop production; b) benefit from livestock production improvement; c) benefit from O&M cost reduction by abolishing pump stations.

As reference, on the top of base case, further benefit d) benefit from conservation of Lake Sevan is also taken into consideration. The benefit is quite important as it is mentioned in national strategies of RA. However, it is not easy to estimate the economic value since the environmental benefit is non-marketed. In this respect, the benefit is calculated as reference only.

Taking irrigation water from the basin may negatively influence other sectors of the region. The most concerning sector is hydropower station of Sevan-Hrazdan cascade operated by Russian company. The opportunity cost of HPPs is taken into account as a negative benefit.

According to JICA's guideline, "land compensation and acquisition cost" have to be considered as "opportunity cost" of the project. Land compensation cost of the project is about 0.9 million USD in total.

Results of Economic Evaluation

Table 8-2 summarizes the economic evaluation by the options. As already mentioned, the economic Project cost consists of base cost and physical contingency. In the economic analysis, benefits and costs are standardized in economic terms using conversion factors. Three indicators have been applied: economic internal rate of return (EIRR), net present value (NPV), and benefit-cost ratio (B/C). NPV and B/C are calculated with 12.0% opportunity cost of capital.

All of the options cannot exceed 12.0% opportunity cost of capital which may reflect the little improvement in yield because the Project components consist only of irrigation systems, and not taking account any agricultural extension and/or other soft components. The Project might produce fruits more if there were other components such as agricultural extension to promote more-profitable but more water-intensive products such as vegetable and fruits.

Comparing the four (4) options, "soil-cement with bentonite sheet" marked highest on EIRR and NPV, indicating 3.68 % of EIRR with -71.9 million USD of NPV, and 0.40 of B/C in base case. Still, it is not regarded as viable even the reference case (including the benefit from conservation of Lake Sevan) as the EIRR is 5.72% against 12.0% referenced opportunity cost of capital.

Table 8-2 Summary of the Economic Evaluation by the Options

Indicators	Options			
	Bentonite Sheet	Bentonite-Soil mixture	Soil-Cement	Soil-cement with bentonite sheet
Project Cost calculated in Cost Estimation				
Grand Total with VAT (Million USD)	231.4	291.2	236.8	226.9
Economic Analysis				
Economic Cost (million USD)	164.3	206.9	168.1	161.3
Incremental O&M Cost (million USD)	1.6	2.1	1.7	1.6
Total Benefit (Base) (million USD)	12.6	12.6	12.6	12.6
EIRR (Base, %)	3.49%	1.60%	3.30%	3.68%
B/C (Base)	0.39	0.31	0.38	0.40
NPV (Base, Million USD)	-74.9M$	-106.6M$	-77.8M$	-71.9M$
Total Benefit (Reference) (million USD)	14.0	14.0	14.0	14.0
EIRR (Reference, %)	5.51%	3.51%	5.31%	5.72%
B/C (Reference)	0.51	0.41	0.50	0.53
NPV (Reference, Million USD)	-59.9M$	-91.5M$	-62.7M$	-56.9M$

Source) The Survey Team

Other Qualitative Benefits

For economic evaluation, benefits have to be limited only on “direct”, ”quantitative”, and “not tentative”. Still, there are other important Project benefits such as; 1) Cultivation of groundwater; 2) Encourage some industries around the Yeghvard area; 3) Creating job opportunity; 4) Contribution for climate change mitigation; and 5) Contribution for tourism and leisure industries.

Proposed Indicators

Several indicators should be established in order to monitoring the Project’s status. There are two (2) kinds of indicators; operational indicator is an indicator measuring whether the output of the Project has been operated and utilized appropriately, while effect indicator is an indicator that aims at measuring whether the Project impact would have been realized as expected. For the usage of these indicators, “proposed indicators” are established based on the expected values of 5 years after the project implementation. In the plan, the year of the completion of construction is 2022, so the proposed indicators are evaluated in 2027.

9. PROCUREMENT PLAN

Condition of Procurement and Contract

During detailed designs stage, there is an approval process to follow making documents of detailed design effective from the governmental agencies under the Ministry of Urban Development (MUD). For the environmental assessment, MNP takes responsibility on document of ESIA.

Two (2) ways; the one is inspected by independent expertise, the other one is done by state expertise due to technical level of the Project. The documents to be prepared by a consultant selected by international bidding shall apply for the approval to the private company who has the license issued by the governmental agency. Which processes whether inspected by private company or government agency, are described in the contract to be signed by and between an implementation agency (PIU/SCWE) and the consultant.

Procurement of Consultant

The expected consultant service is mainly divided into the detailed design (D/D) and the construction supervision (C/S) stages. In case of applying Japanese ODA Loan, the borrower shall be in accordance with the "HANDBOOK for the Procurement under Japanese ODA Loans, April 2012". In addition, the Project shall be suitable harmony with FIDIC.

<u>D/D stage</u>
The consultant for the Project should conduct the investigation, examination and design in this stage. In addition, the consultant should prepare the tender documents for the implementation as the result of D/D. The target facilities for designing are recommended separating by areas, namely; "Target Area 1" for reservoir and "Target Area 2" for irrigation system. Therefore, it is recommended having two packages, one is for "Target Area 1" by International Competitiveness Bidding (ICB), the other one is for "Target Area 2" by National Competitiveness Bidding (NCB). In addition, related ESIA works should be conducted by ESIA consultant selected by NCB with D/D consultant. Therefore, the recommended project Packages are divided into three.

The necessary services for the D/D are summarized as followings;

1) Topographical and geological/hydro-geological field investigations and laboratory test,
2) Review of preliminary designs done during the Feasibility Study (F/S) stage,
3) D/D includes all required hydraulic, structural and hydro-geological calculations, preparation of drawings such as reservoir, feeder, outlet canals and operation manual,
4) Preparation of the pre-qualification documents for tendering,
5) Preparation of tender documents,
6) Preparation of irrigation water management manual including Target area 1 and 2,
7) Preparation of reservoir operation manual, instrumentation of observation and emergency preparedness plans, and
8) Assistance to the conduction of ESIA.

In the D/D stage, the supplemental surveys for finalizing and updating the designs should be conducted due to the changed policy and other unexpected matters.

<u>C/S stage</u>
The consultant shall assist the undertaker in Armenian government for the tender procedure by preparing invitations for pre-qualifications and prior to short listing for the prospective bidders. The consultant shall then accompany the tender procedure and participate in the evaluation of the bids. Assist and task in tender and construction during this stage are suggested, hence bidding and supervision shall be conducted to each package.

<u>ESIA consultant</u>
The regal regulations for ESIA are derived for a number of international conventions in Armenia are a part of and regulated in the Law on Environmental Expert Examination (Law on EEE) adopted in 1995.

The timing for the ESIA is preferably during the early D/D stage to have effective results and to be taken into account before finalizing the designs. The activities of ESIA should be conducted by the international consultant. In the C/S, monitoring and procedure by stipulated in ESIA can be conducted by the construction supervision consultant or by the employed external expertise. The necessary services for the ESIA consultant are summarized as followings;

1) Data collection and investigations such as natural and social conditions
2) Land acquisition and resettlement activities
3) Preparation of draft ESIA report
4) Monitoring of the EMP implementation

Procurement of Contractor

Japanese ODA Loan is the base of request from the government of Armenia. After the request for the Project implementation, JICA will send a Fact Finding (FF) mission and plural appraisal missions prior to Exchange of Note (E/N) and L/A.

10. CONCLUSIONS AND RECOMMENDATIONS

10-1 Viability and Necessity of the Project Implementation

Government of Armenia places this Project; that is “Yeghvard Irrigation System Improvement” as one of the important projects to fulfill the national policies which are; 1) conservation of Lake Sevan being a fundamental source of the livelihood for Armenian people as well as the environmental circumstances, and 2) shifting pump-based to gravity irrigation system prior to reducing governmental subsidies to agricultural water users due to a high rate of electricity.

While one-third (1/3) of population in Armenia is living in the capital city of Yerevan, taking accessibility and marketing into considerations, agricultural activities in the Yeghvard directly connect not to only farmers’ income generation, also food security for inhabitants of the capital because of its location within 20 km to the Yerevan.

Also, since Armenian agricultural development strategy towards promoting; 1) cooperated and competitive market-oriented and 2) export-oriented productions for international trading by shaping favorable conditions, farmers concerned in Yeghvard have much advantage to involve in opportunities obtaining agricultural training/information, extension/machinery services, credit and techniques such water saved irrigation through research institutes under MOA available in Yerevan.

Furthermore, while irrigation projects; Kaps in Shirak Marz and Vedi in Ararat Marz, assisted by KfW and AFD respectively, are under the process of detailed design and tendering stages prior to construction, government of Armenia will concur in developing infrastructural projects in relation to water resource on agriculture/irrigation sectors.

10-2 Conclusions

<u>Scale of the planned reservoir capacity</u>
Alternatives to capacity of the Reservoir is limited since considerable factors for designing is narrowed by 1) demand of crop water requirement of agricultural land with 12,347ha, 2) availability of free water (snow melted water) from March through May in Hrazdan river and 3) capacity of existing Arzni-Shamiram canal which is planned feeding water to the proposed Yeghvard reservoir, while policies to the water resources made by the government of Armenia, i.e. 4) conservation of Lake Sevan and 5) shifting from pumping system to gravity irrigation. Capacity of the planned reservoir, therefore, is fixed with 94MCM from the initial stage of the Survey.

<u>Area of planned reservoir basin (900ha plan or 600ha plan)</u>
Table 10-1 shows advantages and disadvantages in each case of the reservoir basin with 900ha plan and 600ha plan respectively.

Table 10-1 Advantage and Disadvantage by Options of Reservoir Basin Area in Cases of 900ha and 600ha

	900 ha plan	600 ha plan
1) Construction easiness	(Disadvantage) Since area of anti-infiltration works is larger than the case of 600ha, construction period of this work is longer comparatively.	**(Advantage)** Construction period of this work is shorter than the case of 900ha comparatively.
2) Environmental aspect	**(Advantage)** Swampy areas are not formed.	(Disadvantage) Enclosing southern and northern slopes by new dams might form swampy areas at those back side.
3) Acceptance of Armenian side	**(Advantage)** Both existing Dam No.1 and No.2 constructed at USSR era are reused so that past investments are fully utilized.	(Disadvantage) A part of existing Dam No.2 is not reused due to the planning of new dike construction.

While direct construction costs of planned reservoir are not much differed between options of 900ha and 600ha with area of reservoir basin, the one of 900ha is recommended adopting, because the case of 900ha has more advantages than the one of 600ha.

Measure on anti-infiltration works to the reservoir basin
Given conditions geologically and hydro-geologically that the location of the proposed reservoir is located at its high permeability, the cost for anti-infiltration works is occupied approx. more than 60% of the direct construction cost, the Survey team has been conducting alternative studies carefully from the beginning of the Survey period, through investigation of drilling, its in-situ test as well as laboratory soil test, etc. in consideration with results of investigation done in USSR era. Also, simulation for water leakage rate estimation from the reservoir bottom was carried out prior to identifying the most cost-efficiency of necessity area for anti-infiltration works.

Table 10-2 summaries outline of the Project evaluation by examined options done during the Survey. Case by using soil-cement with a sandwiched bentonite sheet for anti-infiltration works is the most economical option, with 900ha of reservoir basin and capacity of reservoir with 94MCM.

Table 10-2 Outline of the Project Evaluation by Options(Reservoir basin: 900ha)	Bentonite sheet with 2 layers	Bentonite soil mixture	Soil-cement	Soil-cement with a sandwiched bentonite sheet
Project cost with VAT (million USD)	231.4	291.2	236.8	226.9
EIRR (including Conservation of Lake Sevan)	3.49% (5.51%)	1.60% (3.51%)	3.30% (5.31%)	3.68% (5.72)%

10-3 Recommendations

Trial Construction for Anti-Infiltration Works

Although soil-cement with a sandwiched bentonite sheet is the best option for anti-infiltration works, some risks of leakage more than design value still remain. Additionally, there are no reservoirs having this structure as anti-infiltration works. Therefore trial construction to find appropriate measures to mitigate hazards of leakage risks and to identify difficult/important points to note on the construction shall be carried out before/during Detail Design stage.

Abolish of Existing Pump Stations

In accordance with national policy in Armenia, i.e. “shifting pump system to gravity irrigation”, the capacity of reservoir is designed in the Project including of proposed new connection canals (by pipelines) and rehabilitation of existing main/secondary canals. While current irrigation system in some areas, however, is dependent on pumping, it is recommended that delays and/or gradual abolishing existing pump facilities with considering the effect of gravity irrigation, especially of deep tube wells should be allowed.

Pilot Farms for Water Saved Irrigation

Two (2) communities are recommended for pilot farms for water saved irrigation, one for fruit and the other one for vegetable cultivation. Water saved irrigation is not adopted in order to reduce water demand in the Project, however, they are recommended for new technology such as reducing an amount of fertilizer and chemical for decreasing expenditure of the agricultural inputs by sprinkler and/or drip as well as the climate changes in future as agricultural supporting projects.

Measures on influences to other utilizations of free water (snow melted water) at the downstream of Hrazdan River

Even though it is evaluated that influences by taking free water with a volume of 103MCM including losses (canal conveyance and evaporation/infiltration from Yeghvard reservoir, etc. with 94MCM) through Arzni-Shamiram canal from March to May annually with the Project, would not be anticipated, by following findings, the Survey Team recommended that;

Since the Project is expected to contribute the conservation of Lake Sevan by reducing water use of approx. 50MCM annually, a part of water volume from the 50MCM is released to Hrazdan river in March to May annually as the substitution of diverting free water to the Project by taking consideration into the influences on the current ecology in the downstream of Hrazdan river.

Emergency Discharge Facility

The Survey team suggests setting up an awareness program for emergency during the detailed design of the Project whenever the natural calamity occur such a large earthquake by establishing a structure of committee.

Compensation for Communities (RAP)

It is recommended to examine request from Yeghvard City and Nor-Yerznka Village, namely, any possible supports to mitigate the land loss within the planned Reservoir before the Loan Agreement (L/A) , since the lands for the Project currently belong to those communities.

YEGHVARD IRRIGATION SYSTEM IMPROVEMENT PROJECT
DRAFT FINAL REPORT (DFR)
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ABBREVIATIONS

ADS	Armenia Development Strategy
ADB	Asian Development Bank
AFD	Agence Française de Developpement
ASMC	Agricultural Support Marz Center
ASRC	Agricultural Support Republic Center
AWLR	Automatic Water Level Reorder
B/C	Benefit-Cost Ratio
CARD	The Center for Agribusiness and Rural Development
CGIAR	Consultative Group on International Agricultural Research
CDM	Clean Development Mechanism
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	International Potato Center
CIS	Commonwealth of Independent States
CJSC	Closed Joins Stock Company
C/S	Construction Supervision
D/D	Detailed Design
DFR	Draft Final Report
DNA	Designated National Authority
EDB	Eurasian Development Bank
EEU	Eurasian Economic Union
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
E/N	Exchange of Notes
ESIA	Environmental and Social Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization
FF	Fact Finding mission
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GHQ	Greenhouse Gas GHG
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPGRI	International Plant Genetic Resources Institute
IRR	Internal Rate of Return
ISNAR	International Service for National Agricultural Research
ITR	Interim Report
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
NPV	Net Present Value
ODA	Official Development Assistance
O&M	Operation and Maintenance
OP.	Open Canal
PAH	Project Affected Household
PAP	Project Affected Person
PIU	Water Sector Project Implementation Unit State Agency
Pre-F/S	Preliminary Feasibility Study
RA	Republic of Armenia
RAP	Resettlement Action Plan
SADS	Sustainable Agriculture Development Strategy of the RA
SCF	Standard Conversion Factor
SCWE	State Committee of Water Economy

SMEs	Small and Medium Enterprises
SNC	Second National Communication on Climate Change
TIN	Triangulated Irregular Network
TIWRM	Towards Integrated Water Resources Management
TNC	Third National Communication on Climate Change
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USSR	Union of Soviet Socialist Republics
WB	World Bank
WRMA	Water Resources Management Agency
WSA	Water Supply Agency
WUA	Water User Association

Unit

mm	:millimeter	m^2	:square meter	m^3	:cubic meter
cm	:centimeter	km^2	:square kilometer	MCM	:million cubic meter
m	:meter	km	:kilometer	ha	:hectare
g	:gram	cm/s	:centimeter per second	Kcal	:kilocalorie
kg	:kilogram	m^3/s	:cubic meter per second	kWh	:kilowatt hour
g/cm^3	:gram per cubic centimeter	lit/sec	:litter per second	Ωm	:ohm meter

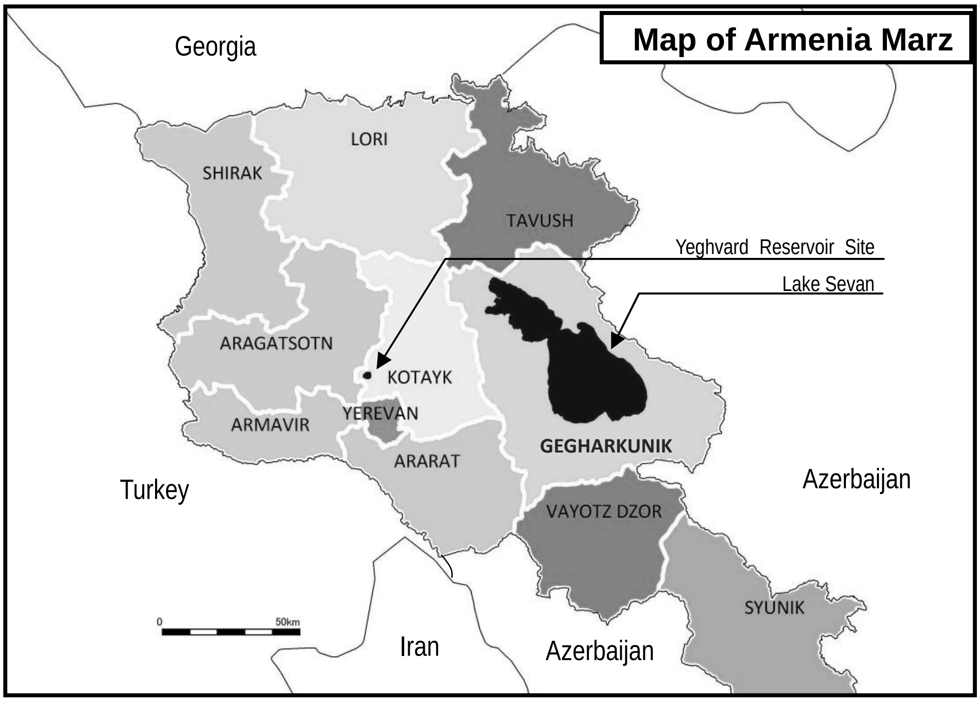
Currency

Japanese Yen	(JPY)
US Dollar	(USD)
Armenia Dram	(AMD)

Exchange rate (as of April 2016)

1 USD = 113.65 JPY (Bank of Tokyo-Mitsubishi UFJ)

1 USD = 486.99 AMD (Central Bank of Armenia)



CHAPTER 1 INRODUCTION

1-1 Background of the Survey

After the request for Official Development Assistance (ODA) loan to the government of Japan was made by the Government of the Republic of Armenia (hereinafter referred to as “Armenia”) in June 2012, JICA had executed to gather information related to the construction of Yeghvard Reservoir by sending the contact missions as well as sending questionnaire in order to formulate the Project.

Based on the information that JICA obtained through the above, JICA proposed two-phased studies; a) Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Project (Pre-feasibility Study: Pre-F/S) and b) Full-scaled Feasibility Study (F/S), and the Government of Armenia agreed the above mentioned proposal.

And JICA dispatched a consultant team as place of the above a) Pre-F/S in June 2014. The consultant team, then conducted a field survey including data/information collection and had a series of discussions with related agencies in Armenia from June through August 2014, and analyzed the collected information prior to prepare a draft final report (DFR) of the Pre-F/S in Japan during September to October 2014. JICA sent a mission to Armenia in November 2014 for the purpose of explanatory discussion for the DFR of the Pre-F/S for the Project, then, the government of Armenia accepted it. In March 2015, JICA sent an official letter decided to dispatch a consultant team for the F/S of Yeghvard Irrigation System Improvement Project (hereinafter referred to as “the Project”). Then, the consultant team (hereinafter referred to as “the Survey Team”) have started the Preparatory Survey for Yeghvard Irrigation System Improvement Project (hereinafter referred to as “the Survey”).

1-2 Objectives of the Project

Objectives of the Project are shown as below;

1) To distribute stable irrigation water to the Project area,
2) To improve agricultural productivity in the Project area by the stable irrigation water,
3) To fulfill the national policies such as; a) conservation of Lake Sevan and b) shifting pump-based to gravity-based irrigation system.

1-3 Scope of the Survey

Scope of the Survey for the Project is shown as below;

<u>Up to Interim Report (ITR)</u>

1. Reconfirm the background and current situation of the Project
2. Study natural condition of the Project site
   1) Topographic survey (reservoir, emergency canal)
   2) Geological, hydro-geological and soil mechanical surveys (around and within reservoir site)
   3) Groundwater level survey (reservoir site)
   4) Hydrological and water resources survey
   5) Fish ecology survey (Hrazdan and Kasakh Rivers)
   6) Water quality survey
3. Study adoptable material and method of construction
4. Study seismic design standard and emergency discharge system
5. Suggest agriculture plan for the Project area
   1) Future farming plan
   2) Cost-benefit analysis
   3) Suggestion of governmental program to promote/support agriculture for the Project area

6. Suggest irrigation plan (management plan) for the Project area
7. Confirm the Project scope
8. Consider alternative options of the Project

<u>Up to Draft Final Report (DFR)</u>

9. Confirm the Project outline
   1) Purpose of the Project
   2) Contents of main facilities (reservoir, dam, irrigation canals)
   3) Contents of consulting service (detailed design, management of construction)
10. Develop preliminary design
11. Study suitable construction method for the Project
12. Formulate the implementation schedule of the Project
13. Study and formulate the implementation system of the Project
14. Study and formulate the maintenance system of the Project
15. Study environmental considerations including support of development of Environmental and Social Impact Assessment (ESIA) report (draft)
16. Study social considerations including support of development of Resettlement Action Plan (RAP) report (draft)
17. Estimate the Project cost
18. Study mitigation and adaptation on climate change
19. Study gender issue considerations
20. Suggest the effective technical cooperation to expand the Project outcome
21. Collect information on the situation of local procurement
22. Set quantitative and qualitative evaluation indexes of the Project

1-4 Project Area

The Project area is located in the surrounding area of Yerevan city within 20km from the capital city of Yerevan, with 22,754 ha of land area of which 12,200 ha or 53.6 % of the land area is registered as a farmland in cadaster. The Project area expands to 27 communities in three (3) Marzes (regions), i.e. Kotayk, Aragatsotn and Armavir. As shown in Table 1-4.1, the whole territory of 22 communities belongs to the Project area, while a part of the territory belongs to the Project area in other 5 communities. Consequently, 91.2 % of total land area in the 27 communities is included in the Project area.

In terms of WUA category, the Project area is divided into 4 (four) WUA command areas, namely; Yeghvard, Ashtarak, Vagharshapat and Khoy. Potential farmland area for irrigation in the Project area is estimated at 12,347 ha by the Survey Team. The area is larger than the registered farmland area in cadaster as actual cultivated area has extended to non-registered farmland area in many communities in Vagharshapat and Khoy command areas.

Table 1-4.1 Project Area by Communities

No	Community	Marz	WUA	Land Area			Registered Farmland (ha)	Potential Farmland for Irrigation (ha)
				Total (ha)	The Project Area (ha)	% of the Project Area		
1	Zovuni	Kotayk	Yeghvard	1,532.0	1,532.0	100.0	654.2	538
2	Kasakh			1,287.5	1,032.0	80.2	634.0	545
3	Proshyan			2,189.0	1,948.5	89.0	1,139.7	936
4	Sasunik	Aragatsotn	Ashtarak	1,989.5	1,989.5	100.0	1,045.8	934
5	Norakert	Amarvir		1,356.0	609.0	44.9	130.0	98
6	Baghramyan			1,071.0	464.0	43.3	200.0	172
7	Merdzavan			879.0	546.0	62.1	363.1	421
8	Mrgastan		Vagharshapat	296.0	296.0	100.0	173.6	114
9	Tsakhkunk			405.0	405.0	100.0	138.4	154
10	Artimet			636.0	636.0	100.0	327.3	444
11	Taroniq			716.0	716.0	100.0	404.9	528
12	Aratashen			976.0	976.0	100.0	723.8	813
13	Khoronk			695.0	695.0	100.0	481.7	562
14	Griboyedov			711.0	711.0	100.0	547.4	512
15	Lernamerdz		Khoy	164.0	164.0	100.0	105.4	97
16	Amberd			451.0	451.0	100.0	352.5	350
17	Aghavnatun			1,139.0	1,139.0	100.0	475.5	462
18	Doghs			384.0	384.0	100.0	285.2	276
19	Aragats			875.0	875.0	100.0	452.7	645
20	Tsaghkalanj			795.0	795.0	100.0	312.0	469
21	Hovtamej			268.0	268.0	100.0	215.3	176
22	Tsiatsan			311.0	311.0	100.0	205.1	202
23	Geghakert			659.0	659.0	100.0	532.6	491
24	Haytagh			1,261.0	1,261.0	100.0	647.6	606
25	Ferik			402.0	402.0	100.0	159.0	167
26	Arshaluys			1,746.0	1746.0	100.0	1,023.0	973
27	Aknalich			1,743.0	1743.0	100.0	471.0	662
	Total			**24,937.0**	**22,754.0**	**91.2**	**12,200.8**	**12,347**

Source) PIU, SCWE

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Outline of Armenia

(1) Main geography of Armenia

Armenia is a landlocked country located in Caucasian Region, surrounded by 4 neighboring countries consisting of Georgia in the northern border, Turkey in the west, Azerbaijan in the east and Iran in the south. Lake Sevan (38 billion m^3 as of 2013), the largest natural lake in Armenia, is situated at the center of the territory as shown in Figure 2-1.1.

Figure 2-1.1 Map of Armenia

Yerevan is a capital city of Armenia with approx. 1.2 million of population (as of 2015) which is one-third (1/3) of the country. And Yeghvard irrigation areas are extent within 5 to 20km at north-west of Yerevan.

Lake Sevan is situated at a highland with its elevation of about 1,900m, flowing down to Hrazdan River that runs through the central part of the Armenian. Water in the Lake has been utilized for irrigation over a vast and flat irrigated farm-area of Ararat Plain (at the altitude of about 500 to 1,000m) with gentle topographical gradient through Hrazdan River.

The irrigation water conveyed from the Lake Sevan has also been used as hydro-power generation utilizing difference of elevation between the Lake and Ararat Plain, however, the period of power-generation is limited from April through November during which irrigation water is distributed to the beneficiary. Thus, Lake Sevan has been regarded as one of precious water resources and from the use of (water) energy point of view though the priority has been given to the side of irrigation.

(2) Background of the request for the Project

Water volume stored in Lake Sevan measured 58,000 million m^3 (MCM) in late 1940s was reduced to 33,000 MCM in early 1970s due to too heavy water use by domestic/industrial sectors as well as irrigation, as a result water level in the Lake dropped by as much as 19 m. As the conservation measures for Lake Sevan suffering from heavy drawdown of lake water level, the Government of Armenia constructed a water tunnel for diverting water from other watershed areas during the period 1960s to 1980s and it also implemented the policy of limiting annual water use for irrigation. However, during the period of energy crisis in 1990s, the lake water was again overused, lowering lake water level.

Yeghvard reservoir project was planned during 1970s as one of the conservation measures for Lake Sevan. Later in 1980s, the work with a scale of 228 MCM had been started, but it was later interrupted due to difficulty in fund supply. Later in 1990s, coping with second recession of lake-water level, reservoir construction plans were studied 16 sites throughout the country from water conservation point of view. Yeghvard reservoir project was included as one of these countermeasure-plans. The scale of this reservoir was reviewed by the country and reduced to around 90 MCM. The plan with this reduced scale has been requested from the Government of Armenian to the Government of Japan as a loan aid project in May 2012.

In the Pre-F/S carried out in 2014, physical strength of dam body of which had been interrupted its construction in 1980s was identified and reports on geological/hydro-geological surveys carried out at the times of Union of Soviet Socialist Republics (USSR) were reviewed as well studies were made on the existing agricultural policies and the state of irrigation practices. It has been identified through this "Survey" that in addition to the necessity of introducing gravity irrigation (abolishing pump irrigation) with the objective of mitigating the government-subsidized operation and maintenance (O/M) cost of pumps, the importance of constructing a reservoir has again been reviewed to mitigate excessive dependency on water in Lake Sevan that suffers from excessive drawdown of lake water-level due to overexploitation of lake water beyond the annual limit of water use (170 MCM) during drought period.

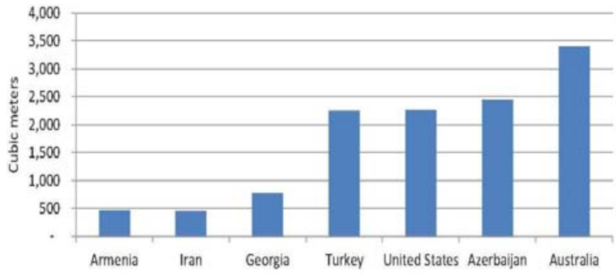
On the other hand, as for the evaluation of current hydro-geologic state of the reservoir and the selection of construction method for anti-infiltration, necessity of further survey has been confirmed since only the review of reports is not enough. As of the date of issuing the request for the loan aid to the Government of Japan in 2014, the Government of Armenia had an idea, namely, covering reservoir basin area with fairly impervious artificial sheet (Bentonite-sheet) as measures of preventing water leakage. According to the stakeholders of the Government of Armenia, an artificial sheet producing factory will domestically start its operation in near future. Because the Government plans to make use of domestically produced inexpensive sheet as anti-infiltration measures for the reservoir basin, the Project is to identify the period of starting the construction of the factory as well as of producing the product and its quality, comparing this sheet-covering method with the other shielding methods reviewed in the Project, thereby examining the applicability of the planned sheet.

2-2 Policy of Water Resources

The average annual rainfall in Armenia is around 600mm and the climate belongs to semi-arid and arid zone area. From the point of sustainable water resources development, construction of reservoir and proper water management has an important role in Armenia. There are 87 medium to small scaled reservoirs in the country, which have been constructed since the period of Soviet time.

However, despite such reservoir construction, the storage capacity of reservoirs/water storage facilities per capita in Armenia is smaller as compared to that in Turkey, one of the neighboring countries, only about 20% of that in the Turkish territory, lying on the opposite side of Ararat Plain. Accordingly, given limited land resources and meteorological conditions, it is imperative for Armenia to secure water resources efficiently and appropriately.

The Government of Armenia has been formulated Water Code in 2002, National Water Policy in 2005 and National Water Program in 2006. Table 2-2.1 shows representative example Code and Laws related to the water management.



Source) WB (2014),Towards Integrated Water Resources Management : Revisited

Figure 2-2.1 Capacity of Water Storage Capacity per Capita in Armenia and Neighboring Countries

Table 2-2.1 Code and Law Related to Water Resource Management in Armenia

Name of Code and Laws	Adoption Year
Water Code	2002
National Water Policy	2005
Water Program	2006
Law on Lake Sevan	2001
Law on Water Users Societies and Associations of Water Users Societies	2002

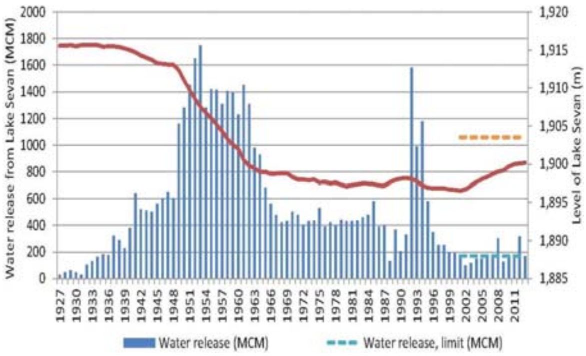
The Water Code is the principal document adopted by the National Assembly. The main purpose of this Code is the conservation of the national water reserve, the satisfaction of water needs of citizens and economy through effective management of useable water resources, securing ecological sustainability of the environment. And the National Water Policy pursues aim to provide accessibility for sufficient quantity, regime and quality of water resources to maintain basic human well-being for present and future generations, socio-economic system development, and to meet economic and ecological needs.

In addition, the National Water Program has been developed, which will guide the water basin management plans and the classification of water resources. The law will serve as the basis for integrated water resources management, and will support more efficient management and protection of water resources.

The National Water Policy defines that water resource allocation among water users shall be performed base on the following order of priorities, which are listed as shown in Table 2-2.2. Agricultural water usage priority is higher than the Energy and Industrial production use.

Table 2-2.2 Priority of Water Usage Defined by National Water Policy

No	Order of Priorities for Water Usage	
1	National water reserve	Conservation and usage of sufficient water resources, to ensure basic needs of population, reduce disease and so on.
2	Traditional use	Historical use for non-industrial purposes
3	Water resources use	Set in the Armenia legislation and international commitments
4	Vital	To ensure vital and cultural water need of population
5	Agricultural	To ensure water need in irrigation, pasture irrigation, animal breeding and other non-industrial purposes
6	Energy	To ensure water needs in energy production
7	Industrial	Water for industrial production needs
8	Recreation	Water use for sports, fishing, swimming and so on.
9	Anti-drought activities	To minimize damage caused by droughts



Source: World Bank (2014),Towards Integrated Water Resources Management : Revisited
Figure 2-2.2 Change in Water Level in Lake Sevan

Together with conservation of river flow, Lake Sevan is also important water resource in Armenia, which has the largest water storage capacity. Armenia has diverted watersheds by constructing the Arpa-Sevan and Vorotan-Arpa tunnels as conservation measures of Lake Sevan, thus keeping relevant use of the Lake, learning from lessons of dropping water levels in this lake that occurred in the past. Furthermore, in 2001, Armenia launched an environmental improvement strategy for Lake Sevan with the target of elevating its water level by 6m (up to 1,903.5m) by 2030. Additionally, the country has not only determined the upper limit of annual releasing (intake) water volume from Lake Sevan to an irrigation network at 170MCM, but it also decided to operate hydropower stations located along the Hrazdan River only during the period of distributing irrigation water, thereby addressing the recovery of the lake-water level is shown in Figure 2-2.2.

As mentioned above, the Government of Armenia has taken the initiative to conserve Lake Sevan in such an integrated manner as watershed diversion by tunnels and practice of limiting intakes from the Lake, in contrast with the current state in neighboring countries where environmental problems have taken place including descending water levels in lakes. As a result, the water level in Lake Sevan tends to have been increasing since 2003, with visible fruit of its strategic effort for recovery. Such a desirable concept will continuously be handed down to younger generations. At the same time, the Government of Armenia not only constructs new reservoirs and conserves natural water resources including the Lake Sevan, but also considers watershed management as an important strategy to relevantly utilize its limited water resources. In the future, it will envisage efficient use of water resources by adequately managing watersheds of individual streams.

2-3 Agricultural Development Policy

The Armenian people focused their economic activity back to the agricultural sector in order to make utmost efforts to accommodate themselves to the economic crisis after the independence. As a result, the sector was headed for recovery and the GDP ratio of the sector grew to 46.3% in 1993. Currently, however, the GDP ratio is reduced to lower than half of that of 1993. This is not attributed to the stagnation of the sector, but rather the smooth recovery and growth of other economic sectors. The current state of agriculture in the country shows that the sector has surpassed the stage of self-subsistence and has entered the next stage of commercialized agriculture that includes vegetables, fruits, industrial crops and livestock, as seen in the USSR era. It is reported that approx. 80% of domestic agricultural production was from irrigated land. Irrigation is a significant infrastructure supporting the country's agriculture.

The government launched its Sustainable Agricultural Development Strategy (SADS) covering the period 2010-2020 as the national agricultural development policy in order to respond to the commercial-oriented agriculture. SADS aims to enhance productivity and value of agricultural products; to improve food security for the population by distributing products appropriately both to domestic and international markets, and to promote its export (targeting 3.5 times increase in the current export volume). More details of SADS are described as follows.

2-3-1 Sustainable Agricultural Development Strategy (SADS)

Vision (in 2020)

- Sustainability and competitiveness agriculture,
- Cooperated and highly competitive, market-oriented production,
- Sustainable provision of food to the population and meeting the demands of the processing industry,
- Increase in gross farm produce though increasing labor productivity,
- Development in SMEs in rural communities,
- Positive change of intrans sectoral structure of plant and livestock production,
- Utilization of agricultural potential, especially land resources, and
- Improvement of food security for the population.

Strategy goal

- Promotion of industrialization of agriculture (value-addition),
- Increase in the food security, and
- Shaping favorable conditions for promoting export-oriented productions.

Production goals of major crops

SADS attempts to increase production of all major crops from the level of 2007 (see Table 2-3-1.1), with special focus on increasing production of fruits and grapes, industrial crops, sheep and poultry.

Fruits, grapes, industrial crops and sheep are expected to be the driving force of value-addition and exporting of agricultural products. On the other hand, poultry is seen as an import substitute. In addition, SADS aims to increase cultivating areas of forage crops rapidly, as a response to high demand in forage crops from livestock sub-sector.

It is interesting that SADS does not plan to increase planted areas of cereals much, though SADS declares "increase in the food security" as a strategy goal, and the country imports a large amount of wheat which is the most important people's staple diet every year. It seems that SADS has a realistic wheat policy which aims to streamline the production instead of to increase the planted area blindly considering a gap between domestic and international prices of wheat.

Table 2-3-1.1 Expected Outcomes of the Strategy (2007-2020)

Crop/Livestock	Planted Area(ha)/Heads (x 1,000)			Production (x 1,000 ton)		
	2007	2020	±(%)	2007	2020	±(%)
Cereals	176.2	190.0	107.8	452.5	662.5	147.0
Potatoes	31.6	30.0	94.9	583.9	750.0	128.4
Vegetables/Melons	31.5	31.0	98.4	1,051.6	1,357.5	129.1
Forage crops	65.0	155.0	238.5	–	–	–
Industrial crops	1.6	15.0	937.5	–	–	–
Fruits	38.0	53.0	139.5	260.2	586.3	225.3
Grapes	15.9	33.2	208.8	218.9	451.2	206.1
Cattle/Beef	629.1	667.0	106.0	78.6	97.0	123.4
Cows/Milk	310.6	328.5	105.8	598.9	850.5	142.0
Pigs/Pork	86.7	210.0	242.2	20.4	24.0	117.6
Sheep & Goats/Mutton	637.1	1,550.0	243.3	15.5	46.5	300.0
Sheep & Goats/Milk	–	–	–	42.3	123.7	292.4
Sheep & Goats/Wool	–	–	–	1.277	3.560	278.8
Poultry/Meat	4,018.2	8,000.0	199.1	7.8	16.0	205.1
Poultry/Egg	–	–	–	545.4 mil. pcs	750.0 mil. pcs	137.5

Source: 2010-2020 Sustainable Agricultural Development Strategy, RA

2-3-2 Agricultural Development Strategy in the Project Area

The SADS specifies agricultural strategies in respective Marzes where beneficial communities of the Project belong to Table 2-3-2.1 shows the development strategies of three (3) Marzes, i.e. Aragatsotn, Armavir, and Kotayk

Table 2-3-2.1 Agricultural Development Strategy of Concerned Marzes

Marz	Current Situation	Prospective Situation
Aragatsotn	Dairy-and-meat cattle breeding; potato and fruits production; and cereals farms	Dairy-and-meat cattle breeding; fruits and potato production; sheep breeding; and fodder production
Armavir	Vegetable production; cereal farms; grapes production; meat-and-dairy cattle breeding; potato and fruits production	Production of grapes, vegetables and fruits; dairy cattle breeding: early ripe potato production
Kotayk	Meat-and-dairy cattle breeding; vegetable and potato production; and cereals farms and fruits production	Meat-and-dairy cattle breeding; poultry farming: fruits production; cereals farms; vegetable production; and fodder production

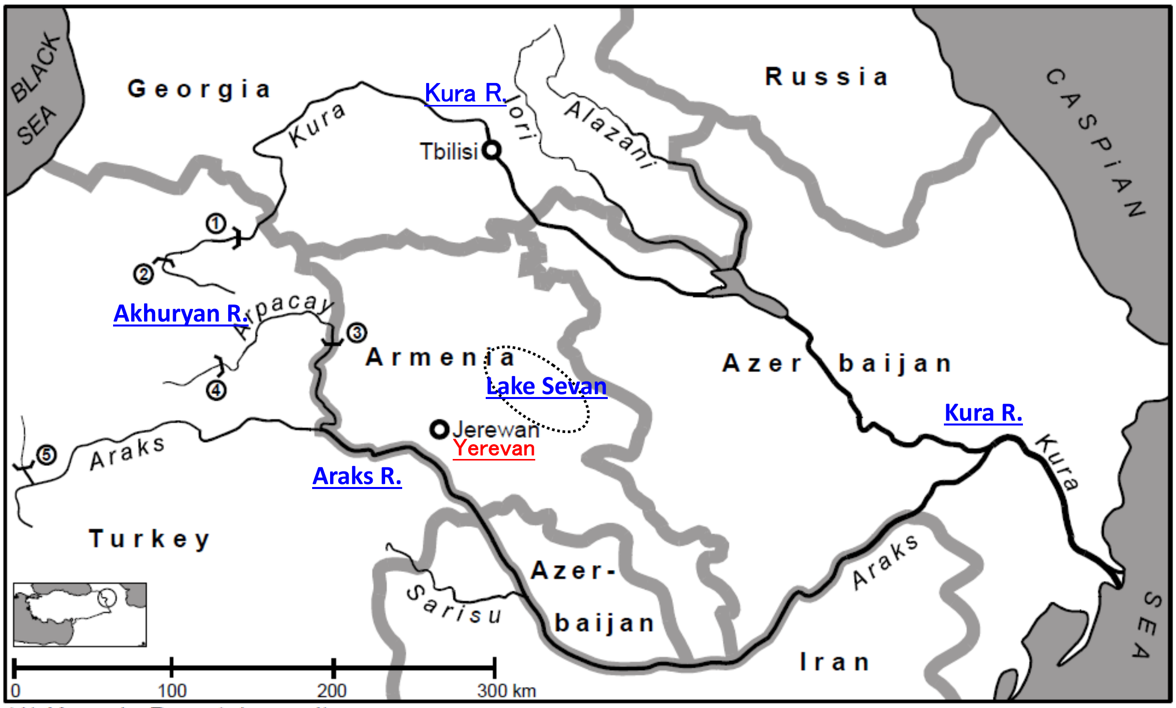
Source) 2010-2020 Sustainable Agricultural Development Strategy, RA

The promotion of animal husbandry, including forage crops, is a major strategy in Aragatsotn Marz as well as cropping of fruits and potatoes. In Armavir Marz, the present major crops such as vegetables, grapes and other fruits will be promoted as well as dairy industries and early varieties of potatoes. In Kotayk Marz, livestock and chicken industry including forage crops and diversification of agriculture with the combination of cereal crops, vegetables, and fruits will be prioritized for promotion.

As the Project area belongs to or borders on the territory of Armavir Marz, the strategy of Armavir Marz should prevail among the area.

2-4 Recent Situations of International River Treaty

The Araks River, which is the main stream of the Hrazdan River, rises from the highland of Armenia, runs through the Turkish territory toward the east, and then flows down along the borders of Armenia with Iran and Azerbaijan, merging into the Kura River, finally flowing into the Caspian Sea (refer to Figure 2-4.1). Ratios of area of the Hrazdan River basin (around 1,200 km^2) to that of the Araks River basin (around 102,000 km^2) and sum of Araks River basin and Kura River basin (around 188,000 km^2) are 1.2% and 0.6%, respectively, very small.



(1) Koroglu Dam (planned)
(2) Besikkaya Dam (planned)
(3) Arpacay Dam **(Akhuryan Dam)**
(4) Bayburt Dam (under constructon)
(5) Demirdoven Dam

Source: Cooperation on Turkey's trans-boundary waters, 2005

Figure 2-4.1 Trans-boundary Rivers in and around Armenia

The overall water use agreements on the Araks River, a trans-boundary river, are summerized in the Table 2-4.1;

Table 2-4.1 Past Water Use Agreements on the Trans-boundary Rivers in Armenia and Adjacent Countries

	Related countries	Agreed period	Outline
1.	Armenia under Soviet Union	January, 1927	Quantity of water intake from Araks River & Akhuryan River was agreed at 1,230 million m^3/year/country (share of water right 50:50)
2.	Turkey, Armenia under Soviet Union	January, 1927	Agreement on the survey & construction of headworks traversing Araks River. Identification on the scale of the facility & joint development by both countries (share of water intake 50:50)
3.	Turkey, Armenia under Soviet Union	October, 1973	Agreement on the joint development of a dam of Akhuryan River (share of water intake 50:50)
4.	Iran, Armenia under Soviet Union	August 1957	Share of water intake for irrigation, power generation and domestic water from Araks River and Atrak River is agreed at 50:50 & the dam is jointly developed.
5.	Republic of Georgia & Republic of Armenia under Soviet Union	November 1971	Detailed agreement on the share of water intake after constructing headworks in Debed River (a tributary of Kura River)
6.	Republic of Azerbaijan and Republic of Armenia under Soviet Union	October 1962	Agreement on the use of water power generation in Arpa River flowing into Lake Sevan
7.	Republic of Azerbaijan and Republic of Armenia under Soviet Union	April 1990	Agreement on controlling discharge in Vorotan River, a tributary of Araks River, the river discharge as of 1990 shared by both countries at the rate of 50:50
8.	Republic of Georgia & Republic of Azerbaijan & republic of Armenia	February 1997 (as a bilateral agreement)	Consultation on monitoring evaluation on the conservation of natural environment / river water conservation of Kura River (though already agreed between Georgia ^ Armenia, still pending between Azerbaijan and Armenia)

Source) Armenia Integrated Water Resources Management Plan (Reference distributed by JICA)

Three (3) Caucasian countries including Armenia participated in the establishment of USSR in 1922 (independence from USSR was achieved in 1991), while Armenia at that time under USSR and Turkey concluded “Convention on Water Use from Transboundary Rivers, Small Rivers and Brooks of USSR and Turkey” in January 1927. It was agreed in this Convention to equally share the quantity of water intake from the Araks River and the Akhuryan River (also called “Arpacay”) 50:50, or 1,230 MCM per year per country. Besides, in the same year, USSR planned to construct a head-works in the Araks River, and obtained the agreement with Turkey in which water was shared 50:50 with joint management of the facility after construction. Later, in October 1973, an agreement was also closed to construct a reservoir in the Akhuryan River (at a site of the border between Turkey and Armenia).

All of the above-cited agreements had been exchanged before the independence of Armenia (1991). However, the stakeholders of SCWE understand they are now still valid. In its background, even though no diplomatic relations have not been established yet between Armenia and Turkey, there lies a fact that water sector stakeholders in both countries have regular meetings as to the application of Akhuryan reservoir located between both countries where the share of 50:50 for water use has been identified.

Also, the Akhuryan reservoir was completely constructed in the 1980s during the regime of USSR, and after the independence of Armenia, it has jointly been utilized. When the reservoir was constructed, it was agreed between both countries that water should be released to Akhuryan reservoir for its conservation with the rate of 150MCM/year for the side of Armenia and 350MCM/year for the side of Turkey in compliance with the share of the territorial watershed area of the reservoir between the two countries. Further, as to the Kaps project, which F/S is completed the Government of Armenia is now planning forward by observing releasing volume of 150MCM/year.

Water distribution of the Hrazdan River is managed by the Sevan-Hrazdanyan Jrar (“Jrar” means intake) Closed Joint Stock Company (CJSC) under the SCWE, and Water Resource Management Agency (WRMA) under the MNP. The Hrazdan River flows within the Armenian territory, therefore, the Hrazdan River is regarded as an in-country river in Armenia, instead of an international river. Therefore, there is no international treaty on utilization of water of the Hrazdan River.

CHAPTER 3 CURRENT CONDITIONS AND ISSUES ON IRRIGATION /AGRICULTURE SECTORS IN ARMENIA

3-1 Armenian Ministries/Agencies related to the Project

The administrative system of Armenia is composed of 19 ministries as shown in Figure 3-1.1, where the State Committee of Water Economy (SCWE), the implementing agency of the Survey, belongs to the Ministry of Agriculture. This committee consists of 1) State Agencies of the System and 2) Organizations of the System. The former takes charge of project formation, design and construction work of irrigation development and is also responsible for the rehabilitating work of the Arpa-Seven water tunnel constructed in 1980 for the purpose of restoring the storage capacity of Lake Sevan. The latter superintends 8 Water Supply Agencies (WSAs) in the field of operating irrigation facilities, domestic water supply and the sewage water system after construction. Out of these 8 WSAs, a) Sevan-Hrazdayan Jrar CJSC (Closed Joint Stock Company) and b) Akhuryan-Araks Jrar CJSC execute operation and maintenance (O/M) of the irrigation system by collecting water fees. WSAs other than these two operate and manage the domestic water supply and the sewage water system.

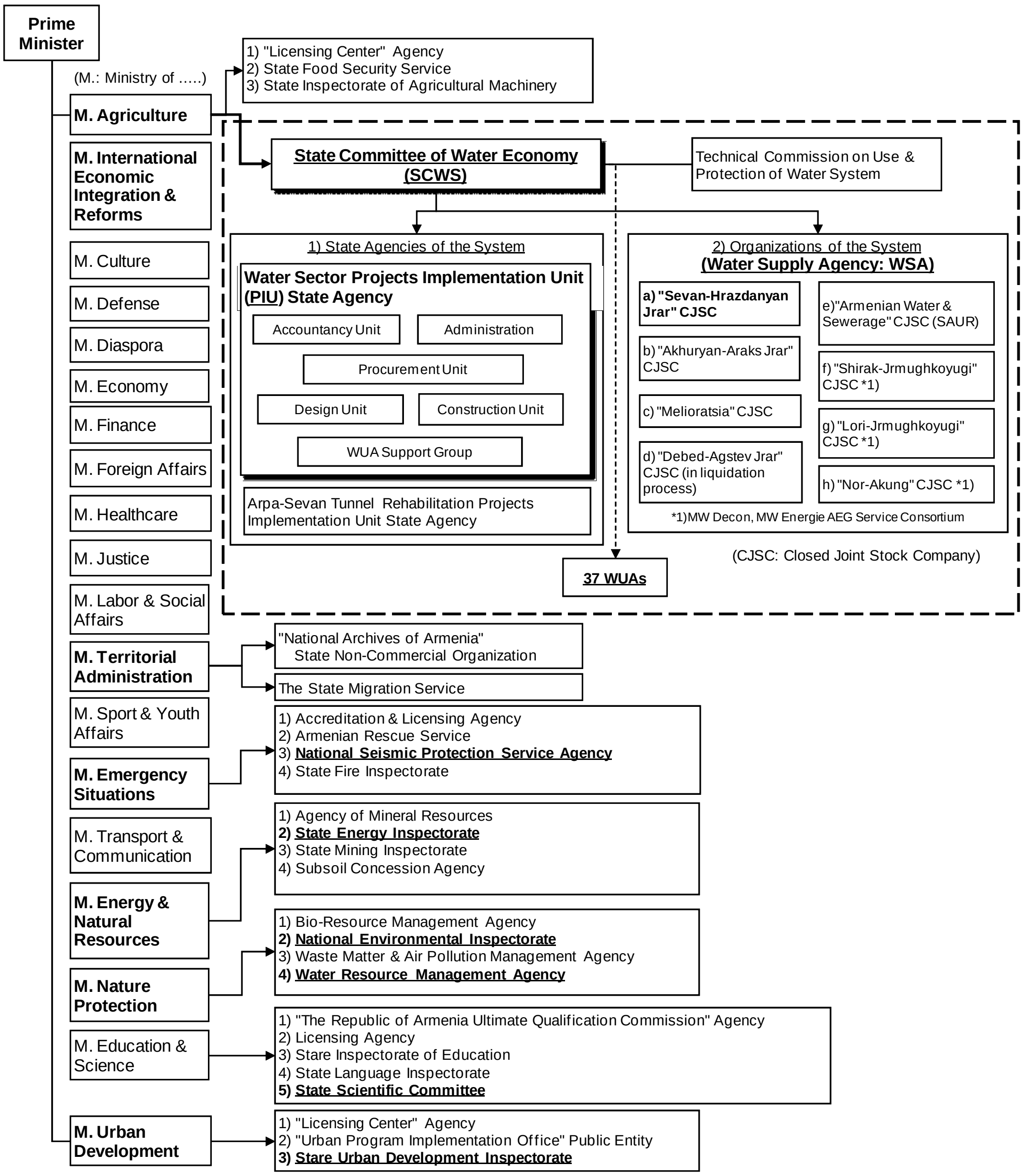


Figure 3-1.1 Administrative System of Armenia

The Water Sector Project Implementation Unit (PIU) State Agency in charge of this survey and is also responsible for the Yeghvard Irrigation System Improvement Project in total staffed with 36. Other than the Project, it currently handles the appraisal of the F/S contents for the Kaps Project with German (KfW) assistance and the Vedi Project with French (AFD) assistance. Major service duties of the PIU include formal actions of project implementation, more concretely, 1) formulation of working schedules required for implementing projects, project cost estimation, provision of tender documents, bidding and bidding evaluation; 2) procurement of services including construction, materials/machinery and consultants; 3) provision of construction contract documents and contract action; and 4) construction supervision, monitoring, etc.

As to related line-ministries in this survey, they include 1) the Ministry of Agriculture in charge of formulation of agricultural development policies, farming extension and assistance, research/educational organizations, 2) the Ministry of Emergency Situations that evaluates existing dams from the aspect of human and social damages in such occasions as collapse of dams, 3) the Ministry of Urban Development that is now revising standard criteria for designing earthquake seismic structures including buildings and dams, and 4) the Ministry of Nature Protection that appraises environmental and social impact assessment applied to the materialization of projects.

In addition, the Ministry of Education and Science takes charge of diversified Institutes in technical sectors. Originally, these institutes were once governmental organizations under the Communist Regime of the Soviet Union, but they were privatized into foundations after the independence in 1991 and have now become profit-making organizations.

As a related institute, four (4) institutes are counted as follows: 1) the Armvod Proekt (Project) Institute that engaged in the F/S study of the Yeghvard reservoir project under the regime of the Soviet Union, later handling a wide spectrum of irrigation projects including planning/designing; 2) the Hayjrnakhagits (Water design) Institute that reviewed the F/S study of the project (water storage capacity: 90MCM), in 1999; 3) the Institute of Geological Science that took part in a geological survey at the time of the F/S study of the the project and is now holding a wide range of hydrology as well as geology related information in Armenia; and 4) the Institute of Geophysics and Engineering Science which is a research institute related to seismology and also handles earthquake seismic designs for structures (located in Gyumuri, the second largest city in Armenia near the epicenter of the Spitak earthquakes).

Table 3-1.1 shows trends of the fiscal budget of the Government of Armenia.

Table 3-1.1 Trends of Annual Budget of Armenian Government

1USD= 410 AMD Unit: USD

Sector / Year	2009	2010	2011	2012	2013	2014	Percent In 2014
1. Public services	300	341	374	403	510	532	17.5%
2. Defense	365	331	357	377	446	473	15.6%
3. Safety and legal cooperation	157	138	148	150	177	201	6.6%
4. Economic relations	251	276	237	278	320	264	8.7%
5. Environmental advocacy	16	15	22	13	13	11	0.4%
6. Housing construction and municipal services	45	113	118	48	63	65	2.2%
7. Health	161	135	152	159	176	197	6.5%
8. Leisure, Culture and Religion	48	40	44	55	44	51	1.7%
9. Education	310	244	264	257	264	312	10.3%
10.Social advocacy	616	596	663	749	743	883	28.9%
11.Other	37	53	63	58	55	49	1.6%
Total	**2,306**	**2,282**	**2,442**	**2,547**	**2,811**	**3,040**	100.0%
(Increased rate based on 2009)	(Base)	(0.99)	(1.06)	(1.10)	(1.22)	(1.32)	

Source) Government of Armenia (Website)

The budget for the 2014 fiscal year indicates an amount equivalent to 3 billion USD, or increased by

32% as compared to 2009 (5 years ago), thus showing steady growth from year to year. As to a sector-wise breakdown, about 29% of the total amount of the budget is allocated to Social advocacy, followed by public services expenses accounting for about 17.5%.

In agriculture sector, an amount of 17.01 million USD is allocated in 2014 fiscal year (Source: Website, Ministry of Agriculture, RA)

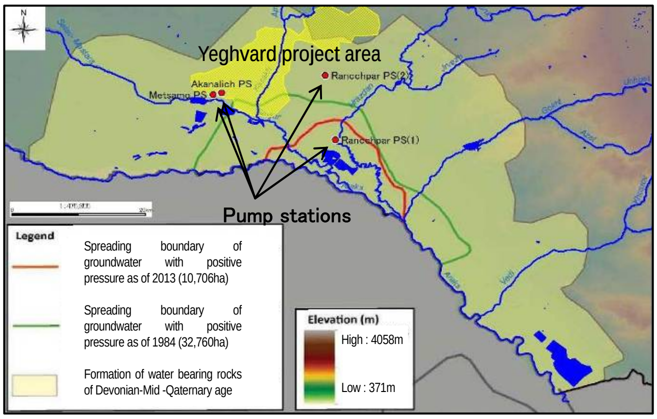
3-2 Status of the Project to the National Development Plans

3-2-1 Irrigation Sector

According to the Armenia Development Strategy for 2014-2015, the expansion of irrigated land areas was quite slow in recent years. However, agriculture in Armenia depends on irrigation. 80 % of agricultural production produced in irrigated lands. And irrigation systems will continue to remain a priority for public investment. The target of the investment policy will be the expansion of irrigated land areas and higher efficiency of the system. Expansion of irrigated land area is to take place in the frames of existing irrigation systems.

With regards to irrigation policies, the government aggressively deploys the policy of converting irrigation methods from pump to gravity-based system. There lies a background behind the strategy of "breakaway from energy intensive agriculture", and an issue of decreasing the groundwater level which causes the difficulty for pumping up irrigation water. In particular, the groundwater level has been drawing down in the Ararat Plain.

Figure 3-2-1.1 shows the distributed range of artesian ground water map provided by the WB, on which the sites of facilities related to the Yeghvard irrigation improvement project are superposed. The green line in this figure indicates the spreading area of artesian groundwater as of 1984, while the red line shows the area as of 2013. Also, the yellow part indicates the beneficiary of the Yeghvard irrigation improvement project (12,347ha) and the red dots show the location of the pumping stations related to the Project. The prevailing state of groundwater drawdown around the sites of pumping stations related to the Project is clearly marked in Figure 3-2-1.1. As such, irrigation policies have been initiated, intending to get the country itself free from agriculture which is heavily dependent on energy, while at the same time focusing on a shift from dependence on groundwater to effective use of surface water.



Source) Base Map: World Bank (2014), Towards Integrated Water Resources Management (Revised)

Figure 3-2-1.1 Groundwater Drawdown in Ararat Plain

3-2-2 Agriculture Sector

Many crops especially vegetables and fruits including grapes are concentrated in the Ararat Plain where the major part of the Project area belongs to. The plain is blessed with plenty of sunshine, relatively higher temperatures and a lower amount of rainfall, in addition to the well-developed irrigation networks. Such condition in the area highly contributes to form a production area of vegetables and fruits. Farm sizes in Ararat Plain are the smallest in the country, but many farmers enjoy the high profitability of those crops. The farmers actively apply new technologies, including greenhouses or drip irrigation, which makes the area an advanced agricultural region. Almost crops in the area record a higher yield.

The government recognizes that the Project area of Yeghvard irrigation project is a strategic area to achieve the goals of SADS, which is the highest level of agricultural development policy in Armenia, for the following reasons.

- The area belongs to a production center of vegetables, fruits and grapes which are expected to be main products for promoting industrialization of agriculture and export-oriented productions declared in SADS.
- The area is located on the suburbs of Yerevan city, where many agro-industries are developed and is the main market of the products.

Table 3-2-2.1 implies that crop production, especially vegetables/melons and grapes, in the Project area contributes much to the national production, though the total land area is only 0.8% of the national land area. Statistical information on agricultural production in Armenia in 2010-2014 is attached in Appendix B-1. Details of agricultural activities in the Project area are discussed in Chapter 4.

Table 3-2-2.1 Production of Major Crops in Armenia and in the Project Area in 2014

Crop	Armenia (A)		Project Area (B)		(B)/(A)	
	Area (x1000 ha)	Production (x1000 ton)	Area (x1000 ha)	Production (x1000 ton)	Area (%)	Production (%)
Grains	188.7	590.6	1.8	6.9	1.0	1.2
Potatoes	31.6	733.2	0.7	29.1	2.2	4.0
Vegetables/Melons	32.2	1,200.4	2.9	91.6	9.0	7.6
Fruits	40.1	291.0	0.9	6.3	2.2	2.2
Grapes	17.2	261.3	1.3	17.5	7.6	6.7
Total land area	2,974.3	-	22.8	-	0.8	-

Source) Statistical Yearbook of Armenia, 2015
27 communities concerned (Crop Area and Production in Project Area 2014)

3-2-3 Activities of Other Donors related and their Project Contents

Table 3-2-3.1 indicates trends of ODA performances to Armenia by five major donors. Amounts of ODA have tended to decrease since 2009 as the total amount, and the amount in 2012 remained at about 50% of the performance in 2008. Year after year, USA and Germany ranked highest for the past 5 years; however, Japan, which occupied a higher rank in the past reduced the amount of ODA to Armenia since 2011.

Table 3-2-3.1 Trends of ODA Performances by Major Donors (Highest Five)

Unit: million USD

Year	2008	2009	2010	2011	2012
First	USA: 93.8	Japan: 98.7	USA: 91.6	USA: 90.5	Germany :44.9
Second	Japan: 57.7	USA: 78.5	Japan: 77.5	Germany: 40.9	USA :37.6
Third	Germany:27.9	Germany: 31.0	Germany:16.7	Japan: 7.4	France :8.1
Fourth	England: 6.6	France: 5.7	France: 4.5	France: 5.6	Switzerland :3.9
Fifth	France: 5.5	Norway: 3.1	Norway: 3.6	Denmark: 4.2	Norway :3.3
Total amount	208.9	235.0	205.8	164.7	108.4

Source) DAC, International Development Statistics (Since only highest ranked 5 countries were listed, total amount does not match)

The state of external assistance by donors and international organizations since 1994 in the agricultural/irrigation sectors is shown in Table 3-2-3.2. Major contents of already implemented projects include the existing dams and intake facilities, rehabilitation/improvement of main/branch canals. In addition, the most important task in this sector aims at the shift from pump irrigation to gravity irrigation in almost all rehabilitation/improvement projects. In this context, the background of this issue includes the fact that WUAs in irrigation project areas, in which pumps are the main water sources, are obliged to depend on the government subsidy, and the subsidy also seriously places a heavy burden on the government budget. Besides, the elevated irrigation efficiency brought about by the consolidation of intake facilities and canals leads to reduction of irrigation water consumption. Thus, the envisaged shift to gravity irrigation has a goal to contribute to the conservation of Lake Sevan, that is, a national policy component.

As to F/S studies, the Kaps irrigation project (assisted by Germany) in the Shirak Marz and the Vedi irrigation project (assisted by France) in the Ararat Marz are currently in the final stage. As for Kaps, it has a main objective of averting risk of dam collapse, but it also envisages lower dependency on pump irrigation. In the case of the Vedi project, the beneficiary of which presently depends on pump irrigation as heavily as 80%, it mainly aims at the conversion into gravity irrigation by means of constructing reservoirs.

In this connection, Germany (KfW) announced that it plans to begin a study on climatic changes and the effect of global warming starting from 2015.

Table 3-2-3.2 External Assistance by Donors and International Organizations for Agriculture/Irrigation Sector

	Name of project	Project outline, target area, perimeter area, beneficiary etc.	Donor	Stage of aid (NR /R*)	Project cost (M.USD)	Project period
1.	Irrigation Rehabilitation Project (IRP)	Emergency assistance project to 8 irrigation project (including 4 reservoirs) in the whole country: the work of rehabilitation was implemented including: total length of canals; 260km, appurtenant structures; 126 sites, total length of drainage canals; 310km and 238 wells.	WB/ IFAD	Implemented (reimbursable)	52	1994 -2001
2.	North-West Agricultural Support Project	Assistance for improving water management techniques in north-western Armenia by participatory approach: Issue extraction on WUA and instruction on efficient water management to WUA were carried out.	IFAD	Implemented (non-reimbursable)	n.a.	n.a.
3.	Two Dam Safety Projects (DSPs) and IDSP (Irrigation Dam Safety Program) II	Rehabilitation project of the existing 74 reservoirs in the country taking account of safety aspect for beneficiary people in their downstream: Safety state of 420,000 beneficiary people in total was improved.	WB	Implemented (reimbursable)	37	2000 -2009
4.	Irrigation Development Project (IDP)	Rehabilitation/ extension of intake facilities in Araks River and main canal with 28km in total length was executed and intake/ conveyance volume was increased from 27 to 53m^3/s. Also, assistance on organization was executed therein, leading to establishment of WUA.	WB	Implemented (reimbursable)	36	2002 -2009
5.	Program of Millennium Challenge in Armenia, Irrigated Agriculture Project	Rehabilitation/ improvement of irrigation systems in the country and strengthening of WUA: Main and secondary/ tertiary canals were improved and the shift from pumping to gravity irrigation was realized in some systems. Also, some pumps were renewed in Ararat Plain and drainage network was improved.	USAID	Implemented (non-reimbursable)	109	2006 -2011
6.	Irrigation Rehabilitation Emergency Project (IREP)	Emergency irrigation facilities rehabilitation project in Aragatsotn & Armavir Marz: Total canal length of 90km was rehabilitated, saving 97MCM/ year (for 8,000ha).	WB	Implemented (reimbursable)	36	2009 -2011
7.	Additional Financing for Irrigation Rehabilitation Emergency Project (IREP)	Emergency irrigation facilities rehabilitation assisting project: Canals were rehabilitated for 110km in total (main canal 58km, tertiary 52km), leading to alleviating conveyance loss by 44MCM/ year.	WB	Implemented (reimbursable)	22	2011 -2013
8.	Construction of Kaps Reservoir and Gravity Irrigation System	A F/S study on the completion of a dam construction of which had been started in 1980s but later suspended in a tributary of Akhuryan River in Shirak Marz, and improvement of the existing irrigation facilities: now the project is put under appraisal, its storage capacity is 25MCM with the beneficiary of 2,280ha, project cost amounting to 94 million USD (Stage-1) as of September 2014. River water is diverted by the dam under suspension during years of Soviet regime where river discharge is released through a water tunnel, but it was choked as it gets dilapidated, thus collapsing risk arises.	Germany (KfW)	F/S Study (non-reimbursable)	n.a.	2012 -2014
9.	Construction of the Vedi Reservoir for Irrigation in the Ararat Valley	F/S study on dam construction and improvement of the existing irrigation system in Vedi River in Ararat Marz: it's now on the way to report finalizing stage (as of September 2014), with the maximum water storage of 40MCM, beneficiary perimeter of 2,820ha, project cost amounting to 197million USD (Option-2 but also another option exists). Though 77% of the intake volume of the	France (AFD)	F/S Study (non-reimbursable)	n.a.	2012 -2014

	Name of project	Project outline, target area, perimeter area, beneficiary etc.	Donor	Stage of aid (NR /R*)	Project cost (M.USD)	Project period
		existing irrigation system presently depend on pumps, the project mainly aims at shift from pump irrigation system to gravity one.				
10.	Toward Integrated Water Resources Management: Revisited	The first edition was published in 2002 targeting to the whole country. Based on change in water resource environment after 2002 and also on the result of review study in 2014 as well as current state of irrigation, the revised edition suggests future outlook of water resources and irrigation strategy.	WB	Policy assistance F/S Study (non-reimbursable)	n.a.	2013 -2014
11.	1st and 2nd Crediting Programs of Community Agricultural Resource Management and Competitiveness (CARMAC)	CARMAC Project is designed to improve the productivity and sustainability of pasture-based livestock farms in 55 mountainous communities in six Marzes of RA by increasing milk production, improving pasture management, and enhancing farm sales of livestock products.	WB	n.a.	1st: 0.9 2nd: 42.67	1st: 2013 -2016 2nd: 2014 -2020
12.	The European Neighborhood Programme for Agriculture and Rural Development (ENPARD)	ENPARD project is providing service to improve capacity of farmers associations and cooperatives and to establish agricultural and non-agricultural pilot value chains contributing to the development of rural areas, development of improved agricultural inputs and production systems in particular for livestock, fruits and vegetables, improve access to local and international markets in Shirak, Lori, Gegharkunik, Aragatsotn, Kotayk, Vayots Dzor Marzes of RA	UNDO, UNIDO	n.a.	European Union:1.35 Austrian Development Agency :0.51	2015 -2017
13.	Market for Meghri (M4M), Rural development project in the region of Meghri	Targets of the project are small-scale producers of fig, persimmon and pomegranate. The project aim at increasing their production & profitability and thereby generate increased and sustainable income.	Swiss	n.a.	CHF 3.5	1st: 2009 -2012 2nd: 2012 -2015
14.	Support for pesticide quality control and residue monitoring in Armenia	The project aim at enabling the country to control the quality of pesticide products on the market in line with international standards and to carry out pesticide residue surveillance monitoring programmes in order to improve the quality of agricultural products.	FAO, the Greek government	n.a.	2.0	
15.	Climate change	(not yet)	Kaps			

Source) MOA and Document of reply from Armenia to the JICA questionnaire, also. F/S reports of Kaps, Vedi irrigation reports
*NR/R: non-reimbursable / reimbursable.

3-3 Food Security

Table 3-3.1 shows the recent food self-sufficiency ratio in the country. It can be said that self-sufficiency ratio of basic foods such as cereals, edible oils and pork meats are at a lower level. In contrast, other foods like vegetables and fruits/grapes show a high rate.

It is difficult to define the adequate food self-sufficiency ratio, as a policy simply pursuing the higher ratio is not always the best strategy to accomplish a sound national food security system. As Table 3-3.1 shows, major foods that constantly reached the level of self-sufficiency (higher than 95%) are potatoes, vegetables, grape, eggs, and meats of sheep/goat. The reason why the ratio of sugar sharply increased after 2012 was the development of sugar processing factories. A large amount of sugar beet is, however, still imported every year according to the MOA. The self-sufficiency ratio of beef and milk is relatively high. However, it is evaluated that beef and milk have still weak production foundations considering a lower self-sufficiency ratio of cereals which should be a major feed for cattle when the commercial production will be developed.

Table 3-3.1 Self-sufficiency (%) of Major Foods & Per-capita Calorie Supply (2010-2014)

Food	2010	2011	2012	2013	2014
Wheat	33,5	36,5	32,9	46.8	48.7
Barley	78.3	90.3	96.6	93.1	95.4
Maize	20,8	26,5	32,6	20.3	27.9
Potatoes	100,2	98,2	99,0	102.5	101.1
Vegetables	98,3	98,2	99,3	99.5	99.1
Fruits	79,8	90.0	96,1	99.6	93.8
Grape	101,1	101,4	102,6	102.0	101.9
Leguminous crops	41,7	47,3	56,0	54.3	51.9
Oil crops	4,1	2,8	9,1	15.1	13.2
Sugar	24,6	43,9	93,1	92.6	93.1
Eggs	99,2	94,1	99,5	96.3	97.2
Milk	87,0	82,9	83,1	85.0	84.2
Beef	85,1	78,4	81,6	86.2	87.9
Pork	41,1	43,3	38,3	46.0	54.2
Mutton and goat meat	100,0	100,0	100,0	100.0	103.4
Poultry meat	12,4	12,2	19,1	19.8	20.0
Per capita calorie supply (kcal/day)	2,786	2,809	2,849	2,808	2,899

Source) MOA, RA and FAOSTAT

The SADS emphasizes domestic food security as a strategic pillar. Taking the given circumstances into consideration, a rise in cereals production and promotion of animal husbandry with an increase in forage crops should be the main strategy. Actually, the self-sufficiency ratio of cereals, especially wheat shows a trend toward the improvement in recent years. Nevertheless, since major cereals and forage crops are internationally commercialized, it is inevitable to rely on cheap imported products in order to pursue economic efficiency. It is crucial to keep a careful balance between the improvement of food self-sufficiency ratio and economic efficiency.

Total calorie supply remains at reasonable level in recent years as per capita calorie supply reached 2,800 kcal per day in 2011, while it was about 2,200 kcal per day in 2000. It is evaluated that sufficient amount of food is supplied to the population at national level. With regard to the breakdown, the calorie supply from animal products is increasing, while the supply from vegetable products is gradually decreasing from 2006.

3-4 International Trade of Agricultural Products

Since Armenia’s independence, the government has promoted agricultural sector with some successes. However, as mentioned above, the production of many crops cannot meet domestic demands; the country still depends on substantial amount of imported products.

As Table 3-4.1 shows, wheat is the most imported product. While wheat is regarded as a major staple food, it has a low self-sufficiency ratio as demonstrated by the country’s unceasing importation of wheat. Because wheat is less profitable, it cannot be considered by farmers as a priority crop in terms of effective land utilization. Though an increase in wheat production is a key to improve domestic food security, the current situation necessitates continuous importing of wheat to meet domestic demand. Besides wheat, a substantial amount of barley and maize, used for food and feed, is imported every year. In addition to the cereals, a great amount of meats and milk are also imported. Given this background and current import pattern, it is understandable why the SADS highlights the enhancement of production of forage crops and promotion of livestock farming. Among meats, poultry meat (mostly chicken) is the most imported product. Oil crops are another notable commodity in terms of importation. Imported fruits likewise show high import volume but they are probably tropical or semi-tropical fruits which are unable to grow in Armenia. Imported vegetables are seen only during the limited season of winter (January-March) when the domestic production is scarce.

Table 3-4.1 Import & Export of Agricultural Products (2012-2014)

No	Food Commodity* (fresh & processed)	Import (x 1000 ton or liter)			Export (x 1000 ton or liter)		
		2012	2013	2014	2012	2013	2014
1	Wheat	502.7	371.4	367.3	7.8	17.5	10.9
2	Barley	6.9	14.7	10.4	0.9	0.7	0.7
3	Maize	39.5	82.3	52.1	0.0	0.0	0.0
4	Rice	10.4	10.3	10.6	0.0	0.0	0.0
5	Leguminous crops	4.0	4.3	5.1	0.0	0.0	0.0
6	Potatoes	7.8	7.6	12.9	1.1	23.5	21.2
7	Tomatoes	0.3	0.5	2.7	5.1	5.3	2.5
8	Cucumber	1.5	1.2	1.7	0.3	1.4	0.6
9	Cabbage	0.1	0.6	3.0	0.9	0.3	2.4
10	Water melon	0.3	0.3	0.4	0.4	0.8	1.6
11	Other vegetables/melons	19.1	19.0	19.8	6.9	9.0	10.6
12	Oil crops	26.9	26.4	26.2	0.0	0.0	0.0
13	Apples	1.6	1.4	1.8	0.6	1.4	0.6
14	Apricot	0.4	0.2	0.3	13.4	23.0	2.0
15	Grapes	4.0	2.9	3.0	10.2	7.6	7.8
16	Other fruits	37.2	37.8	39.6	11.6	13.6	19.7
17	Beef	11.3	8.8	8.4	0.6	0.2	0.3
18	Pork	15.5	15.0	14.0	0.2	0.2	0.3
19	Mutton/goat meat	0.0	0.0	0.0	0.0	0.0	0.3
20	Poultry meat	35.3	33.4	33.8	0.1	0.2	0.2
21	Eggs	0.2	1.3	1.0	0.0	0.0	0.0
22	Milk	134.8	133.6	151.9	9.0	17.8	20.8
23	Alcoholic beverages	2.9	3.2	3.3	21.5	21.9	22.7
24	Sugar (processed)	3.8	4.9	5.6	0.4	0.9	0.2

Note) * Processed products are converted to equivalent weight of fresh products. Alcoholic beverages are not counted.
Source) MOA, RA and National Statistical Service

Table 3-4.1 also shows the major exporting crops in Armenia. Both the variety of exporting commodities, mainly; vegetables, fruits and alcoholic beverages, and the volume are limited. The volume of potato export has jumped since 2013. Alcoholic beverages are the highest exported item which is mainly composed of brandy made from grapes. Brandy is one of the three most exported goods from Armenia. Vegetables show excess of imports over the amount of exports every year although the balance is changeable year to year.

The data on imports and exports indicate that vegetables and fruits/grapes have a certain level of competitiveness in international market. According to private traders, most vegetables and fruits are exported to Russia, followed by the Commonwealth of Independent States (CISs), such as Georgia, the Ukraine, and Belarus (Iran and Turkey may be importing from Armenia, including through unofficial channels). Export destinations are dominated by such traditional markets, mainly because of the strength of the Armenian brand established during the USSR era, which remains in high demand. This is particularly evident with Armenian fruits. It is expected that an economic partnership between Armenia and the traditional markets shall be consolidated further after Armenia became a full member of the EEU (Eurasian Economic Union) which comprises Russia, Belarus and Kazakhstan from January 2nd, 2015.

The well-established relationship between Armenia and the traditional markets, on the downside, has kept Armenia from exploring new markets since its independence. The dependency on limited markets creates a vulnerable trade structure of Armenian agricultural products. For this reason, it is essential to exploit new markets with a long-term perspective. Geopolitically speaking, the European Union (EU) is a promising alternative market. However, there are a number of challenges to tackle that include diversification of the products in accordance with the market needs, strict quality regulation, food hygiene (security and safety) and stable supply in order to export the country's products to the EU market. A mid- to long-term comprehensive engagement is necessary, not only by individual farmers but also by the nation as a whole.

3-5 Marketing of Agricultural Products

Farm products are classified into two categories as for personal consumption (including gift and barter exchange) and for market sales. As shown in Table 3-5.1, cereals, potatoes, eggs and sheep wool are mainly consumed by producers themselves. On the other hand, comparatively high percentage of vegetables (including melon), fruits, grapes and meats are marketed. These commodities are recognized as important cash income sources of farmers.

Table 3-5.1 Marketing of Major Agricultural Products

Agricultural products	Selling (%)	Personal Consumption and others (%)	Total (%)
Cereal and legume crops	21.9	78.1	100
Potato	38.0	62.0	100
Vegetable	71.3	28.7	100
Melons	84.2	15.8	100
Fruit and berries	58.0	42.0	100
Grape	76.5	23.5	100
Meat	80.9	19.1	100
Milk	44.7	55.3	100
Eggs	37.8	62.2	100
Wool	26.2	73.8	100
Honey	49.7	50.3	100

Source) MOA, RA

Many farmers sell their products to the middlemen at the farm-gate. Regarding grape producers, they tend to sell their products directly to the neighbor processing company. Organized cooperatives or group marketing by farmers are not common. Although all farmers recognize the difficulties for securing advantaged selling channels and favorable selling prices of their products, no one can figure out the certain images or ideas of solution for the problems. Not a few numbers of farmers still hold a way of thinking that expecting someone to purchase all products at an appropriate price as they experienced in USSR era. As a result of this rigid mind, general farmers have little awareness of agricultural marketing. SADS aims at improving the distribution of agricultural products to the domestic and the international markets. However, farmers have difficulty to market their products sometimes in a peak harvesting season due to saturation of the domestic market after the increased production in recent years.

Middlemen are playing significant role in the distribution of farm products, since most of farmers are selling their products to them. Generally, farmers regard the middlemen’s work as extortionate profit-making as indicated by farmers’ criticism of them. However, many farmers are also recognizing that selling their products to middlemen is more rational than selling the products by themselves at the market according to the last survey. While middlemen vary from permanent workers to side business workers with farmers, most of them run a business on an individual basis. They are divided into different hierarchies, and the trading between them is commonly practiced.

Wholesalers and traders are not as small-scale as middlemen, but most of them run their businesses under private or family management. Generally, they purchase farm products through specified middlemen, and sell them to retailers and supermarkets, to middlemen from other regions and to exporters. Some wholesalers also work as traders, and they are exporting or importing seasonally advantageous fruits and vegetables. However, importation of some crops such as banana and pineapple are monopolized by the government control policy. In Armenia, there is only one company to trade vegetables and fruits on a certain large scale, so other traders are remaining at a private enterprise level.

It is estimated that a substantial percentage of marketed vegetables and fruits are transacted at Yerevan markets. The reason of this assumption is that about one third of national population is densely concentrated in Yerevan city and the main producing areas of vegetables and fruits are located next to the city. The Malatia market is the biggest market in Yerevan city, and the prices of vegetables and fruits in the country are basically based on the Malatia market prices. Many middlemen from various places in the country gather in the market.

3-6 Agricultural Processing

Table 3-6.1 and 3-6.2 show domestic production and international trade of agricultural processed products in 2012-2014.

Table 3-6.1 Production of Major Agricultural Processed Products and Their Market Share

Products	Unit	Production			Domestic Market Share of Local Products (%)		
		2012	2013	2014	2012	2013	2014
Meat products, including sausages	Ton	4,757	4,944	5,718	43.6	45.9	47.2
Cheese	Ton	17,658	17,375	18,317	94.1	92.7	93.4
Canned fruits and vegetables	‘000 lit.	8,356	9,990	11,715	14.2	19.9	19.9
Juice	Ton	16,742	19,544	21,106	72.0	79.8	85.9
Confectionery	Ton	14,320	16,544	18,093	46.8	48.5	49.7
Macaroni	Ton	3,563	4,093	4,468	44.1	44.9	44.8
Brandy	‘000 lit.	18,514	20,383	18,726	87.4	98.2	44.6
Wine	‘000 lit.	6,193	7,217	6,765	91.6	93.9	94.1
Beer	‘000 lit.	13,668	19,848	23,717	82.8	86.5	88.4
Vegetable oil	Ton	2,656	4,650	3,968	9.0	15.0	13.1
Sugar	ton	69,267	69,625	89,189	94.7	93.4	94.0

Source) National Statistics Service, RA

Table 3-6.2 International Trade of Major Agricultural Processed Products

Products	Unit	Export			Import		
		2012	2013	2014	2012	2013	2014
Meat products, including sausages	Ton	625	367	412	5,345	5,388	5,943
Cheese	Ton	904	1,541	1,542	1,053	1,244	1,188
Canned fruits and vegetables	‘000 lit.	7,242	7,955	9,600	6,661	8,175	8,520
Juice	Ton	2,126	2,013	2,942	5,685	4,430	2,992
Confectionery	Ton	793	1,119	1,536	15,403	16,374	16,765
Macaroni	Ton	154	157	128	4,315	4,825	5,338
Brandy	‘000 lit.	17,518	18,188	18,556	143	41	211
Wine	‘000 lit.	1,186	1,399	2,121	459	380	289
Beer	‘000 lit.	2,795	2,346	1,988	2,263	2,731	2,838
Vegetable oil	Ton	4	2	1	26,964	26,431	26,205
Sugar	ton	400	899	200	3,830	4,851	5,644

Source) National Statistics Service, RA

During USSR era, agricultural processing industries had been well developed in Armenia due to the high demand for brandy, wine and canned fruits and vegetables from other republics. However, the country had lost those dominant markets since its independence in 1991, and numerous processing factories had been forced to close their operation because of devastating impacts of the markets lost. As a result of those transfigurations, agricultural processing had only been carried by small scale cottage industries and home manufacturing. Since 1998, the country has actively utilized overseas' assistance (the WB, IFAD, USDA, USAID, etc.) to rebuilt agricultural processing industries. Table 3-6.3 shows number of agricultural processing companies recognized by the Department of Agro-Processing Development of MOA. According to the department, there are about 1,500 agricultural processing companies in Armenia as of 2014, if unrecognized tiny companies are also counted. Alcoholic & non-alcoholic beverage, meats & dairy products and preserved foods are the priority commodities in the government policy.

Table 3-6.3 The Number of Agricultural Processing Companies Recognized by the Ministry of Agriculture

Sector	Number
Foods & juice processing	35
Dry foods processing	100
Grape processing (including winery)	50
Dairy and meat processing	70
Slaughtering	20
Flour mill	60
Fish processing	10
Bakery	More than 500
Confectionery	135
Beverages (non-alcohol)	More than 50
Beer brewery	7
Tea and coffee	30
Vegetable oil	3
Sugar	2
Salt	1

Source) Department of Agro-Processing Development, Ministry of Agriculture, RA

As a result of the promotion policies, the total purchased volume of vegetables, fruits and grapes by agro-processing industries had increased since 1998. The increase, however, has been stagnating from around the late 2000s. The volumes of agricultural processing products are still well below the recorded volumes before independence, with exception of brandy. This indicates that the rehabilitation of Armenian agricultural processing industries is still only at the halfway mark despite of vigorous supportive policies of the government. The reason of this stagnation is due less to material shortages and more to the failure of agricultural products' market penetration. The first thing the industries need to do is to develop the market not only by recovering the shrunken traditional markets in CIS countries but also by developing new markets, including domestic markets as Armenia still depend on imported products for considerable amount of the domestic demand. While Armenia became a member of the EEU in January, 2015, it is anticipated that the accession would have a positive impact on recovering and developing the markets in the Russian economic bloc.

The Department of Agro-Processing Development recognizes the following problems on the development of agricultural processing industries.

1) Limited market (the industries have over processing capacity)
2) High production-cost structure (raw materials, energy, management, etc.)
3) Inconvenient loan condition (financial institutions reluctant to provide a long-term loan)
4) Limited transportation routes due to geopolitical constraint

3-7 Agricultural Inputs

3-7-1 Fertilizers

Armenia is an importing country of fertilizers. Currently, there is no domestic manufacturer of fertilizers. The government is importing fertilizers in order to provide cheaper fertilizers to farmers under the subsidy system. Most of farmers heavily depend on the subsidized fertilizers for their crop farming, and a limited volume of miscellaneous compound fertilizers mainly used for vegetables and flowers are distributed through the private channel. According to MOA, the subsidized fertilizers cover more than 95% of the annual domestic demand.

Table 3-7-1.1 shows volume and price of fertilizers procured by the government in 2015. The procurement volume of the fertilizers is decided by MOA based on the request from individual farmers. The requested volume collected through each community office is finally integrated by the Ministry. Then, the fertilizers are distributed through the reverse process of the request. Several private companies are selected for the procurement and distribution by the Ministry through international bidding. While farmers can order a nitrogen fertilizer maximum 300 kg per hectare farmland, there is no limitation volume of order about other fertilizers. Following figures indicate that farmers are demanding mainly on nitrogen fertilizer, and the demands of other fertilizers are quite limited. Farmers tend to input more volume of nitrogen fertilizer, probably due to its immediate effect on their crop productivity. The government is, however, subsidizing more on phosphate and potassium fertilizers than a nitrogen fertilizer in order to set similar price ranges of fertilizers for farmers.

Table 3-7-1.1 Volume and Price of Fertilizers under the Government Subsidy in 2015

Fertilizer	Procurement volume (ton)	Origin country	Procurement price (A) (AMD/50kg)	Selling price (B) (AMD/50kg)	Subsidy (A-B) (AMD/50kg)
Ammonium nitrate	35,300	Iran, Russia, Georgia	9,215	6,000	3,215
Double superphosphate	3,100	Iran, Russia, Georgia, China	13,800	7,000	6,800
Potassium chloride	1,600	Iran, Russia, Georgia, China	13,800	7,000	6,800

Source) MOA, RA

“Agrochemical Service” which is a state non-profit agency under MOA researches soil condition of farmland all over the country. The agency has been inspecting soil samples from all communities in Armenia. It also provides consultancy service of proper fertilization to farmers in collaborating with the Agricultural Support Centers by using the result of the soil analyses. According to the agency, there are growing concerns about overuse of nitrogen fertilizers counting the imported amount of nitrogen fertilizers and total cropped area in the country. On the other hand, the agency concerns about less use of phosphate and potassium fertilizers. Appendix B-2 shows the result of soil analysis on phosphate and potassium components compiled by Marzes. The result shows that less than 15% of the soil samples are in good condition about potassium and phosphate. Especially, more than 65% of the samples show weak condition of phosphate fertilizer content. The Ministry of Agriculture is trying to encourage balanced fertilization through agricultural extension activity. However, not only the extension activity but also reviewing the current subsidy system would be an effective countermeasure to address the issue.

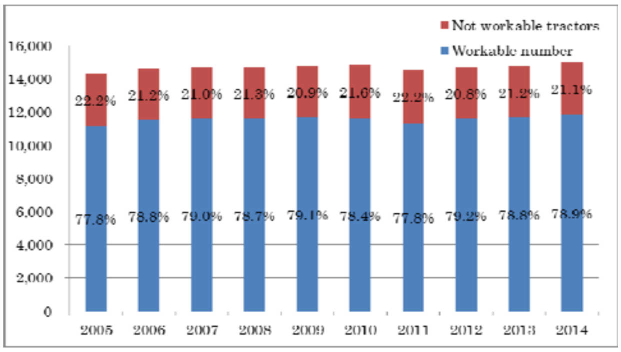
3-7-2 Agricultural Chemicals

All agrochemicals are imported from foreign countries, as same as fertilizers, in Armenia. In contrast to fertilizers, agrochemicals are marketed only through the private channel, as the government are not subsidizing for them. The government has imposed a registration system of agrochemicals which prohibits importation and distribution of unregistered agrochemicals in Armenia. A division in charge of agrochemicals under MOA inspects agrochemical shops periodically in order to control unregistered or obsolete agrochemicals.

MOA pays serious attention to the use of such prohibited agrochemicals at present. The standards of pesticides residue for agricultural products were established in Armenia based on the European standards. All agricultural products beyond the norm for the standards are prohibited to distribute in Armenian markets. Then, a pesticide testing laboratory was established with FAO’s assistance. FAO also extended its technical cooperation for the proper management of agrochemicals in collaboration with the EU. However, there is no workable system to monitor the pesticide residue at the harvest points or in the markets in the country. Establishment and implementation of the workable system is a challenging issue of the government.

3-7-3 Agricultural Machinery

Most of current workable agricultural machinery in Armenia was procured in the USSR era. According to the Figure 3-7-3.1, there have been about 11,000-12,000 workable tractors since 2005 and there was no drastic change of those figures in the last decade. Table 3-7-3.1 indicates the number of brand-new tractors procured from 1976 to 2015. The table shows that a limited number of tractors were procured, mainly by assistances from donor countries including Japan, after the independence. Those assistances encouraged the renewal of decrepit machinery, but still at least 90% of workable tractors in Armenia are more than 25 years old. The situations of other agricultural machinery such as combine harvesters are similar to tractors. Renewal of decrepit agricultural machinery is a pressing issue in Armenia.



Source) Ministry of Agriculture

Figure 3-7-3.1 Total Numbers of Tractors

Table 3-7-3.1 Numbers of Procured Tractors through Normal Channel (Commercial & Aid)

Year	1976-91	1992-96	1997	1998	1999	2000	2001	2002	2003	2004
Total	17,469	0	15	43	63	156	45	35	40	51
Year	2005	2006	2007	2008	2010	2011	2012	2013	2014	2015
Total	99	240	67	88	61	0	0	20	200	72

Source) Ministry of Agriculture

The agricultural machinery was imported through the government channel including international assistance programs and the private channel since 1997. While 1,295 units of tractors were imported in 1997-2005 (see Table 3-7-3.1), only above 200 units were procured through the private channel, according to MOA. It implies that the government has played a significant role in the import of agricultural machinery, though there are several private dealers importing agricultural machinery. The private dealers usually deal in construction machinery, etc. other than agricultural machinery, as actual market demand for the agricultural machinery on commercial basis is still limited, mainly due to weak paying capacity of each individual farmer, despite the high potential demand. There is no agricultural-machinery manufacturer in Armenia, while a joint venture company with a Chinese company assembles tractors and their attachments imported from China.

The agricultural machinery has been imported from, Russia, Belarus, China, India, Japan, etc. Russia and Belarus machinery is widely used in Armenia, as they have the following historical, technical and economic advantages over the machinery from other countries.

1) Familiarity with the machinery for long time (convenient for O/M)
2) Easy procurement of main body and spare-parts (established distribution channels)
3) No import tax after becoming a full member of the EEU

3-8 Agricultural Research and Extension

3-8-1 Agricultural Research

According to the Ministry of Agriculture, there are three agricultural research institutions under the Ministry (See Table 3-8-1.1).

Table 3-8-1.1 Research Institutions under the Ministry of Agriculture

Name of Institution	Location	Main Research Activity/Crop
The Scientific Centre for Agriculture	Ejmiatsin, Amarvir Marz	Growing of wheat, barley and leguminous crops
The Scientific Centre of Vegetables and Industrial crops	Darakert, Ararat Marz	Selection of varieties and seed production (solanaceous, cucurbitaceous and cabbage crops)
Experimental Centre for Technical Crops		Selection of varieties and seed production (soya, tobacco, linseed and sugar beet)

Source) MOA

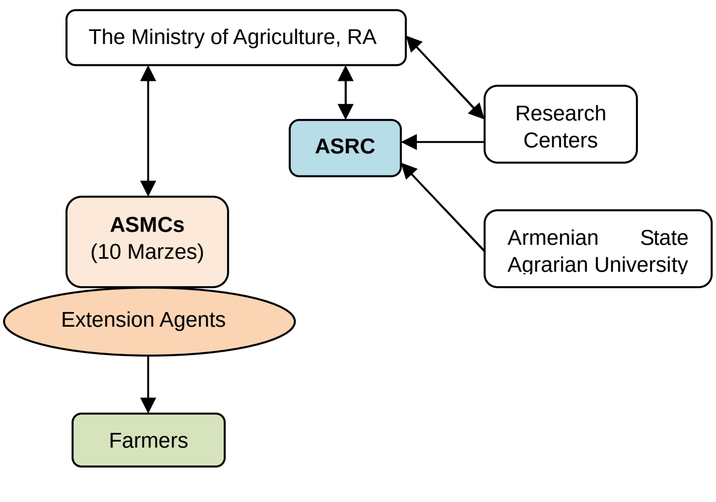
According to "Agricultural and Food Processing in Armenia (USDA & CARD)" written by Samvel Avetisyan in 2010, there are the "Research Center for Soil Science", the "Research Center for Horticulture, Viticulture and Winemaking", the "Research Center for Livestock Management and Veterinary" and the "Research Center for Agri-Bio Technology" in addition to the research institutions shown in the table above. As of 2010, the number of agricultural researchers in Armenia was 249, and only 25 of them hold a doctoral degree (122 are doctoral candidates). Thus, an increased number of agricultural researchers must be one of the critical challenges of Armenian agricultural development. Dealing with this circumstance, the government is aggressively promoting research cooperation programs with international agricultural research institutions such as CGIAR, ICARDA, CIMMYT, IPGRI, ISNAR and CIP as well as institutions in other countries.

In addition, the government also promotes to foster domestic agricultural researchers and experts. MOA manages the Armenian State Agrarian University, which is the only agricultural university in the country, and 10 State agricultural colleges which are located in 7 Marzes across the country. The state agricultural colleges aim to develop human resources to work as a bridge between research institutions and the actual field.

Breeding of promising varieties is the most expectative task to the agricultural research sector, especially, in the situation that the Armenian government promotes export oriented agriculture. The researchers should give full attention to dissatisfaction of agribusiness with the present crop-varieties popularly grown in Armenia. According to an agricultural products exporter, popular crop-varieties in Armenia often don't match to requirements in the international market. For instance, indigenous grape varieties for fresh consumption popular in Armenia are not highly evaluated internationally, while a red grape variety "red glove" is highly demanded due to its good taste and storage stability. One of the leading wine breweries also said that they had difficulty in procuring appropriate grape varieties for wine brewing in Armenia. Therefore, they introduced several grape varieties from foreign countries by themselves. The government commitment to conscientious research on the development and introduction of new crop-varieties will expand the possibility of future development not only of agricultural production but also of agribusiness industry.

3-8-2 Agricultural Extension

In Armenia, agricultural extension services are implemented by specialized agencies: the ASRC (Agricultural Support Republic Centre) and ASMCs (Agricultural Support Marz Centres). ASRC is placed at the central level and one ASMC is established in each Marz at the regional level (10 ASMCs in a country). The ASRC and ASMCs are autonomous body under the jurisdiction of the Ministry of Agriculture. There is no official hierarchical relation between them, but the ASRC plays a role of umbrella administration for agricultural extension programs in the country (See Figure 3-8-2.1). ASMCs are responsible for agricultural extension services to individual farmers in respective Marzes, and 130 agricultural extension agents are allocated to ASMCs in total (The total number of ASMCs staff is 240, including the agricultural extension agents). It seems that the number of extension agents is too small to implement elaborate



Source: MOA, RA

Figure 3-8-2.1 Agricultural Extension System in Armenia

agricultural extension services, as there are 914 communities in Armenia.

Table 3-8-2.1 indicates a list of agricultural consultancy services provided by ASMCs/ASRC in 2013. Those extension activities were decided from the result of farmers' demand survey. The survey is implemented by the collaboration between ASRC and ASMCs. However, farmers regard that the agricultural extension programs are not adequate for them even though the agencies provide such a wide variety of services.

Table 3-8-2.1 Agricultural Consultancy Services provided by ASMCs/ASRC in 2013

Activity	Times/Numbers
Workshops	1,119
Field trainings	872
Technical consultancy events	22,049
Demonstration experimental activities	173
Radio and TV programs	96
Number of topics published in leaflets/brochures	466
(Printing quantity)	(115,270)
Edit materials	158
(Printing quantity)	(209,100)

Source) Ministry of Agriculture, RA

Table 3-8-2.2 shows the results of a questionnaire survey conducted by the JICA team on Data Collection Survey on Agriculture and Irrigation Sector in Armenia in 2014. According to the results, most of the farmers recognized that they've never had any opportunities of agricultural extension or supporting services. Farmers, who are even experienced in the extension services, are thinking that they are not provided their demanded services at the time of need. Some farmers insisted that when damage of plant occurred by pest or disease in their farmland, they really need consultancy services about how to use agrochemicals or prevention measures. But it is difficult to make a contact with extension agents when necessary. Many farmers also do not understand the contents of agricultural extension services properly. During the Soviet era, farm management was prescribed by agronomists who are allocated in Kolkhoz and Sovkhoz, and there were no agricultural assistance services for individual farmers. Therefore, some farmers misunderstand that an agricultural extension service is assistance from the government providing some materials or goods to farmers.

Table 3-8-2.2 Agricultural Consultancy Services Provided by ASMC/ASRC in 2013

Service	Number of Farmers	
	Yes	No
Crop production	2	18
Vegetable production	1	19
Fruits/grape production	0	20
Animal husbandry	1	19
Food processing	0	20
Agricultural; credit	5	15

Source) Final Report, Data Collection Survey on Agriculture and Irrigation Sector in Armenia, JICA

CHAPTER 4 CURRENT CONDITIONS OF YEGHVARD IRRIGATION PROJECT SITE

4-1 Meteorological and Hydrological Conditions

4-1-1 Outline of Investigation for Meteorological and Hydrological Data

Meteorological and hydrological data have been observed by Armenia State Hydro-meteorological and Monitoring Service, Ministry of Territorial Administration Development. Table 4-1-1.1 shows the meteorological stations located in and around the Project Sites. Thirty years period data were collected through this investigation. Meteorological data include rainfall, average temperature, relative humidity, wind speed and evaporation by monthly based data. Table 4-1-1.2 shows the Hydrological data which is 10 days decade based river discharge data at each observation station. Figure 4-1-1.1 and 4-1-1.2 describe the location map of meteorological and hydrological observation station, respectively.

Table 4-1-1.1 Meteorological Stations in and around the Project Sites

N	Station name	Opened (Year)	Elevation (meter)	Geographic coordinates	
				latitude	longitude
1	Hrazdan	1936	1,765	40°32'12"	44°46'16"
2	Fantan	1891	1,800	40°23'54"	44°41'13"
3	Yeghvard	1936	1,337	40°19'14"	44°28'44"
4	Ashtarak	1957	1,090	40°17'17"	44°20'55"
5	Yerevan agro	1951	942	40°10'47"	44°24'18"

Table 4-1-1.2 Hydrological Stations in and around the Project Sites

N	River	Station name	Opened (Year)	Catchment Area (km^2)	Geographic coordinates	
					latitude	longitude
1	Outflow from Sevan to HPP	Geghamavan	1949	-	40° 34’ 05”	44° 53’ 58”
2	Hrazdan	Hrazdan	1965	806	40° 31’ 13”	44° 46’ 04”
3	Hrazdan	Lusakert	1965	1,292	40° 22’ 51”	44° 36’ 19”
4	Kasakh	Ashtarak	1932	1,018	40° 17’ 25”	44° 21’ 32”

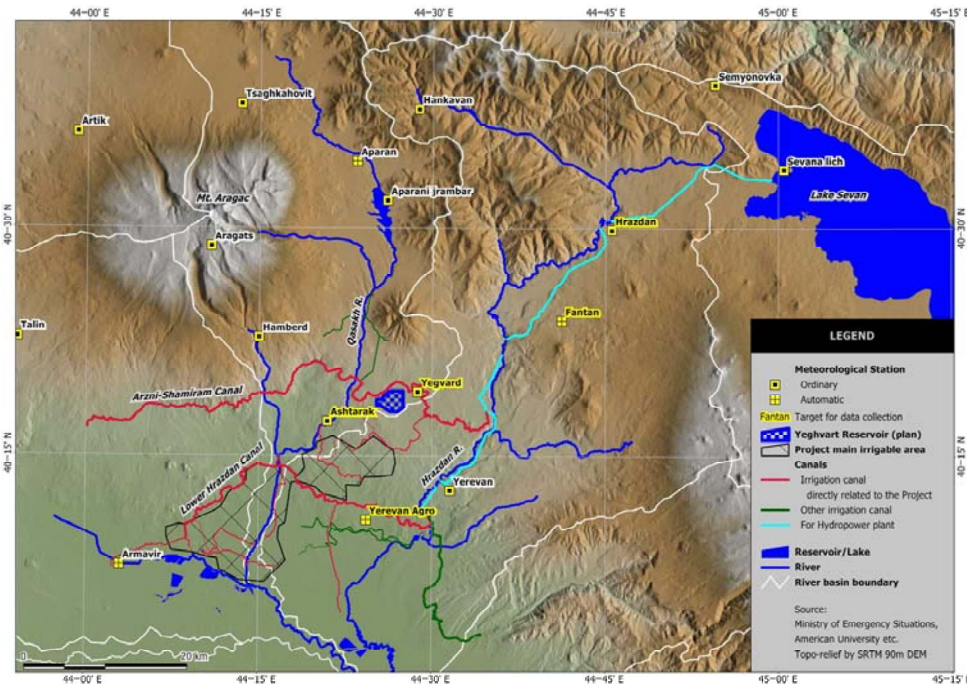


Figure 4-1-1.1 Meteorological Stations in and around the Project Sites

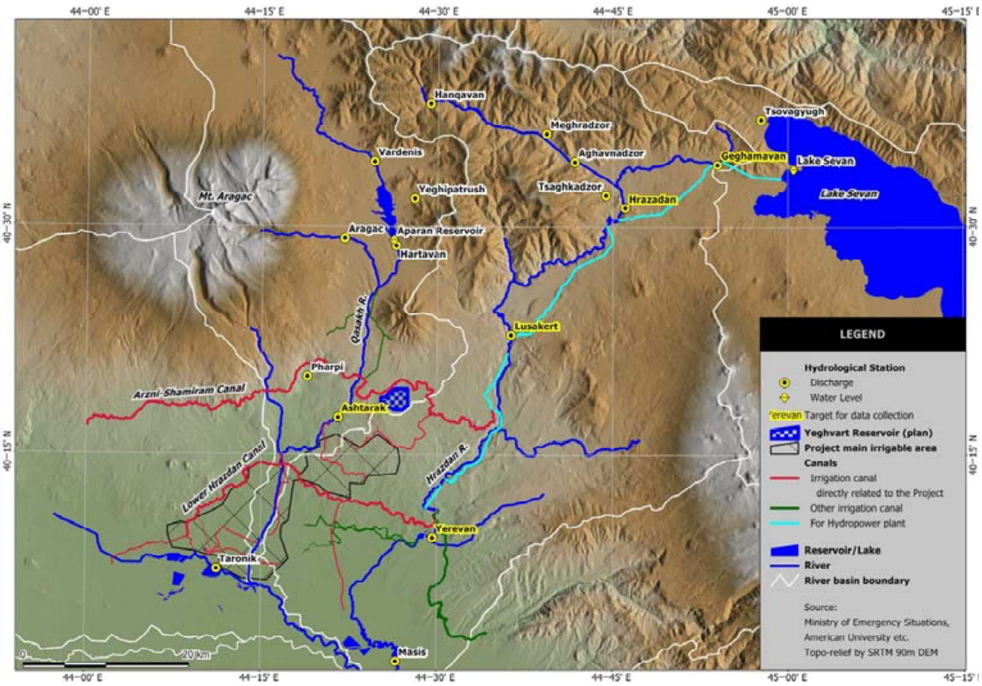


Figure 4-1-1.2 Hydrological Observation Stations in and around the Project Sites

4-1-2 Current Meteoro-hydrological Conditions

(1) Meteorological data

Table 4-1-2.1 shows the characteristics of each station. The average rainfall data in Hrazdan and Yeghvard station is 742 mm and 439 mm, respectively. The maximum average temperature is observed around July or August. The average temperature from December to February is negative in all meteorological stations.

Table 4-1-2.1 Annual Rainfall and Average Temperature

Station name	Annual Rainfall (mm)	Average Temperature (°C)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hrazdan	742	-7.1	-5.7	-0.5	5.9	10.4	14.7	17.9	17.7	13.9	7.8	1.3	-4.6
Yeghvard	439	-4.1	-2.3	3.2	10.0	14.2	19.4	23.0	22.9	18.7	11.9	5.0	-1.2
Fantan	669	-6.0	-4.8	-0.2	6.3	10.7	15.1	18.3	18.6	14.9	8.9	2.3	-3.6
Ashtarak	387	-3.0	-0.7	5.3	11.6	16.0	21.2	24.8	25.2	20.3	13.8	6.1	-0.7
Yerevan agro	311	-4.3	-0.8	5.9	12.6	17.1	22.2	26.0	25.9	21.0	13.7	5.9	-1.1

Figure 4-1-2.1 shows the monthly data of rainfall, evaporation and average temperature at Hrazdan and Yeghvard stations. Monthly rainfall is in maximum on April and May and decrease to August. Evaporation is in maximum on June.

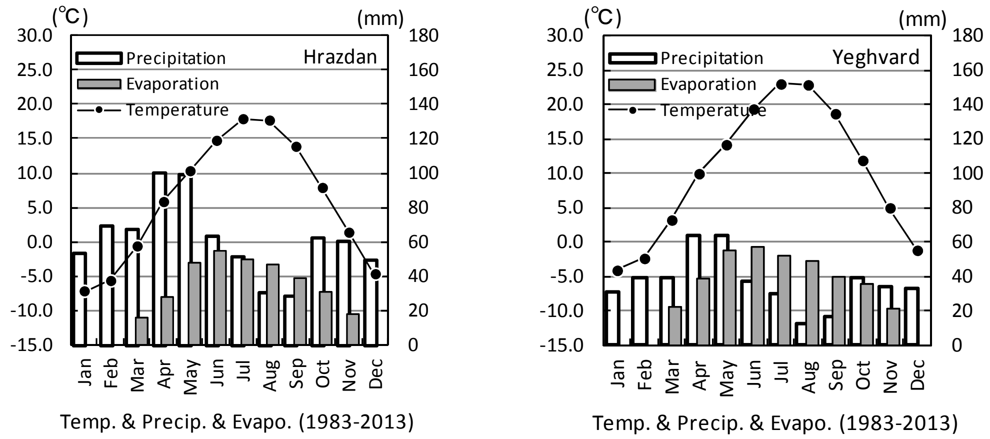


Figure 4-1-2.1 Meteorological Data at Hrazdan and Yeghvard Stations

Figure 4-1-2.2 shows the yearly trend of annual rainfall at Hrazdan (EL.742m) and Yeghvard (EL.439m) station, and dotted line indicate the long-term average. At the Hrazdan station around latest ten years, annual rainfall in 2008, 2012 and 2013 are less than the average (742mm). Annual rainfall in 2004, 2012 and 2013 at Yeghvard station is less than average (439mm) around latest 10 years.

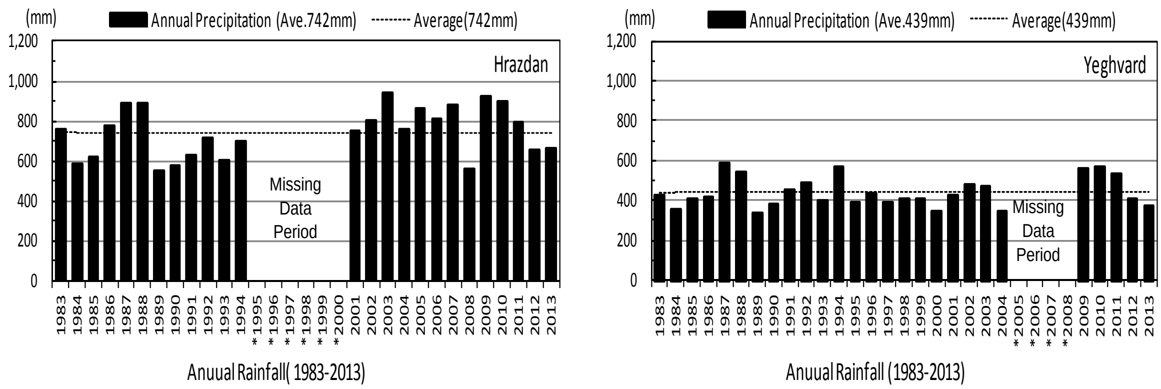


Figure 4-1-2.2 Annual Rainfall Data at Hrazdan and Yeghvard Stations

For the evaluation of rainfall trend at Hrazdan station, probability of annual rainfall is calculated. Calculation is done for two kind of period. One is long-term from 1983 to 2013, and the other one is latest 10 years from 2004 to 2013. The reason to evaluate by the Hrazdan station's data is that Yeghvard reservoir will be filled by the river flow from Hrazdan River's watershed area, so Hrazdan station's data will be presumed that it has relationship between rainfall and river flow. Based on the following result, year of 2008 is extremely low amount of rainfall, especially in the latest 10 years.

Table 4-1-2.2 Return Period and Probability of Non-Exceedance for Rainfall at Hrazdan Station

Year	Target Period		Year	Target Period	
	1983-2013	2004-2013		1983-2013	2004-2013
2004	-	1/3 (66%)	2009	-	-
2005	-	-	2010	-	-
2006	-	-	2011	-	-
2007	-	-	2012	1/3 (70%)	1/16 (94%)
2008	1/16 (94%)	1/6 (84%)	2013	1/3 (66%)	1/4 (74%)

Note) 1983 - 2013 (except no data period of 1995-2000), 2004 – 2013

(2) Hydrological data

Table 4-1-2.3 shows the monthly river flow at Hazdan and Lusakert station along Hrazdan River and Ashtarak station along Kasakh River from 1983 to 2013. Figure 4-1-2.3 shows fluctuation of the 10 days decade data. Based on Table 4-1-2.3 and Figure 4-1-2.3, it comes out that discharge of river flow rise up from March and maximum on April or May. Table 4-1-2.4 shows runoff ratio at Hrazdan station along Hrazdan River and Ashtarak station along Kasakh River and those are respectively 43% and 25%.

Table 4-1-2.3 Monthly Average River Flow

Observation Station	Monthly Average River Flow (MCM)												Total (MCM)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hrazdan [1)]	8.4	7.4	16.7	55.5	77.5	30.2	13.0	9.7	9.0	9.7	10.1	9.4	257
Lusakert [2)]	7.9	7.6	12.1	21.0	20.8	11.2	9.1	8.6	8.4	10.6	10.0	8.7	136
Ashtarak [3]	7.0	6.3	10.5	17.7	8.1	6.7	6.4	6.5	6.2	6.9	7.4	7.2	97

1)Averaged period is 1983-2013 except data missing year of 1998
2)Averaged period is 1983-2013 except data missing year from 1990 to1998
3)Averaged period is 1983-2013

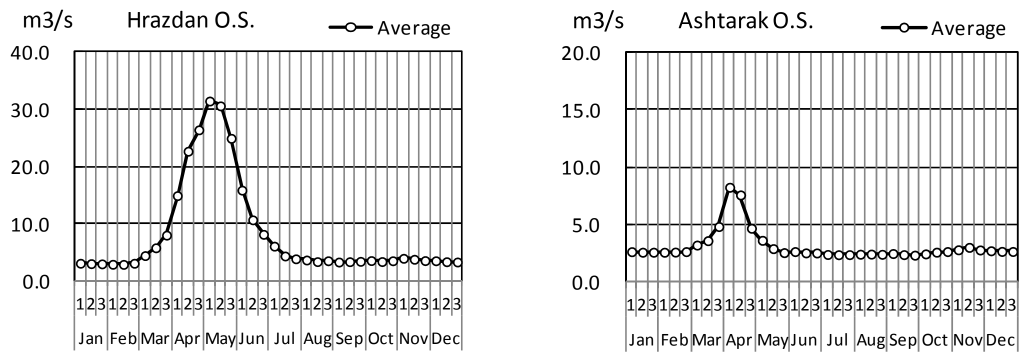


Figure 4-1-2.3 River Flow of Average 10 Days Decade at Hrazdan and Ashtarak Stations

Table 4-1-2.4 Runoff Ratio

Observation Station	Catchment Area (km^2)	Annual Rainfall (mm)	Annual Average Flow (MCM)	Runoff Ratio (%)
Hrazdan O.S. [1)]	806	742	257	43%
Ashtarak O.S. [2)]	1,018	387	97	25%

1)Averaged period is 1983-2013 except data missing year of 1998
2)Averaged period is 1983-2013

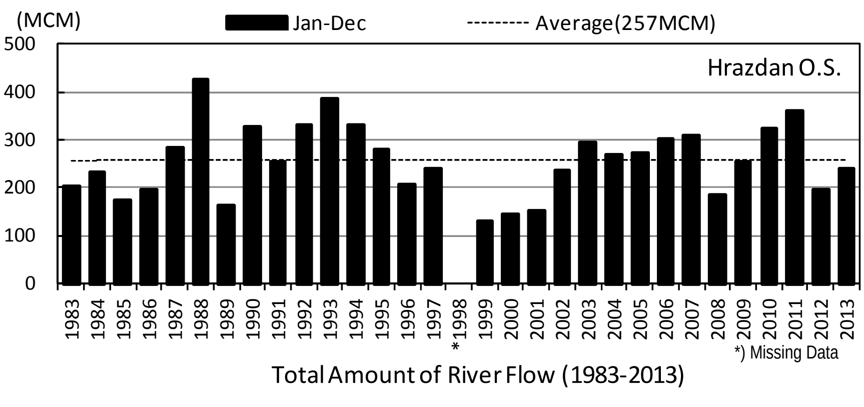


Figure 4-1-2.4 Yearly Trend of River Flow at Hrazdan Station

Above mentioned Figure 4-1-2.4 shows the yearly trend of river flow at Hrazdan station, and dotted line indicate the long-term average. Yearly river flow in 2008, 2012 and 2013 are less than the average (257 MCM) through the latest ten years. Since the river flow changed the fluctuation pattern, the meteorological and hydrological data for data analysis will be evaluated focus to the latest 10 years (2004-2013).

Probability of Hrazdan River flow is evaluated through 2004 to 2013, and the target of evaluation month's data are sum-up the river flow discharge from March to October. To be precise, irrigation starts from April and ends in October. River flow water to Yeghvard reservoir's distribution will start from March in this project. Therefore the evaluated period for probability include March. Based on the Table 4-1-2.5, probability of 75% is 2013, and it shows that 2008 and 2012 are the relatively dry year.

Table 4-1-2-5 Return Period and Probability of Non-Exceedance for River Flow at Hrazdan Station from March to May

Year	March to October		Year	March to May	
	River Flow (MCM)	R.P. and Probability		River Flow (MCM)	R.P. and Probability
2004	234	-	2009	216	1/3 (65%)
2005	234	-	2010	277	-
2006	269	-	2011	320	-
2007	275	-	2012	160	1/6 (84%)
2008	154	1/16 (94%)	2013	205	1/4 (74%)

Note) Latest 10 years from 2004 to 2013.

Figure 4-1-2.5 shows the distributed water from Lake Sevan, which has been observed at Geghamavan station. Geghamavan station is located between Lake Sevan and observes all the water comes from Lake Sevan. As mentioned before, Armenia Government launched an environmental improvement strategy for Lake Sevan in 2001 for rising up the water level by 2030. However, especially in 1993 after independent from Soviet Union, the distributed water is 1,699MCM which was ten times of latest volume (170MCM) under government control.

Figure 4-1-2.6 shows the comparison of 1993 and 2013 about the distributed water from Lake Sevan. It is clearly shown in Figure that the maximum discharge was around 70m^3/s in 1993 and it was used for hydropower generation. In contrast with its situation, the maxim discharge is about 30m^3/s in 2013 and this water is used for irrigation prior to hydropower generation. The operation of Lake Sevan and hydropower generation is completely changed in the past 20 years.

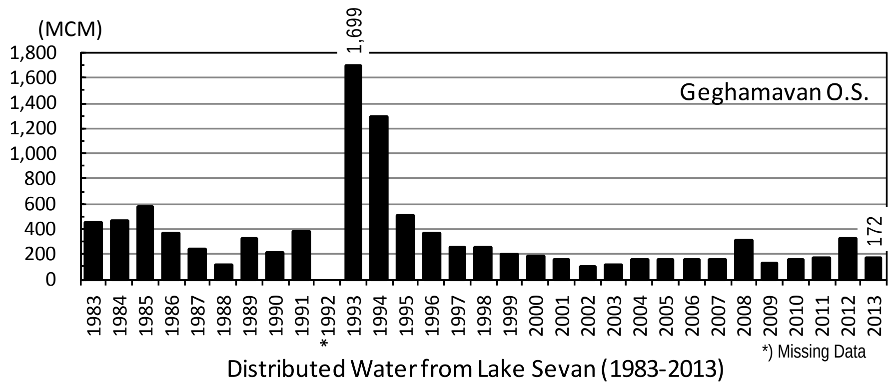


Figure 4-1-2.5 Yearly Trend of Distributed Water from Lake Sevan

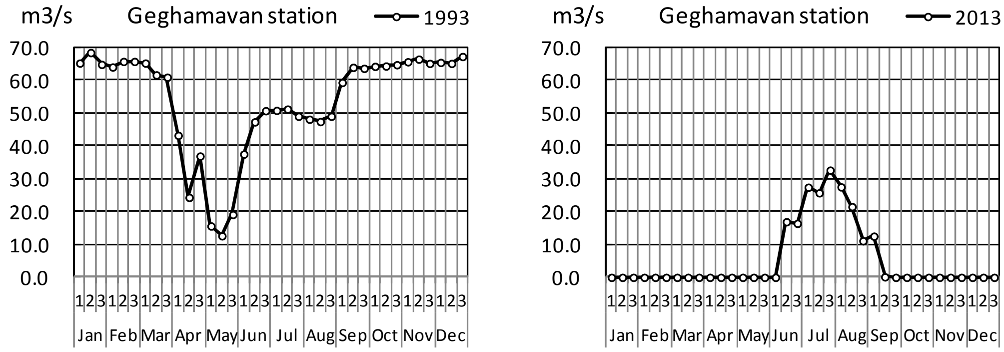


Figure 4-1-2.6 Comparison of Distributed Water from Lake Sevan between 1993 and 2013

4-2 Water Utilization Conditions

4-2-1 Current Conditions of Lake Sevan

(1) Outline

In the Project area, main water sources of main canals are Hrazdan and Kasakh Rivers. When the water is short to the demand, water is supplemented from Lake Sevan through Sevan-Hrazdan Hydropower Plants Cascade Scheme. The release waterfrom Lake Sevan for irrigation has been limited to 170 MCM/year for the preservation of Lake Sevan since 2001. In addition, the hydropower generation along Hrazdan River is allowed to operate only during the irrigation period.

These limitations are aimed to restore water level of Lake Sevan, which is planned to increase to EL.1903.5 m by 2030. The water level has successfully risen from 1896.32 m on January 1st, 2002 to 1900.13m on January 1st, 2015 and 3.4m remains to reach to the target level. However, the limitation of the usage of lake water for irrigation would not be applied in case of drought year.

If the restoration of water level proceeds well, the limitation would be weakened. What amount of water of Lake Sevan can be used in a drought year affects largely to the reservoir planning of the present project. Therefore the data on water use and controlled discharge information of Lake Sevan were collected in this stage.

(2) Water use

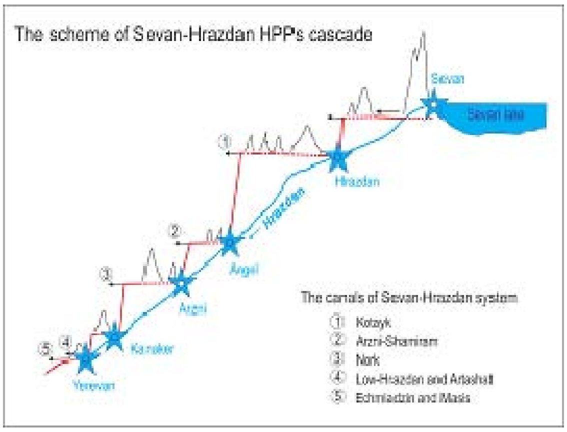
1) Release to Sevan-Hrazdan Hydropower Plants Cascade

Most use of the lake water is released to the Sevan-Hrazdan Hydropower Plants Cascade (see Figure 4-2-1.1) and the released water is used for power generation and irrigation. Table 4-2-1.1 shows its amount and duration of use since 2001. Around 100 to 170 MCM has been used in each year except the drought ones - 2008, 2012 and 2014.

Table 4-2-1.1 Water Release Amount and Duration to Sevan-Hrazdan HPPs Cascade

Year	Start Date	Duration (days)	Total Discharge (MCM)
2002	18.06	117	99.46
2003	13.06	129	118.31
2004	14.06	149	149.00
2005	14.06	141	149.55
2006	7.06	110	152.00
2007	11.06	122	155.00
2008	23.04	174	303.69
2009	11.06	99	126.49
2010	11.06	110	157.74
2011	21.06	96	168.33
2012	2.05	147	317.62
2013	11.06	90	169.95
2014	23.04	130	269.63

Source: Ministry of Emergency Situations of RA (2015)



Source: ATLAS(2007)

Figure 4-2-1.1 Sevan-Hrazdan HPPs Cascade

2) Irrigation to Farmland near Lake Sevan

In the watershed of Lake Sevan, there are three WUAs as shown in Figure 4-2-1.2. Only Martuni WUA is using the lake water for irrigation among them. As shown in Table 4-2-1.2, the amount is very small compared with the released water above-mentioned.

Table 4-2-1.2 Water Amount of Lake Sevan to Used by Martuni WUA for Irrigation

Years	Water volume, (MCM)
2007	1.4
2008	2.1
2009	1.1
2010	1.7
2011	1.6
2012	2.6
2013	2.4
2014	3.5
Average	***2.05***

Source) Martuni WUA

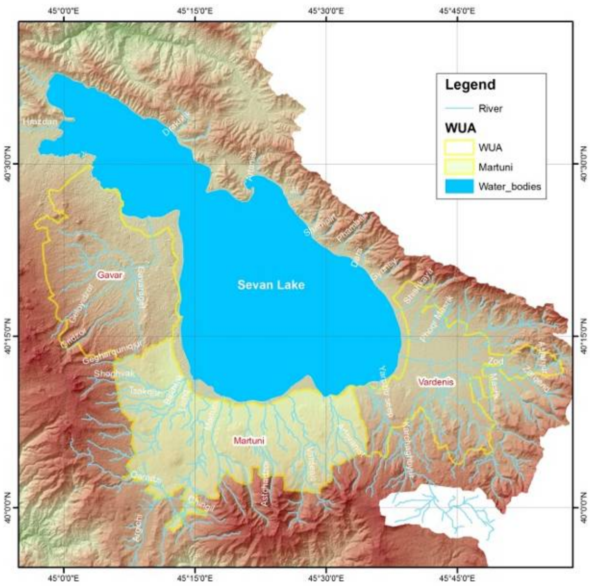


Figure 4-2-1.2 Location of Martini WUA

3) Others

Lake Sevan is used for sightseeing, recreation and fishery etc., but there is no significant water intake amount than that of for irrigation.

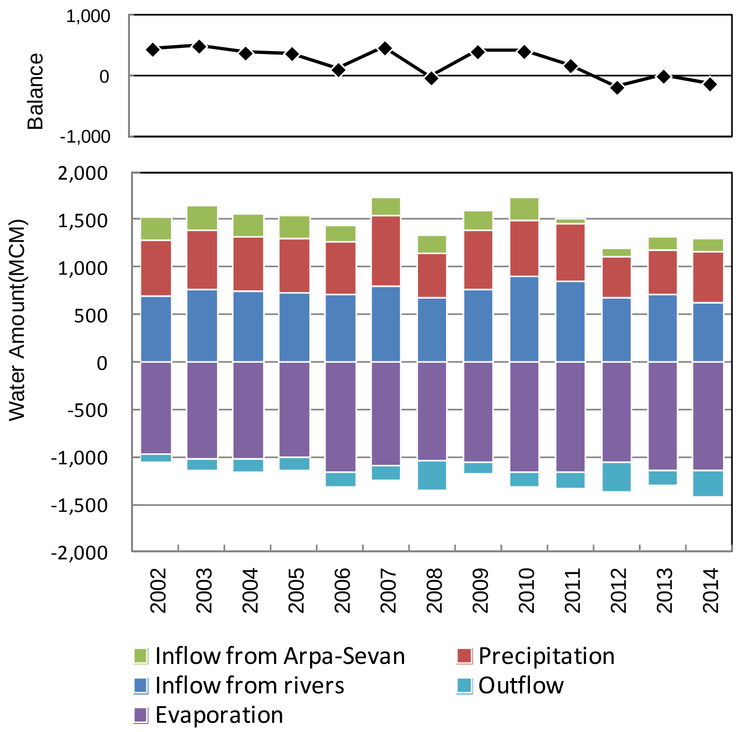
(3) Water balance and annual change of water level

Figure 4-2-1.3 shows the estimated annual water balance of tLake Sevan during 2002 to 2014. The large components in the balance are inflow from rivers in the watershed, precipitation to the lake and evaporation from the lake. The remaining components are the released water to Sevan-Hrazdan

Hydropower Plants Cascade and the inflow from Arpa-Sevan Conduit. Base on the black line drawn in Figure 4-2-1.3, the water balance on 2008, 2012, 2013 and 2014 is being balanced or negative balance. The inflow from the conduit comes from the different watersheds of Arpa River and Vortan River as shown in Figure 4-2-1.4.

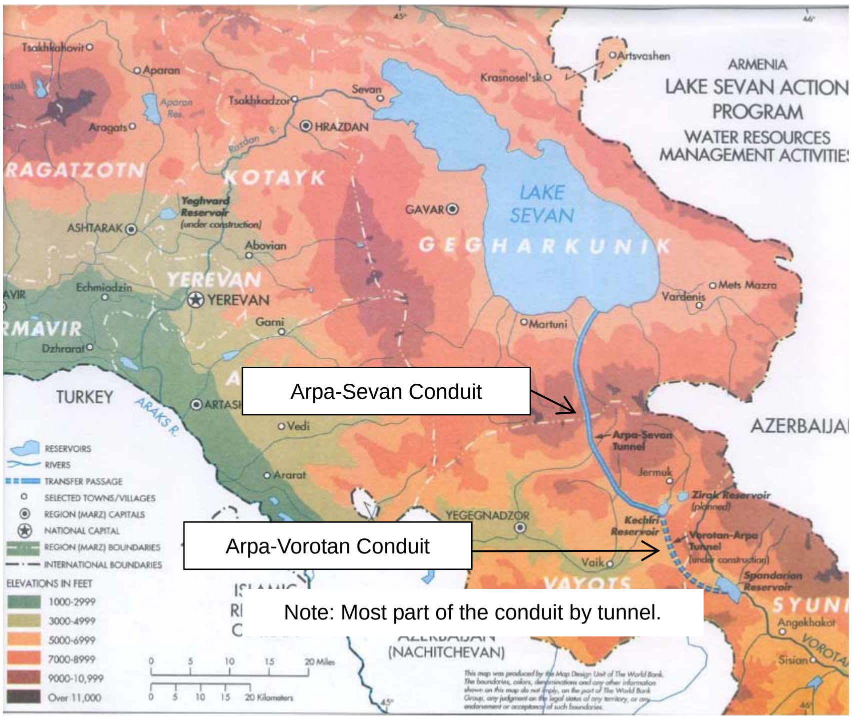
Figure 4-2-1.5 and 4-2-1.6 show the annual amount of the released water and the inflow from the conduit. The released water volume ranges from 100 to 170 MCM/year except drought years, whereas the inflow from the conduit ranges from 170 to 260 MCM/year and exceeds the released amount until 2010. However, since 2011, the released water has exceeded the inflow, because the Arpa-Vorotan conduit has been closed for rehabilitation and inflow comes only from watershed of Arpa river.

Figure 4-2-1.7 shows the variation of lake water level on the first day of year since 2002. The water level has increased gradually until 2011, but was held almost constant since 2012. This change looks well reflected to the reduction of inflow from Arpa-Sevan conduit.



Source) Ministry of Territorial Administration Development, RA

Figure 4-2-1.3 Estimation of Water Balance of Lake Sevan



Source) European Environmental Agency (2015); original figure by WB; retouched.

Figure 4-2-1.4 Location of Arpa-Sevan and Arpa-Vorotan Conduits

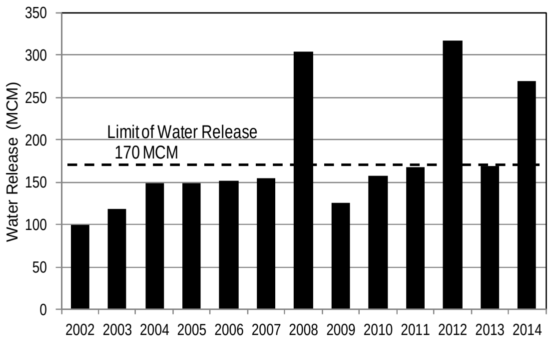


Figure 4-2-1.5 Water Release from Lake Sevan to Sevan-Hrazdan HPPs Cascade

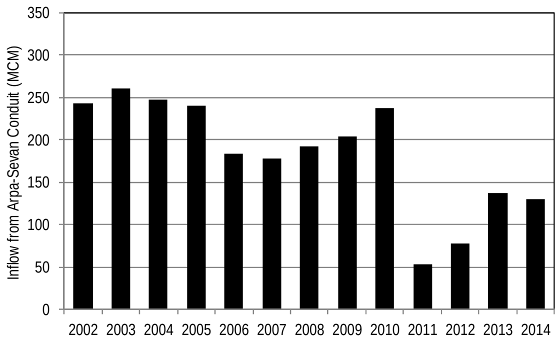
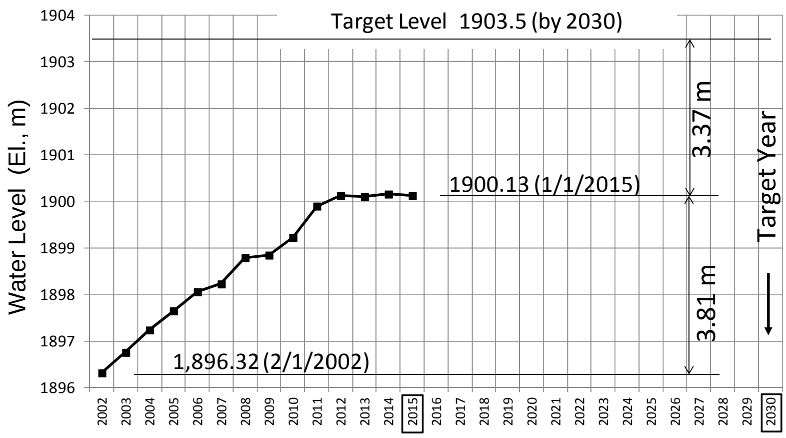


Figure 4-2-1.6 Inflow to Lake Sevan from Arpa-Sevan Conduit



Source: Ministry of Territorial Administration and Emergency Situations of RA

Figure 4-2-1.7 Annual Change of Water Level of Lake Sevan

(4) Prospects of water balance and water level in future

The lake water level rose by approx. 3.7m in ten years until 2011 under the circumstances that sufficient water comes from Arpa-Sevan conduit and the release to Sevan-Hrazdan HPPs Cascade is limited basically to 170 MCM/year. The required water level rise to the target is 3.4m at present, so that if the circumstances are the same, the water level probably reaches the target level within next 10 years.

That is, if the released amount of water can be controlled under 170 MCM/year for a non-drought year after completion of rehabilitation work of the Arpa-Vorotan tunnel, the release exceeding 170 MCM in a drought year probably doesn't affect the restoration plan of the lake water level as far as many drought years do not repeat successively.

4-2-2 Water Utilization along Hrazdan and Kasakh River

Water Resource Management Agency (WRMA) is the responsible organization to permit the water right regarding irrigation, hydropower, drinking water, fish breeding and industries. WRMA has been reported summary report of water use permits every year. In generally, surface water is used for irrigation, hydropower and production facility. Ground water is used for irrigation, drinking water and fish breeding.

Current situation of water utilization along Hrazdan and Kasakh Rivers is same as general condition in Armenia. The major water user along Hrazdan River is irrigation and hydropower plant, and the major user along Kasakh River is irrigation. Water source for drinking water is ground water and the discharge volume of utilization for industries is very few compare to irrigation use. Thus, irrigation and hydropower plant is considered as major water user along Hrazdan and Kasakh River. Table 4-2-2.1 shows the water utilization by surface water or ground water along Hrazdan and Kasakh Rivers.

Table 4-2-2.1 Water Utilization along Hrazdan and Kasakh River

	Irrigation	Hydro Power Plant	Drinking water	Fish breeding	Industries
Surface water	x	x			x (very few)
Ground water	x		x	x	x

The water user along Hrazdan and Kasakh Rivers is Sevan-Hrazdanyan Jrar CJSC. The water right for this CJSC has been already permitted by WRMA, and there is no conflict among hydro power plants. As it was mentioned in "2-2 Policy of Water Resource" in Chapter 2, the agricultural water usage has higher priority than the energy and industrial production use.

4-2-3 Current Water Utilization of Yeghvard Irrigation Project Site

Table 4-2-3.1 indicates the flow discharge and ratio of supplied water source for the current Yeghvard Irrigation Project Site. The water sources are classified into two main canals, one river, three pumps which belong to WSA and other pumps and deep wells. The period of collected data is from 2012 to 2014 and all data were received from WUA.

Table 4-2-3.1 Water Source for Current Yeghvard Irrigation Project Area

2012-2014	WUA				Total (MCM)	Ratio (%)	Total (MCM)	Ratio (%)
	Yeghvard	Ashtarak	Vagarshapat	Khoy				
Arzni-Shamiram	7.871	1.737			9.608	8	38.389	34
Lower Hrazdan				28.781	28.781	25		
Kasakh River		2.699		12.993	15.692	14	15.692	14
Ranchpar Pump				10.666	10.666	9	29.791	26
Aknalich Pump			4.639	8.917	13.556	12		
Metsamor Pump				5.569	5.569	5		
Other Pumps			1.642	5.900	7.542	7	30.142	26
Deep Well			11.125	11.475	22.600	20		
Total					114.014	100	114.014	100

Figure 4-2-3.1 shows the ratio of supplied water volume for current Yeghvard Irrigation Project Site by sourece. Based on the figure, current Yeghvard area depends on more than fifty percent of pump-based irrigation water. The 26% of supplied water comes from pump station and 25% of it comes from small pump and deep well. Shift from pump-based to gravity-based irrigation has an important role in this area.

Figure 4-2-3.2 shows the distributed water volume of Aknalich Pump Station from Lake Aknalich. This lake's water comes from ground water. Aknalich pump station is taking irrigation water from this lake. It is cleared that the discharged volume has been decreasing year by year.

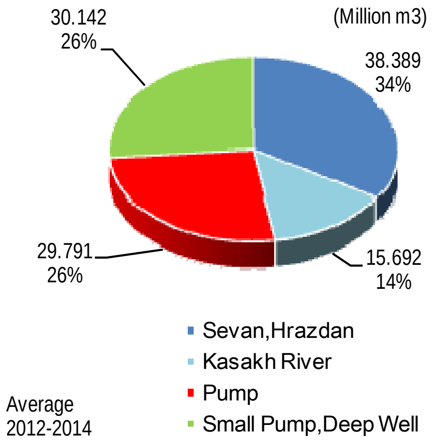
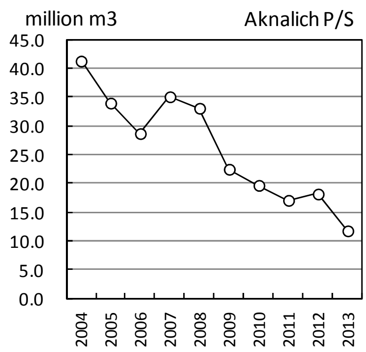


Figure 4-2-3.1 Ratio of Water Source

Energy reduction by shifting to gravity-based irrigation from pump-based irrigation is the important policy in agriculture sector. In addition, from the view point of ground water resources, abolishment of pump facilities contributes not only energy reduction but also conservation of ground water resources in the Project site.



Source) WUA, WSA, JICA Survey Team

Figure 4-2-3.2 Annual Change of Water Level of Lake Aknalich

4-3 Current Situation of Planned Reservoir

4-3-1 Outline of Geological/Hydrogeological/Soil Investigation

In the early stage of the field work on the Project, a series of field geological, hydrogeological, and soil investigation works were conducted in and around the planned reservoir, which is called as "Initial Geological Investigation". After the completion of initial series of investigation work, some additional geological/hydrogeological investigation work has been carried out to complement the initial investigation, which is called as "Additional Geological Investigation".

Major purposes of the both initial and additional investigations, contents, and schedules of these works shall be explained in this section.

(1) Purposes of the initial geological/hydrogeological investigation

Major purposes of the initial geological, hydrogeological, and soil investigation works were summarized as below;

a) Reconfirming the ex-USSR's geological and hydrogeological investigation results,
b) Checking the permeability and its anisotropy of the reservoir ground, and
c) Revealing the groundwater condition on dam-site.

As it was well known, a huge volume of geological, hydrogeological investigation, and a geophysical prospecting were carried out in both Feasibility Study (F/S: 1979-80) and Detailed Design Study (D/D: 1984-85) periods. Based on the D/D, a part of dam bodies had been constructed (No.1 and No.2 Dams in Yeghvard reservoir). The first purpose of the investigation was to reconfirm and review the results of their investigation works.

In the previous geological/hydrogeological investigation, many permeability tests were conducted through mainly a pressure water injection method and there were no consideration on anisotropy of the permeability. However, the anisotropy on permeability is very significant to consider water seepage into the ground, through the reservoir bottom or slopes. The second major purpose of the investigation was to check and study the anisotropy of the ground permeability.

Then, the third major purpose of the investigation was to reveal a groundwater condition of the reservoir area in detail. It's also well known that the groundwater level near around the dam-site is quite deep, and because of such reason, a little information on groundwater condition are available right now, even though the groundwater condition is one of the quite significant factors on seepage analysis. Drilled holes for groundwater investigation were completed as an observation well and served as "Groundwater Monitoring Wells" after the investigation work.

In accordance with the consideration on the results of initial geological and hydrogeological investigation (these are explained later in detail), the anisotropy of ground permeability was emphasized. And, the fact that the layer regarded as an aquitard (almost impervious layer) in the reservoir area was not only "Recent Alluvium" (① layer: refer to Table 4-3-3.1) but "Pleistocene Alluvium" (⑥ layer: same) also was revealed. Based on these facts and their significance related to the dam water seepage analysis, the additional geological/hydrogeological investigation works, mainly targeting to "Pleistocene Alluvium" (⑥ layer), were conducted.

(2) Contents of the investigation

Those investigation works were actually conducted under "Sub-contract". To make the contract, the investigation works were separated into four categories of; 1) Geological Investigation Boring, 2) Monitoring Well Drilling, 3) Soil Investigation Boring, and 4) Additional Investigation Boring. Work volumes actually conducted were as follows:

1) Geological investigation boring;

a) All-core Boring: 10 holes (depth 30 – 50m, total 320m)
b) In-situ Tests: - Standard Penetration Test (SPT) (every 1.0m)
- Permeability Test <Horizontal test> (3.0 – 5.0m span)
- Permeability Test <Vertical test> (every 5.0m)
- Natural γ-ray Logging (every hole)

2) Monitoring well drilling;

c) Deep Well Drilling: 5 wells (depth 120 – 150m, total 660m)
d) In-situ Tests: - Natural γ -ray Logging (every well)
-Resistivity Logging with SP log (3 wells but partially)
e) Completion to Monitoring Wells: 5 wells
f) Installation of Automatic Water Level Recorder (AWLR): 5 wells

3) Geophysical prospecting and soil investigation boring;

g) Geophysical prospecting: 53 points (VES, 120m analyses)
h) All-core Boring: 5 holes (depth 17 – 30m, total 137m)
i) In-situ Tests: - Standard Penetration Test (SPT) (every 1.0m)
- Permeability Test <Horizontal test> (3.0 – 5.0m span)
- Permeability Test <Vertical test> (every 5.0m)

4) Additional investigation boring;

j) All-core Boring: 6 holes (depth 60 – 100m, total 480m)
k) In-situ Tests: - Standard Penetration Test (SPT) (every 1.0 – 2.0 m)
- Permeability Test <Horizontal test> (3.0 – 5.0m span)
- Permeability Test <Vertical test> (every 5.0m)

(3) Actual works schedule

Total work schedule of the Project was, originally, from early June 2015 to the beginning of August 2016. The Sub-contract of the initial geological and hydrogeological investigation works were concluded on 1st July, 2015, and the actual field and laboratory works had been completed in January, 2016. Then, the additional geological/hydrogeological investigation works were commenced in the middle of February, and completed by the end of April, 2016. The actual work schedules on all geological/hydrogeological investigation works are shown in the Figure 4-3-1.1.

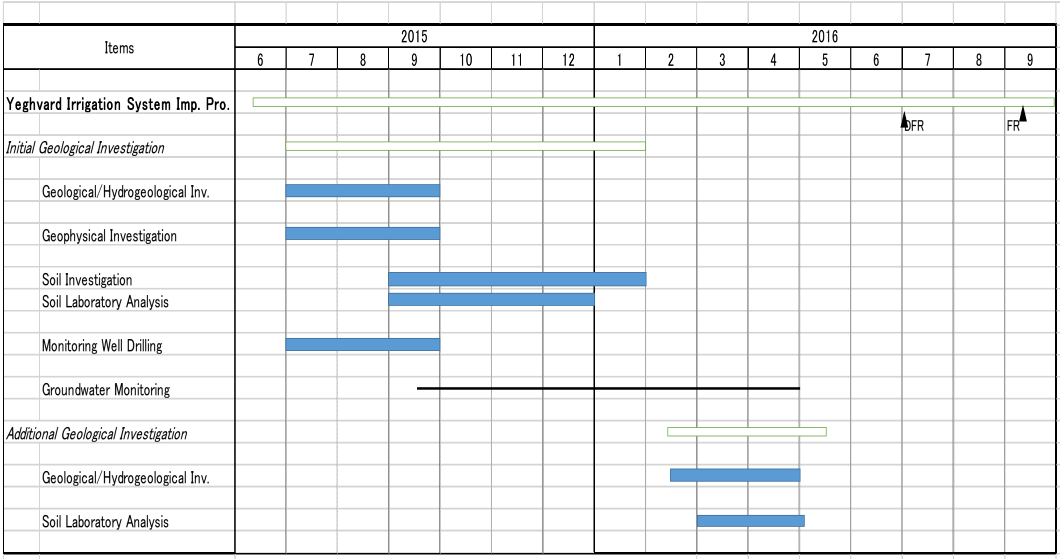


Figure 4-3-1.1 Work Schedule on Geological/Hydrogeological Investigation

4-3-2 Results of Geological/Hydrogeological Investigation

In this section, a methodology and a result of each investigation work such as investigation boring (not only geological/hydrogeological but soil investigation also), in-situ tests conducted in every boring hole, monitoring well drilling, and so on, are to be explained. And finally, results on "review of the previous geological investigation" by ex-USSR, one of the major purposes of the initial investigation, shall be considered.

Drilling Rig

(1) Geological/Soil investigation results

(a) Geological investigation boring

Major works conducted under this category were 10 holes of "all-core boring" together with in-situ tests of; "Standard Penetration Tests" (SPT), "Permeability Test" (PT), and "Gamma-Ray Logging" (GRL). Two kinds of PT were tried to know a horizontal (HPT) and a vertical permeability (VPT). All of the investigation holes have been buried completely by clayey soil after completion of all boring and tests. Drilling rigs used in this job were top-drive rotary drilling rig; type "УР Б 2А2" model made in USSR (refer to the right picture).

Location of geological investigation boring is shown in Figure 4-3-2.1.

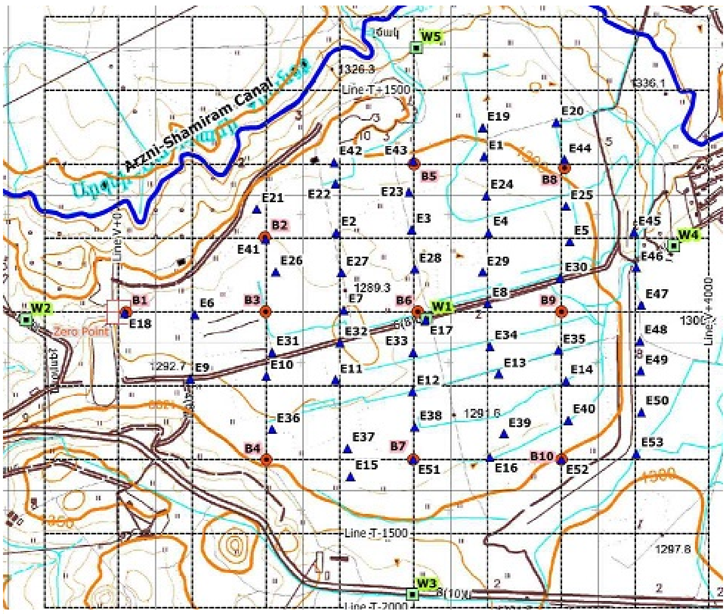


Figure 4-3-2.1 Location Map of Geological Investigation

Results of core-boring in this category were arranged into “Boring Log” together with all results of in-situ tests such as SPT, VPT and HPT (refer to Figure 4-3-2.2), and attached in Appendix F-1 all together.

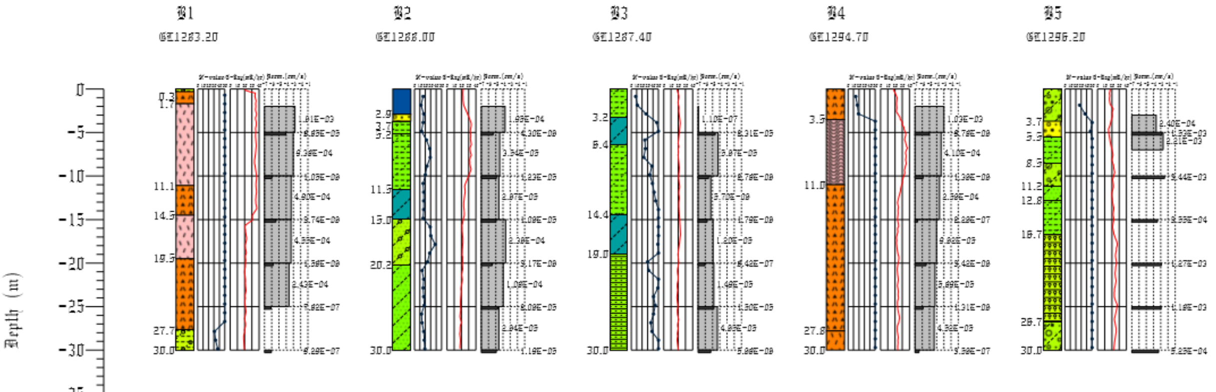


Figure 4-3-2.2 Samples of Boring Log

Based on these boring log (but including other geological log obtained through other investigation), several geological cross-sections (N-W sections) and profiles (E-W sections) were provided to understand the total geological condition of the dam-site. A sample of the section is shown as Figure 4-3-2.3 (Profile No.3). All geological cross-sections and profiles are attached in Appendix F-2, and explained partially in the following section.

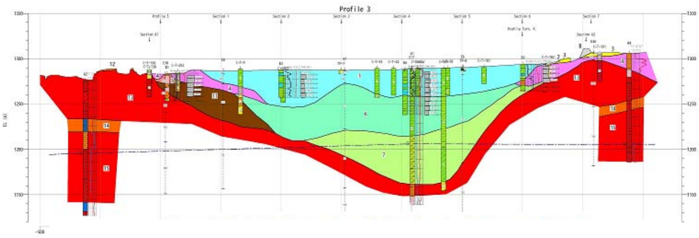


Figure 4-3-2.3 Sample of Geological Cross Section

The geological investigation boring revealed a distribution and properties of major geological formations consisting the site, such as many volcanogenic layers, mainly fluvial sand and gravels (pebbles and cobbles partially), and rather impervious loamy soil layers. Anisotropy of permeability of these formations was clarified. Furthermore, quite high Gamma-ray radiations were detected at some of the boring in their upper portion. This phenomena was observed in some holes of “Soil investigation boring” and “Monitoring well drilling” also, and it shows a characteristics of Tuff-breccia erupted in the same timing from, supposedly, Mt. Arailer standing in just north.

(b) Geophysical prospecting and soil investigation boring

Under the category of “Quality/Quantity Survey on Embankment Materials”, total 53 points of geophysical prospecting were conducted, and based on the analyses of the prospecting, total five (5) “all-core boring” with a series of in-situ tests (same with geological/hydrogeological investigation) were drilled as “Soil Investigation Boring”. However in these boring, soil samples taken by a SPT (one meter interval) were sent to a laboratory to make three (3) kinds of soil tests (1.Moisture contents, 2.Specific Gravity and 3.Grain-size Distribution Analysis).

VES Equipment

Geophysical prospecting was carried out as so-called “Vertical Electric Sounding” (VES). Electrode arrangement was “Schlumberger Method”, with electrode distances of 340m (AB). The maximum analysis depth was 70m originally but extended to 120m later. Equipment used in this prospecting was Electric Auto-compensator “AЭ-72”, Russian made (1980); measuring limit 1000 MV (refer to the picture in the previous page). Field observation data were analyzed into ρ - α curve through a standard curve fitting method (refer to Figure 4-3-2.4).

Results of VES revealed the wide and deep distribution of very thick low apparent resistivity zone ($\rho\alpha < 25\ \Omega$m), which can be considered as almost impervious clayey layer, in the central portion of planned reservoir (it was confirmed by additional geological investigation, later). All of these results were used as reference to build up geological cross-sections and profiles.

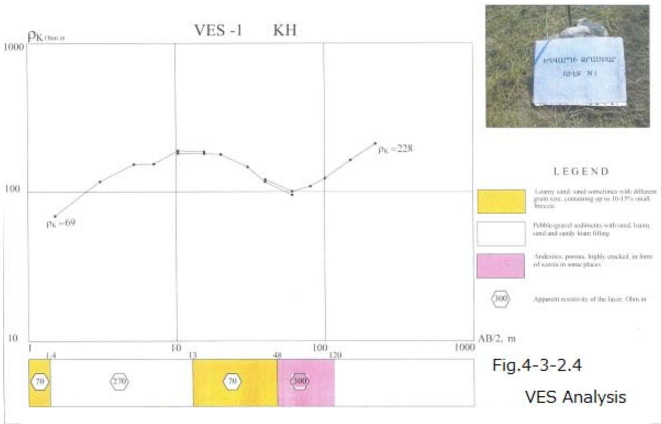


Figure 4-3-2.4 Sample of VES Analysis

Soil investigation boring, drilled consequently to the depth of 30m (as a rule) near around the center of the planned reservoir, found out deep loamy layers showing rather low permeability of both vertical and horizontal, to the bottoms of holes excepting SB-5 which reached to volcanic rocks at shallow depth.

Results of the laboratory analyses indicate clearly loamy zones, clayey zones, and sandy zones, and these information are quite useful to zoning the geological layers (details are explained in the following section).

Location of VES and Soil Investigation Boring are shown in Figure 4-3-2.5. Then, boring log on soil investigation boring are also attached in Appendix F-1, together with the boring log of geological/hydrogeological investigation.

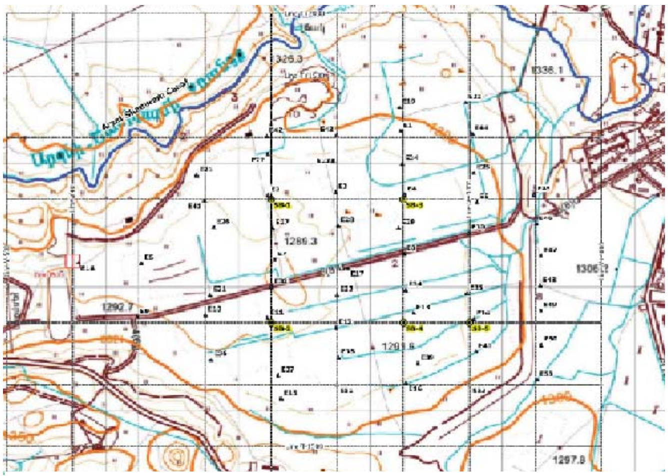


Figure 4-3-2.5 Location Map of VES & Soil Investigation

(c) Additional geological /hydrogeological boring

The main purposes of the initial geological investigation work were to reconfirm the results of previous geological investigation work, therefore, investigation boring were distributed widely but rather shallow.

Major targets of Additional Geological Investigation are Alluvial deposits of “Holocene” and “Pleistocene” (① and ⑥ in Stratigraphy: Table 4-3-3.1 shown later), and the work contents were; “all-core boring” up to 100m depth at maximum to know their properties and distribution, “VPT and HPT” to measure a permeability and their anisotropy, “SPT” to check a toughness of the layer and to take soil samples, and “Soil Laboratory Analysis” to grasp the soil properties of each layer.

Additional boring, from 60 to 100m depths, made clear the distribution of thick (more than 25m) clayey layer with very low permeability (VPT: 1.28 x 10^{-6} cm/sec in an average) in the central and west central parts, and distribution of sand-and-gravelly ❼ layer in the central east part of the reservoir. The ❼ layer was consisted of rather course materials but vertical permeability (VP) was not so high, around 2.1 x 10^{-5} cm/sec in an average, against rather high horizontal permeability (HP). Through the total six (6) additional boring, the distribution of these mostly impervious loamy layers

(① and ⑥) was more clearly distinguished, and then, enough numbers of permeability coefficients on impervious ① and ⑥ layers, and on semi pervious ❼ layer were obtained.

The two 100m-depth boreholes (AB-1 and AB-2) drilled along with Profile No.3, which expected to reach the practical basement of the area (⑬ Basalt Lava), however, did not arrived at the basement within 100m depth. That the ①, ⑥ and ❼ layers have the total depth of more than 100m was one of the quite important information. The second deepest borehole, AB-3 (on the Profile No.5: 80m depth), also could not reach the basement (⑬), and very thick ⑥ layer continued from 40m depth to the bottom. Borehole AB-4 (along the same profile), originally planned to drill 70m, was stopped to drill at 60m because it reached to the volcanic layer (Welded tuff in ⑬ layers) at around 57 m. Along with the Profile No.1, AB-5 and AB-6 were drilled to the depth 70m, respectively. AB-5 (in the western side) drilled thin surface gravel at first, then, drilled volcanic formations of ④ and ⑤ layers till 26m. Then, it passed through thin ⑥ layer (around 7m thickness) and drilled through rather thick ❼ layer. It reached to the basement of ⑬ at the depth of 63m. AB-6 (eastern side) drilled through the thick volcanic formations of ④ and ⑤ for nearly 33m, and then, drilled through only 3m of ⑥ layer and rather thick ❼ layer the bottom of 70m.

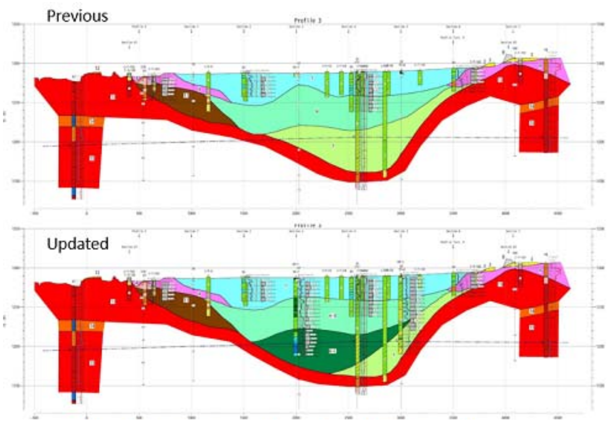


Figure 4-3-2.6 Sample of Modified Profile

Based on the results of additional geological investigation, most of geological cross-sections and profiles were modified, and both VP and HP of these ①, ⑥ and ❼ layers were rearranged, and sent to the expert of water seepage analysis. As a sample of modification, a supposed geological profile No.3, before and after the additional investigation were shown as Figure 4-3-2.6.

Location map of the additional investigation boring are shown in Figure 4-3-2.7. All boring and in-situ tests results are arranged into boring log, and attached in Appendix F-1.

(2) In situ-tests

(a) SPT and Soil laboratory analyses

Standard penetration tests (SPT) were conducted in the all core-boring holes, in one meter (1.0m) interval until 50m depth and in two meters (2.0m) interval till the borehole bottom (max. 100m depth).

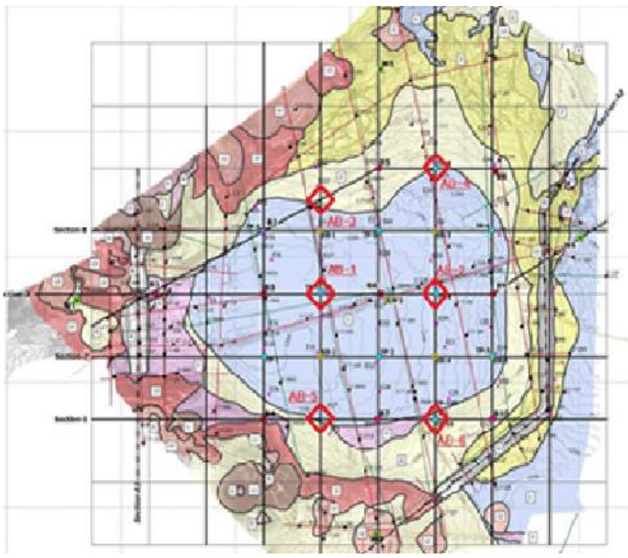


Figure 4-3-2.7 Location Map of Additional Investigation

Technical specification on the test was mainly compliant with ASTM (D 1586 – 99, USA). However, N-value was calculated by summing up of blows in every 10cm penetrations x 3 spans (Japanese Standard), and Results of SPT are figured out in each boring log. Remarks are N-values at just below the permeability test spans where usually saturated by test water and show not true value. Soil samples taken through a split barrel (refer to Figure 4-3-2.8) were send to a soil laboratory for a series of laboratory tests (moisture contents, specific gravity, and grain size distribution test). All results of SPT (N values) are attached in the every boring log.

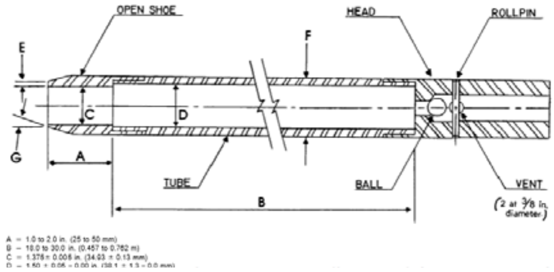


Figure 4-3-2.8 Split Barrel (STM, D 1586)

Results of laboratory tests in every boring hole are summarized as Figure 4-3-2.9. As shown in those figures, a field moisture contents were around 20% or somewhat higher than 20%. However, it's strongly affected by a permeability tests conducted in almost 5.0m interval. A plasticity index and 0.05mm grain contents suggest the layers are consisted of mostly loamy soil but including several thin sand layers and clay layers partially.

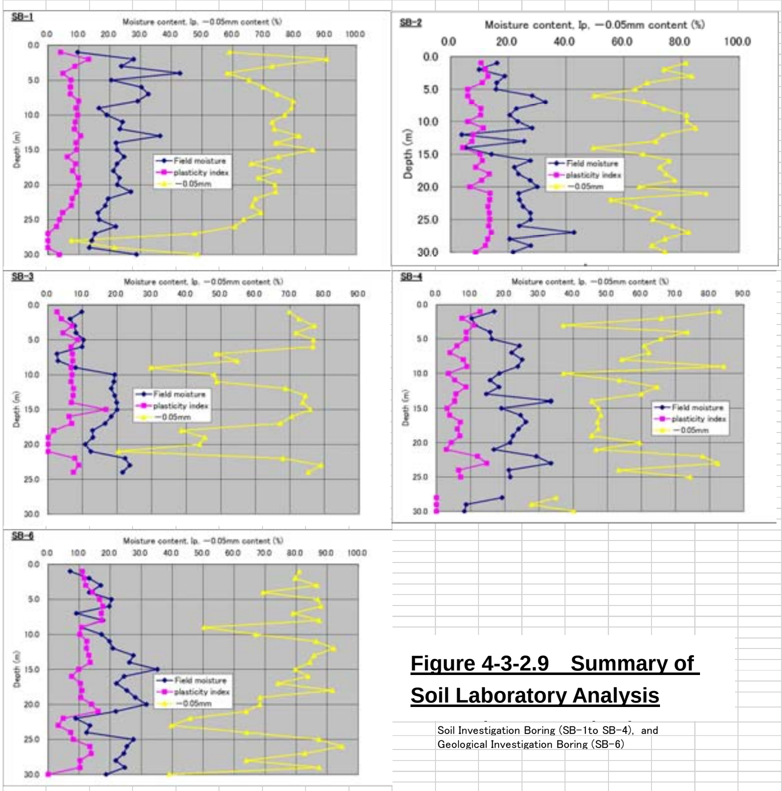


Figure 4-3-2.9 Summary of Soil Laboratory Analysis

Soil Investigation Boring (SB-1to SB-4), and Geological Investigation Boring (SB-6)

(b) Permeability test (VPT and HPT)

As explained before, two types of permeability tests were conducted; vertical (HPT) and horizontal (VPT) permeability tests. For HPT, a popular permeability method of "Packer Method" was employed, and for VPT so-called "Tube Method" was introduced (refer to section 4-3-3 (4) for further detail).

Packer method is to inject water into a certain span of boring (usually 5.0m span), using a packer (air packer in this case) to separate the test span from the other portion. Water is injected into the test span by a certain pressure and measured the injected volume (water loss) by a water meter (refer to Figure 4-3-2.10). Horizontal Permeability Coefficient (*k*), in the packer method, is calculated by the following equation:

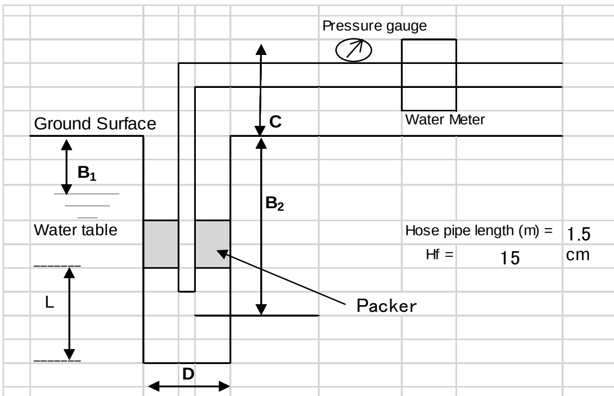


Figure 4-3-2.10 Horizontal Permeability Test

$$k = (q \times 10^3 \ln (L/r)) / (2\pi LH \times 60)$$

Where k: Permeability coefficient (cm/sec)

q: water loss (lit/min)

L: Length of test section (cm)

r: radius of the test hole (cm)

H: Total water head (cm)

While in the case of VPT, a water loss injected through the bottom of core-tube is measured by a measuring cylinder at the top of the rod connected to the core-tube (refer to Figure 4-3-2.11), in the case of "Constant Head Method". In the case of "Falling Head Method", the water level falling down to the bottom of the hole shall be followed by water-level meter (refer to the same figure). Vertical permeability k is calculated by the equation used in laboratory permeability test for falling head or constant head.

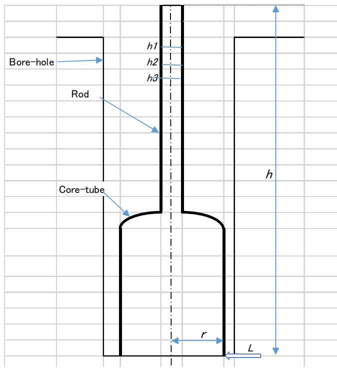


Figure 4-3-2.11 VPT System

Table 4-3-2.1 Average Permeability in Layer

Layer	Geology	VPT (cm/s)	HPT (cm/s)
①	Surface cover	8.25E-06	5.19E-05
②	Alluvial S/G	2.48E-05	4.06E-04
❸	Morane Dep.	6.32E-05	5.99E-04
④	Welded Tuff	1.63E-05	2.28E-04
⑤	Basalt Lava	1.92E-06	2.13E-04
⑥	Dilluvial Sediment	6.21E-06	2.52E-05
❼	Dilluvial S/G	2.13E-05	6.38E-05
⑪	Basalt Lava	9.09E-06	1.76E-04
⑬	Tuff Breccia	6.39E-06	1.17E-04

All results of both horizontal and vertical permeability tests were arranged and analyzed. VPT and HPT calculated are attached in all boring log, illustrated. Further details on the permeability and its anisotropy shall be discussed in the section "4-3-3 (4) Permeability and its anisotropy in the reservoir area", and only the summarized permeability on each geological classification are shown as Table 4-3-2.1.

(c) Natural γ-ray logging and Resistivity/SP logging

In all initial geological/hydrogeological and soil investigation boring (total 15 holes) and in all monitoring wells (total 5 wells), a natural γ-ray logging was conducted. In the three wells among 5 monitoring wells, a resistivity logging associated with SP logging was also carried out because some of groundwater or drilling fluid was remained in the wells. The other two wells could not be logged by resistivity/SP because they were dry.

Logging Car

Both γ-ray logging and resistivity logging were carried out using a serial issued logging station "CK-1-74" mounted on "GAZ-66 Truck" (refer to the left picture), and logging cable and winch was "KΓ-30-40-90", all of these were made in USSR. Measurement unit of γ-ray was "m-R (milli-Roentgen)" and resistivity logging was "Ωm".

Results of γ-ray logging were attached into boring log and well log, illustrated in accordance with the depth. Results of resistivity/SP logging were also attached in three well log, respectively. Figure 4-3-2.12 shows γ-ray, resistivity, and SP logging results in the three wells which had water in wells.

(3) Monitoring well drilling and Groundwater measurement

(a) Monitoring well drilling

In the category of initial geological investigation, five (5) monitoring wells were drilled in and surrounding the reservoir area. Originally planned depths were 120m because USSR Report noted that the groundwater level were detected in between 96m to 106m in their boring. However, three wells among five (5) were drilled more 30m (up to 150m depth) due to confirm the groundwater table.

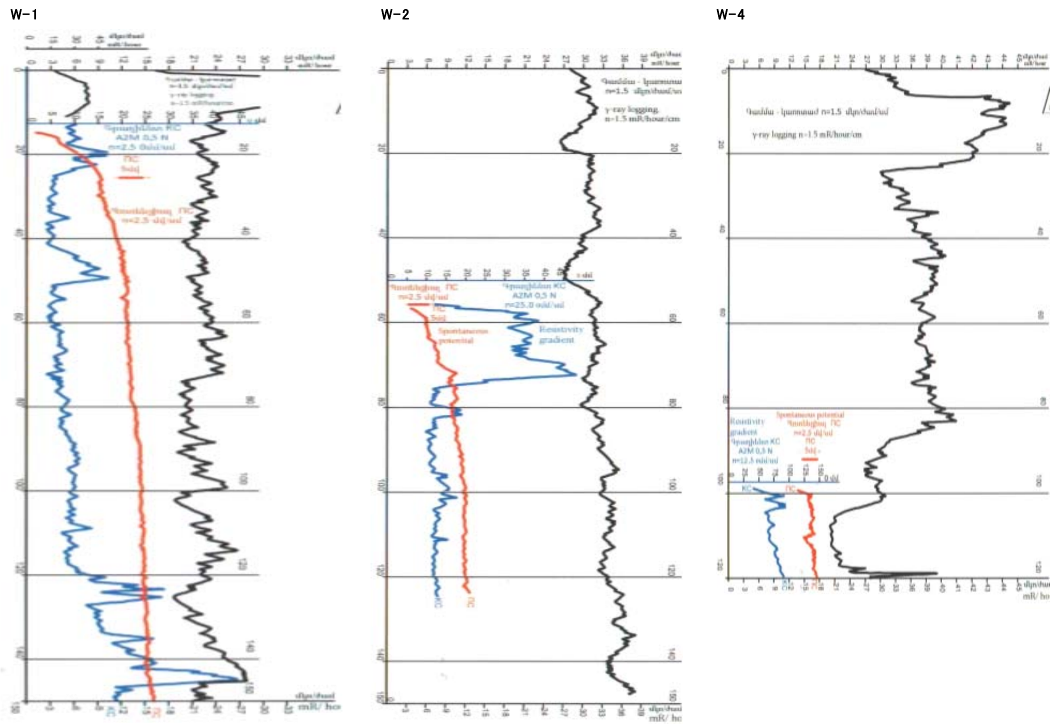


Figure 4-3-2.12 Results of γ-ray and Resistivity Logging

Monitoring well No.1 (called W1) was drilled at almost center of the reservoir area, to check the groundwater table in the reservoir center, then the other wells were drilled at N, S, E, and W of the dam-site but outsides the planned reservoir, because they must be remained and controlled as monitoring wells even after the dam has been completed (except W1 well).

Wells were drilled by 244mm drilling bit in the most part and reduced its diameter to 215mm in the lower portion. Steel casing and slotted screen with diameter of 114mm were installed. At the bottom 30m, screen was installed and filter gravels were set surrounding the screen. Figure 4-3-2.12 shows a standard monitoring well structure. After the well development, Gamma-Ray Logging throughout the well depth was carried out. And, only when the well has high water level inside, a Resistivity/SP logging was also conducted from the bottom to the depth of mud or ground-water.

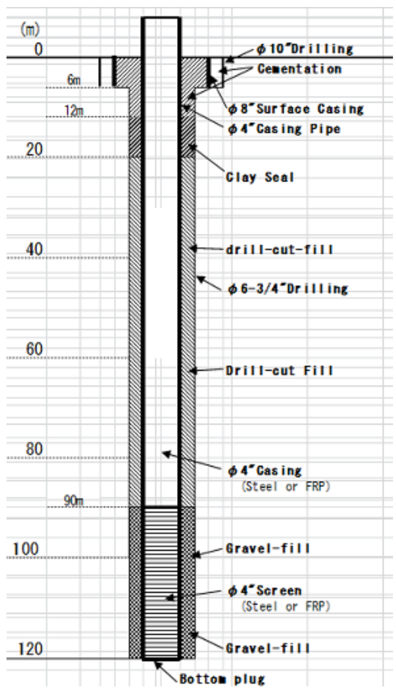


Figure 4-3-2.13 Monitoring Well

Groundwater table was detected in the all monitoring wells but depths were varying from around 80m to 131m, mainly because of the differences of the ground elevations at where they drilled.

W1 well drilled in the center of reservoir penetrated trough very thick Sandy Loam up to 127m depth and encountered to volcanogenic formation at last. It was Welded-tuff with characteristic brick red color. In this well, very high Gamma-ray radiation was observed at the uppermost 7m. W2 was drilled at the downstream of dam-site, near the entrance to the lower village. It drilled through almost volcanogenic formations from the mouth to the bottom. It was including some clayey formations but they should be weathered volcanic ash. From 55m to 75m, it had quite pervious portion, which was detected by Resistivity Logging. W3 well was drilled at along the national road passing the south of reservoir area. Because of its high elevation, the well was also drilled to 150m depth, and the groundwater table was touched at 129.9m depth. The well drilled through all volcanic rocks without the top of the well. W4 was drilled just upstream of the dam-site, near the church of Yeghvard under construction (as of October 2015). It also drilled through rather hard rock formation. It had quite high gamma-ray radiation at its 6m to 22m span, mostly brown to red Tuff. Below the Tuff, it had pyroclastic portion where need cementation to stop full seepage out of drilling mud-water. W5 was drilled at northern hill surrounding the reservoir. It also drilled through volcanic formations, hard and crackly, and needed sometimes heavy cementations. Only at top 2 meters, the well had high gamma-ray radiation. Results of these deep well drilling were rearranged into "Well Log" together with all γ -ray and partially resistivity logging results. These are attached in Appendix F-1. Groundwater depth and Air pressure measured by AWLR are shown in Appendix F-3.

(b) Groundwater level measurement

Table 4-3-2.2 Depth of Groundwater Table (manual)

Well No.	Elevation (m)	2015				2016	
		4-Sep	8-Sep	22-Sep	12-Oct	3-Mar	15-Apr
W1	1288.97	83.25	83.18	83.16	83.16	82.23	83.27
W2	1275.58	81.4	80.3	79.98	79.84	80.188	80.20
W3	1322.77	129.9	130	130.30	130.735	132.95	132.95
W4	1305.97	100.2	100.2	100.10	100.065	100.515	100.54
W5	1318.15	-	-	104.04	104.01	104.39	114.40

In the all monitoring wells, an Automatic Water Level Reorder (AWLR) was installed after their completion. AWLR was set to measure the groundwater depth at every two (2) hours interval. However, the groundwater depth must be measured manually whenever the data were read up to convert the records to real groundwater depth. Table 4-3-2.2 shows the depths of groundwater tables measured manually. Results of AWLR measuring are shown later (in Figure 4-3-3.4). AWLR measures the water table through sensing water head above the pressure sensor of each AWLR, therefore, the true depth and elevation of groundwater table must be converted/compensated through the actual ground elevation and air pressure near around the site. The maximum fluctuation was, which occurred in W5, only 56.7 cm for around a half year.

(4) Review of the previous geological investigation

(a) Outline of previous geological investigation

The first systematic geological investigation under the concept of Yeghvard Reservoir was carried out from 1931 to 1932. In 1940, additional geological investigation in the planed reservoir area was conducted by the "TVIAGIDEP" Institute of ex-USSR, and the need of counter measurement for infiltration was reported. After the long remoteness, in 1979, "GiproVodStroy" conducted systematic geological and hydrogeological investigation for the Feasibility Study (F/S) on Yeghvard Reservoir. Then, in 1984, "ArmGiproVodxoz" performed again large scale systematic geological, hydrogeological, and geophysical investigation for the Detail Design Study (D/D) of the Yeghvard Reservoir (in this time the planned reservoir capacity was 228 MCM). Table 4-3-2.3 shows summary of geological investigation works carried out in the above mentioned F/S and D/D by ex-USSR. As shown in the table, nearly 7,660m of core-boring, around 600m of test-pits and trench excavation, and 340 points of VES, were conducted only for the reservoir area in D/D stage.

(b) Geological investigation results

Miocene to Pliocene, and Quaternary formations mainly consist the designed water reservoir. A general stratigraphy is shown in Table 4-3-2.4.

The Miocene is represented by Hrazdan Stratum and is composed of Clays, Marls and Sandstone occurring at the depth of 200-230m in the reservoir, representing a basement for the entire effusive rocks complex of the Late Neogene to Quaternary systems.

The bottom of the reservoir is composed by macro-porous, pulverscent loamy sand and loams with overall thickness of ranging up to 120m (layer ①, ⑥ and ⑧). These are underlain with Pliocene Alluvial soils of Gravel and Pebble-stone (layer ⑫), that are up to 150m thick. The latter cover lava formations - Basaltic Andesites of the lower cover, their Scoria diversities and Dacites.

Dam bodies shall be lied on rather firm and stable rock or on semi-hard rock layers such as Basaltic Andesite, Pyroclasic Tuff and scarified diversities of the Andesite, characterized by various rates of fracturing and relatively high water permeability.

Table 4-3-2.3

Quantities of Geological/Geophysical Investigation Works

No.	Activity	Quantity F/S	Quantity D/D	Unit
1	Geological Reconnaissance Survey (Damsite, 1:5,000. scale)	2	12	km^2
2	Geological Reconnaissance Survey (Canal, roads,and others, 1:5,000. scale)	–	45	km^2
3	Core Boring for Damsite Investigation			
	a) By "ArmGiproVodKhoz" Institute	1,152.0	4,510.4	(run) m
	b) By "ArmGIIGIS" Institute		1,443.0	(run) m
4	Core Boring for seismic micro-zoning By "ArmGiproVodKhoz" Institute	–	209.7	(run) m
5	Non-core Boring for Damsite	344.3	–	(run) m
6	Core Boring 3 (for pumping station and canal route)	–	1,150.0	(run) m
7	Test Pit Excavation (in the reservoir area)	32.2	435.8	(run) m
8	Trench Excavation (in the reservoir area)	–	135	(run) m
9	Water Filtration Test			
	a) Pouring/injection tests in boreholes	44	145	times
	b) Pouring tests in Test Pits	2	52	times
10	Lithological Logging (for boreholes)	51	290	holes
11	Geophysical Prospectings			
	a) Vertical Electrical Soundings (Reservoir area, AB=2,000m)	–	150	points
	b) Vertical Electrical Soundings (Quarry site, AB=2,250m)	–	190	points
	c) Geoelectric Borehole Loggings	–	300	(run) m
	d) Vertical Electrical Soundings (Interfluve area, AB=3,000m)	–	70	points
	e) VES Interpretations	–	410	points
12	Soil/Rock Sampling for Laboratory Test	194	123	samples

Table 4-3-2.4 General Stratigraphy of Yeghvard Dam Site

Age			No.	Mark*	Lithology	Thickness	Note
Quaternary	Holocene		①	$_{Vdp}\ Q_{IV}$	Aeolian-Diluvial-Proluvial Formation	35-40m	
			2*	$_{pa}\ Q_{IV}$	Proluvial-Alluvial Sediments	2-27m	Embank materials
			②	$_{ed}\ Q_{IV}$	Eluvial and Deluvial Sediments	1-5m	
	Pleistcene	Upper	④	$\beta\, Q_{III}$	Volcanogenic Formations	5-25m, 30m	
		Middle	⑤	$\beta\, Q_{II}$	Volcanogenic Formations	10-50m	
			⑥-⑧	$_{lap-ap-lap}\ Q_{I-II}$	Alluvial-Proluvial-Lacustrine Sediments	110-120m***	
		Lower	⑨	$\beta\, Q_{I}$	Lithoidal Pumices	10m	
			⑩	$\beta\, Q_{I}$	Volcanogenic Pyroclastic Tuffs	<10m	no-outcrop**
Tertiary	Pliocene		⑪	$\beta\, N_2$	Volcanogenic Scoria Formation	100-150m	
			⑫	$\alpha\, N_2$	Pliocene Alluvial Sediments	40-150m	no-outcrop
			⑬	$\alpha+\beta\, N_2$	Olivine Basaltic Andesite	50-160m	
			⑮	$\alpha\, N_2$	Hornblend-Hyperthene Andesite	50-160m	no-outcrop
			⑰	$\alpha\, N_1$	Pliocene Dacites	100-300m	
	Miocene		⑱	N_1	Sarmation Sediments (Hrazdan Suite)	300-350m	no-outcrop

(c) Hydrogeological conditions

Hydro-geologically, groundwater within the reservoir area were drilled by three boreholes in the central part of the reservoir, at the depths ranging from 80.0 to 120.5m. In addition, Borehole T-56 located in the central part of the reservoir drilled a local horizon of "perched groundwater" at the depth of 25.1m, which indicates the presence of a limited lens-like confining bed. It formed as a result of infiltration from the Arzni-Shamiran canal and from irrigation waters.

The main direction of the underground water flow is to the southwest, toward the Kasakh River canyon. The underground water is fresh, with TDS of 0.21 - 0.54 g/lit, belonging to HCO3-Mg-Ca type and does not have aggressive properties with respect to concrete.

The lack of permanent natural water flow in the area of reservoir, presence of rather highly water-permeable soils on its banks and bottom parts, big depth of groundwater occurrence and the features of wide stretching design of reservoir determine special conditions of filtration in case it is filled with water.

(d) Permeability and infiltration analysis

The Soviet survey revealed that the permeability of each geological formation were very high, as listed Table 4-3-2.5. As shown in the Table, permeability coefficients of the formations are varying from 10^{-2} cm/sec order to 10^{-5} cm/sec order but mostly in 1 x 10^{-3} cm/sec order, rather permeable. Furthermore, the layers having high permeability (sand and gravel/pebble) lay in the northern part of the reservoir area, and in surrounding slop zone, other highly pervious volcanic formations are distributed.

Table 4-3-2.5 Permeability Coefficients of Major Formation

No.	Formations	Permeability Coefficient (cm/s)
1	Recent Loamy sand, loam (vdpQ_{IV})	1.97 x 10^{-4}
2	Sand and gravel/pebble (paQ_{IV})	5.03 x 10^{-3}
3	Recent Eluvial, Deluvial formation ($_{ed}Q_{IV}$)	1.63 x 10^{-3}
4	Late Quaternary Tuffs (β Q_{III})	4.68 x 10^{-3}
5	Middle Qua. Andecite lava (β Q_{II})	8.04 x 10^{-3}
6	Early Qua. Lap-ap-lap Q_{IV}	1.16 x 10^{-5}
7	Early Qua. Alluvial/proluvial sediments	3.08 x 10^{-3}
8	Late Pliocene, volcanic rocks	3.24 x 10^{-4}
9	Middle Pliocene,Pumices ($_{\beta}Q_{I}$)	1.57 x 10^{-2}
10	Andecite/Scoria ($_{\beta}N_2$)	9.83 x 10^{-3}
11	Andecite layer (N_1)	2.83 x 10^{-3}

Based on the calculations of losses by infiltration from the central part of the reservoir, bounded by a vast zone with filtration without confinement and, with the need for unconditional reliable counter-filtration measures, comprises 311 MCM/year over an area of 391.5 ha; this emphasizes that the use of reliable counter-filtration measures also in the central part, hence, over the entire water reservoir, is inevitable.

4-3-3 Geological/Hydrogeological Conditions of Dam Site

Based on the results of every investigation works explained so far, in the above sections, geological conditions on the dam site shall be explained here, in accordance with the geological stratigraphy. A permeability and hydrogeological circumstance of the reservoir area shall also be explained coincidentally. Then, the permeability of the ground and groundwater condition are considered to furnish those data to the field of seepage flow analysis.

(1) Revised geological stratigraphy

Through their F/S (1979) and D/D (1985) Studies, USSR geologists formulated a standard stratigraphy of Yeghvard Reservoir area. The stratigraphy started from Holocene and traced back to Miocene. This was explained already in the previous section 4-3-2 (4) and shown as Table 4-3-2.3. The Survey Team also followed to this stratigraphy as a general but modified their naming and interpretations for some parts, based on the field reconnaissance and newly obtained geological information.

Major modifications were as follows. Lowest Pliocene Gravel formation (old series ⑫) was changed to Pyroclastic flow consisting the base of Volcanic Breccia (series ⑪) and merged into Volcanic Breccia (series new ⓫), then, Lower Quaternary sediments series (series ⑦ to ⑧) are combined into new series ❼. Holocene Proluvial-alluvial sediments (series ②) is renamed as Moraine deposit (new series ❸), and Eluvial-diluvial sediments of the same age is renamed from Gravel to as Surface Gravels (series ②). Thus, a comparison table on the old and new stratigraphy of the study area is summarized as Table 4-3-3.1.

Table 4-3-3.1 General Stratigraphy of Yeghvard Dam Site

Age			Genetic Classification	Symbol	No.	Main Facies	New No.	Main Facies
Quaternary	Holocene		Aeolian–Diluvial–Proluvial Formation	${}_{Vdp}Q_{IV}$	①~1a	Sandy Loam and Loam	①	Sandy Loam and Loam
			Eluvial and Deluvial Sediments	${}_{ed}Q_{IV}$	2^a	Gravel	②	Surface Gravel
			Proluvial–Alluvial Sediments	${}_{pa}Q_{IV}$	②	Gravel	❸	Moraine Deposits
	Pleistcene	Upper	Volcanogenic Formations	${}_{\beta}Q_{III}$	④	Welded Tuff	④	Welded Tuff
		Middle	Volcanogenic Formations	${}_{\beta}Q_{II}$	⑤	Lava	⑤	Lava (North bank)
		Lower middle	Lacustrine–alluvial–proluvial Sediments	${}_{lap}Q_{I-II}$	⑥	Loamy Sand and Loam	⑥	Loamy Sand and Loam
		Lower	Alluvial–proluvial Sediments	${}_{ap}Q_{I}$	⑦–7^a	Sand – Loamy Sand	❼	Sandy Loam to Loamy Sand
			Lacustrine–alluvial–proluvial Sediments	${}_{lap}Q_{I}$	⑧	Loamy Sand and Loam		
			Volcanogenic Formations	${}_{\beta}Q$	⑨	Lithoidal Pumices	⑨	Lithoidal Pumices
			Volcanogenic Formations	${}_{\beta}Q_{I}$	⑩	Welded Tuff	⑩	Welded Tuff
Tertiary	Pliocene		Volcanogenic Formations	${}_{\alpha}N_{II}$	⑪	Volcanic Breccia (Scoria)	⓫	Volcanic Breccia (Scoria)
			Alluvia deposits		⑫	Gravel		Pyroclasic flow deposits
			Volcanogenic Scoria Formation	${}_{\alpha+\beta}N_{II}$	⑬	Lava	⑬	Lava (South bank)
			Volcanogenic Formations		⑭	Volcanic Breccia	⑭	Volcanic Breccia
			Volcanogenic Formations	${}_{\alpha}N_{II}$	⑮	Lava	⑮	Lava
	Mio–cene		Volcanogenic Formations	${}_{\alpha}N_{I}$	⑰	Dacites	⑰	Dacites
			Sarmation Sediments (Hrazdan Suite)		⑱	Sandstone, Clay, Marls	⑱	Sandstone, Clay, Marls

(2) General geology of the dam site

Based on the geological stratigraphy, explained above, general geology of the dam-site shall be described;

Practical geologic basement of the Yeghvard Reservoir area is a sedimentary rock formation belonging to Miocene, usually called as "Hrazdan Suite," which is consisted of Sandstones, Clays and Marls (series ⑱ in the Table 4-3-3.1). The Suite forms impervious basement in this area, hydro-geologically. Upper surface of the Miocene sediments near around the reservoir area inclined from east to west, and the maximum inclination of the basement is located just near the dam site. On a significant scale, the surface of Miocene was dissected and heavily covered by many volcanic formations emerged from the Aragats and Alairer Volcanos in mainly Pleistocene age.

Volcanic activities of these volcanos were quite heavy throughout the Pliocene and continued to the almost end of the Pleistocene in the Quaternary age. The oldest volcanic formation in this area is Dacites (series ⑰) in late Miocene, covering the Miocene sediments (Hrazdan Suite) but dissected strongly so as merely cropping out on some gentle hill tops.

Covering the oldest Dacites, several volcanogenic formations together with a few sedimentary formations, were accumulated in the high land between Kasakh and Hrazdan rivers in early Pliocene. At first, amphibole Andesite (⑮ series) filled after the Dacites lava, emerging in the Kasakh canyon. A little later than the amphibole andesite lava, andesite-basalt slags (pyroclastic flow (⑭ series) covered them. Then, Olivine-basaltic Andesites in middle Pliocene (series ⑬) emerged in large scale and formed the framework of southern and western banks of dam site. Then, covering the olivine-basaltic andesite lava, Andesites slags including volcanic breccia, scoria, pumices, and volcanic sand, accompanied with basal pyroclastic flow deposits (⓫ series).

In the early Quaternary (lower Pleistocene), volcanic activities were still continued and some volcanogenic formations, such as Welded Tuff (⑩ series) and Welded (or Lithoidal) Pumices (⑨ series) were formed. However, these formations were not so developed and not cropped out widely.

After this, there was a rather long rest of volcanic activities, and in this period, a thick alluvial, diluvial and proluvial deposits accumulated thickly, filling up the deep valley dissected on the andesite lava (⑥ and ❼ series). Those are mainly sandy loam but at lower portion of ⑥ series, there was almost impermeable clay layer, which can be evaluated as an aquitard (⑥low series). The base of these layers (❼ series) is mostly sandy to gravelly sediments with rather high permeability. Covering these Pleistocene alluvium to diluvium, more younger Olivine-basaltic Andesites in middle Quaternary (series ⑤) flowed down as lavas formed the main body of the northern bank of reservoir area. And, directly covering the Andesite lava, characteristic brick red color Scoria (or Welded Tuffs) is distributing (series ④). Notably, the tuffs show quite high gamma-ray radiation. The formation changes its facies from hard rock to rather soft scoria, and pyroclastic flow deposits looking like sand-and-gravels.

The low-land of planned reservoir was an enormous dissected valley in lower Quaternary and buried several volcanogenic and alluvial deposits through upper Pleistocene to Holocene. At the end of Pleistocene, huge volume of moraine deposits were left in northwest bank of the reservoir area (series ❸). The deposits were consisted of huge basalt blocks, boulders, cobles, pebble, sand and gravels, without selection. They were diverted as dam body materials during the ex-USSR time. Moraine deposits are now covered by recent eluvial and diluvial sediments (series ② or ① sometime) thinly, but it is rather difficult to distinguish in the site.

Recent Aeolian diluvial-proluvial formations (series ①) covers almost all of the central portion of the reservoir area, represented by gray Sandy Loam with comparatively impervious property. Thin sand or clay layers are intercalated everywhere. Thickness of the formation is said from 35 to 40m in the central portion, however, the total thickness of relatively impervious layers including Lower to Lower-middle Pleistocene Lacustrine-alluvial deposits (series ⑥) shall be beyond 120m in the central portion.

(3) Geological map and cross-section/profiles

In accordance with such modifications, and referenced to the information obtained through newly drilled boreholes, a geological map of the reservoir area was revised Based on the revised geological map, and results of two terms of geological investigations, as well as monitoring well drilling, geological cross sections and profiles were drawn up to understand the general geology of the area and a distribution of relatively impervious formations in the planned reservoir.

A cut-down sized geological map as shown in Figure 4-3-3.1. A typical cross-section is shown as Figure 4-3-3.1, and the other sections and profiles are attached as Annex F-2. As results, Holocene Loamy soils (series ①), Lower middle Pleistocene alluvial sediments (series ⑥), and Lower

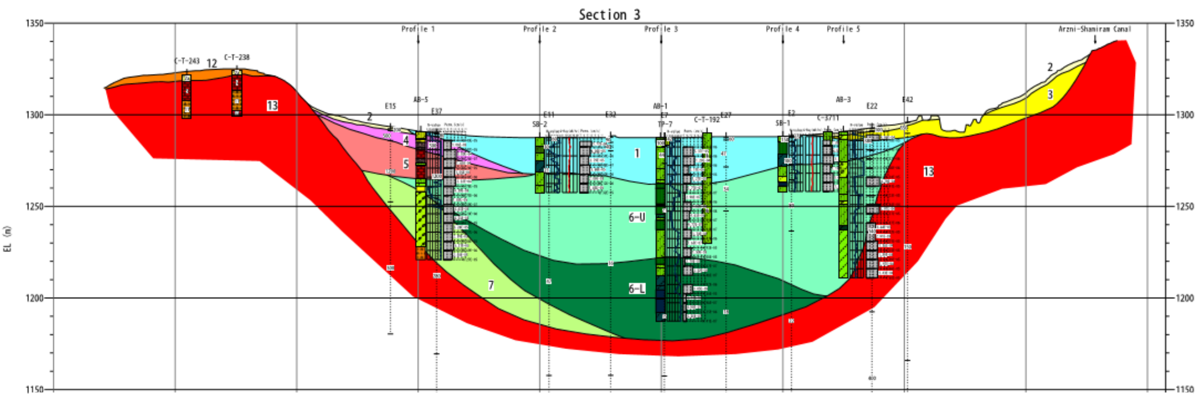


Figure 4-3-3.1 Typical Cross Section

Pleistocene sediments (❼), were deposited very thickly in the central portion of the reservoir area with more than 120m depth in maximum. Among them, a permeability on ①and ⑥ layers were rather low and seemed to be almost impervious layer. Such comparatively impervious formations were abruptly reduced its thickness at near around the peripheral zones in various directions. The situations are almost same with the Soviet Report, however, the bottom of the impervious layer was more clearly confirmed by this new investigation.

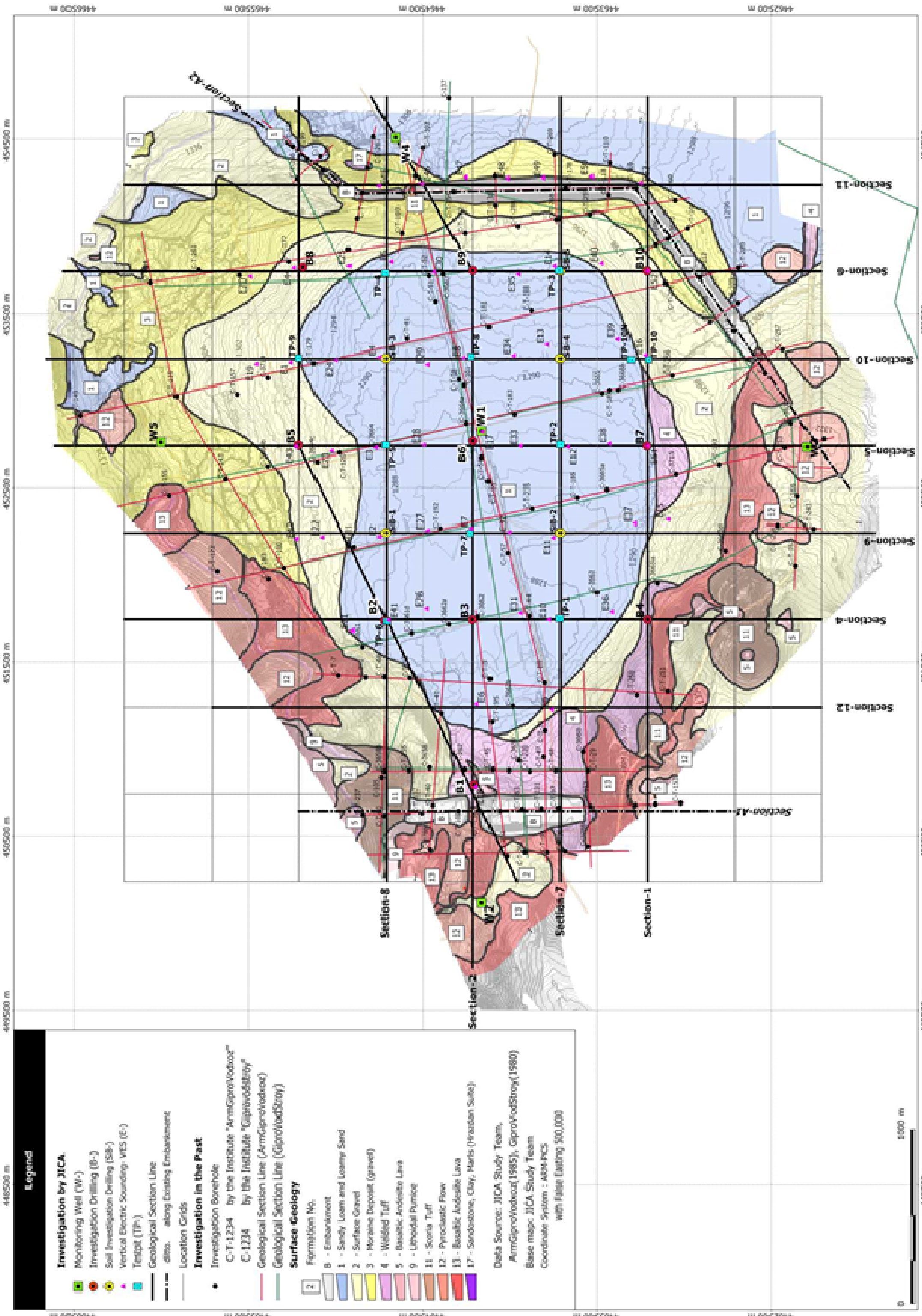


Figure 4-3-3.2 Geological Map & Locations of Cross-section/Profiles

(4) Permeability and its anisotropy of reservoir basin

In and around the planned Yeghvard Reservoir, three major categories of geological facies are distributing: 1) volcanogenic formations forming mainly slopes surrounding the depression, 2) moraine deposits distributing north-western corner of the reservoir area, and 3) relatively impervious Loamy Sediments distributing in the main part of the depression. However, both moraine deposits and Loamy sediments are underlain by volcanogenic formations at several depths. In accordance with the previous USSR Study, all of volcanogenic formation, Proluvial-Alluvial Sediments (Gravels; ②), and moraine deposits (❸) had quite high permeability. On the other hand, permeability of Loamy formation (such as ①) showed rather low permeability. However, the permeability tests conducted by USSR Team were so-called packer method: injecting water in the test span through a packer under high pressure. This method is very popular in Japan also but the permeability obtained through this way is horizontal permeability. Although they did not distinguished an anisotropic of permeability, the Survey Team made a special attention to the anisotropic permeability of the relatively impervious formation, because seepage of dam water shall happen into vertical direction, not horizontal.

Anisotropy of permeability in sedimentary formation was well known in Japan. In this study, we made two papers as main references: 1) "Proposed method for field measurement of horizontal and vertical permeability of soil," and 2) "Some Studies on the Analyses of In-situ Permeability Tests", both by Professors M. Nishigaki and I. Khono, (1984).

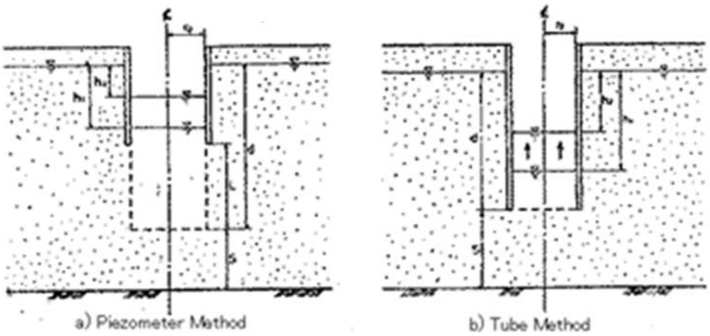


Figure 4-3-3.3 Geometory of Permeability Tests

They suggested there mainly are two methods to evaluate the permeability in the test hole, one is so-called a "piezometer method" and another is a "tube method" which is a special case of piezometer method (refer to Figure 4-3-3.3). They said the piezometer method indicates mainly horizontal permeability (abbrev. as HP) and the tube method showed vertical permeability (abbrev. as VP) mainly. In the actual investigation work, we made both permeability tests, a horizontal permeability test (HPT) by packer method (refer to Figure 4-3-2.10), in the previous section) and a vertical permeability test (VPT) by tube method (refer to Figure 4-3-2.11). In the tube method test, two kinds of water injection were tries; one was constant head method to keep water head steady, and the other was falling head method to follow the water heads in time. To evaluate the vertical permeability in tube method, in the falling head method, the following formula was adopted (by Schmid, 1967, original):

$$k = \frac{r0}{4(t2 - t1)} * \ln\left(\frac{h1}{h2}\right)$$

Where r0: radius of the hole (cm)

t1, t2: measuring times (sec)

h1, h2: water heads from the bottom(cm).

In the case of constant head method, following formula was adopted;

$$k = qL/\pi r^2 h$$

Where *r:* radius of the hole (cm)

q: water volume injected in unit time (cm^3/sec)

L: Length of the test span (1 cm in this case))

h; constant water head from the bottom (cm).

Table 4-3-3.2 Summary of Permeability Tests (Unit: cm/sec)

No.	Dep .(m)	AB-1			AB-2			AB-3			AB-4			AB-5			AB-6		
		Lith*	VPT**	HPT***	Lith	VPT	HPT	Lith	VPT	HPT	Lith	VPT	HPT	Lith	VPT	HPT	Lith	VPT	HPT
1	5	①	1.46E-06	S.O	①	9.24E-06	1.81E-03	②	1.18E-05	4.06E-04	②-❸	2.04E-05	9.79E-04	①-②	3.40E-05	S.O	④	1.90E-05	4.97E-04
2	10	①	4.86E-06	5.37E-05	①	1.10E-06	1.15E-04	①	5.14E-06	S.O	❸	7.33E-07	1.01E-03	④	1.47E-05	1.06E-05	④	1.58E-05	1.12E-05
3	15	①	3.29E-06	1.29E-04	①	4.51E-06	8.83E-05	①	3.37E-06	S.O	❸	7.46E-05	8.67E-04	⑤	4.27E-07	3.00E-04	④⑤	2.49E-05	1.03E-04
4	20	①	2.87E-05	3.11E-06	①	1.23E-05	5.95E-05	①-⑥	5.08E-06	S.O	⑥	1.56E-06	6.72E-04	⑤	2.26E-05	1.65E-04	⑤⑥	6.99E-05	1.92E-04
5	25	①	1.01E-05	1.27E-05	①	7.16E-06	2.11E-04	⑥	3.24E-05	S.O	⑥	5.16E-07	S.O	⑤	1.49E-06	1.05E-04	⑥	5.61E-05	9.42E-03
6	30	⑥u	3.05E-07	7.77E-07	①	5.79E-06	1.06E-04	⑥	4.41E-05	4.79E-04	⑥	1.67E-04	S.O	⑥	1.78E-05	2.32E-04	⑥	4.57E-05	1.08E-04
7	35	⑥u	8.34E-06	2.98E-07	①⑥u	1.82E-06	1.97E-04	⑥	2.23E-05	S.O	⑥	1.61E-07	4.59E-04	⑥	2.73E-06	4.30E-05	⑥	2.93E-06	1.10E-04
8	40	⑥u	6.50E-08	1.52E-05	⑥u	2.40E-06	3.04E-05	⑥	7.87E-04	S.O	⑥	1.60E-07	S.O	⑥	1.59E-07	1.83E-05	⑥❼	1.53E-05	1.27E-04
9	45	⑥u	2.99E-07	4.63E-06	⑥u	2.11E-05	2.83E-04	⑥	1.17E-05	3.97E-04	⑥	2.83E-06	1.13E-05	⑥	1.20E-06	4.63E-05	❼	3.56E-05	1.02E-04
10	50	⑥u	9.94E-07	9.77E-07	⑥u	1.63E-05	2.83E-04	⑥	2.57E-06	S.O	❼	5.09E-07	3.99E-04	❼	1.15E-05	4.53E-05	❼	6.15E-06	7.09E-05
11	55	⑥u	8.47E-06	1.70E-05	⑥u	8.25E-06	2.92E-04	⑥	2.32E-05	3.64E-05	❼	1.08E-05	5.44E-04	❼	6.07E-06	3.28E-05	❼	1.48E-05	3.68E-05
12	60	⑥u	4.93E-05	7.65E-07	⑥u	8.33E-05	1.88E-05	⑥	2.01E-05	2.91E-05	⑬	5.31E-07	N.D	❼	1.86E-05	2.59E-05	❼	1.26E-05	5.00E-05
13	65	⑥u	1.08E-05	1.50E-05	⑥u	1.60E-05	2.14E-04	⑥	4.03E-05	1.38E-04				❼⑫	5.69E-06	5.21E-05	❼	6.92E-06	6.23E-05
14	70	⑥u	3.67E-07	2.70E-07	⑥u	5.69E-06	2.43E-04	⑥	3.39E-05	1.29E-04				⑬	1.27E-05	2.50E-05	❼	2.56E-06	1.25E-05
15	75	⑥l	1.48E-07	3.32E-05	⑥❼	N.D	S.O	⑥	1.66E-05	1.97E-04						Lith*	: Lithology (Layer No.)		
16	80	⑥l	1.92E-06	S.O	❼	N.D	S.O	⑥	1.60E-05	1.43E-04						VPT**	: Vertical Permeability		
17	85	⑥l	1.36E-05	3.05E-05	❼	N.D	S.O									HPT***	: Horizontal Permeability		
18	90	⑥l	9.88E-07	6.11E-07	❼	N.D	S.O												
19	95	⑥l	1.25E-06	4.90E-07	❼	N.D	S.O												
20	100	⑥l	9.41E-07	5.50E-07	❼	N.D	S.O												

	Initial Investigation			Additional Investigation			All (Geomean) Average		
Lith	NOS	VPT	HPT	NOS	VPT	HPT	No.	VPT	HPT
①	32	9.86E-06	4.39E-05	13	5.32E-06	7.83E-05	45	8.25E-06	5.19E-05
②	1	1.10E-04	-	2	1.18E-05	4.06E-04	3	2.48E-05	4.06E-04
❸	4	1.85E-04	4.80E-04	2	7.40E-06	9.36E-04	4	6.32E-05	5.99E-04
④	10	2.09E-05	3.25E-04	2	4.62E-06	3.89E-05	12	1.63E-05	2.28E-04
⑤	1	3.74E-06	4.90E-04	4	1.62E-06	1.73E-04	5	1.92E-06	2.13E-04
⑥	15	1.38E-05	2.53E-05	42	4.67E-06	2.52E-05	57	6.21E-06	2.52E-05
❼	3	9.23E-04	-	11	7.64E-06	6.38E-05	14	2.13E-05	6.38E-05
⑪	0	-	-	6	9.09E-06	1.76E-04	6	9.09E-06	1.76E-04
⑬	15	7.21E-06	1.97E-04	2	2.60E-06	2.50E-05	3	6.39E-06	1.17E-04

Results of all permeability tests were summarized as Table 4-3-3.2. The anisotropic of permeability was quite clearly detected, mostly the VP were lower than the HP around one third to more than one order. Of course there were some exceptions that VP was higher than HP, mainly in volcanogenic formations and moraine deposits. These can be easily considered through the cause or origin of the formations.

As shown in the above Table 4-3-3.2, HP of moraine deposits (❸), young volcanogenic formations (④,⑤), and surface gravels (②) were rather high. Sand and Gravel of moraine showed high 6.0 x 10^{-4} cm/sec order, and young Tuff and Lava showed 2.1 - 2.3 x 10^{-4} cm/sec. These values are almost same with the test results made by USSR Team. However, VP of relatively impervious formations such as Holocene Sandy Loam (①) or Lower middle Pleistocene Sediments (⑥) indicated low VP: the former showed 8.3 x 10^{-6} cm/sec and the later showed 6.2 x 10^{-6} cm/sec in an average, less than 1/4 of HP. Especially, the lower clay in ⑥ layer (called as ⑥low) showed very low VP as 1.28 x 10^{-6} cm/sec in an average. The minimum VP of 1.48 x 10^{-7} cm/sec was observed in the formation ⑥low in AB-1 Borehole. VP of volcanic formations are not so much meaningful because of the test method (water injection through only φ114mm of casing pipe), however, the fact that VP of these volcanic rocks were very low even in an average value suggests the volcanogenic formations underlain impervious soil formation (or pervious Sand and Gravel) may have rather low permeability. At least, they shall not have such very high permeability of 4.7 x10^{-3} - 1.6 x 10^{-2} cm/sec of VP as they introduced in the previous D/D Study Report.

(5) Monitoring wells and groundwater condition

As alrady descrived before, in the category of geological/hydrogeological investigation, five (5) monitoring wells were drilled in and surrounding the reservoir area. In the all monitoring wells, an Automatic Water Level Reorder (AWLR) was installed after their completion. AWLR was set to measure the groundwater depth every two (2) hours. It can measure and record groundwater level for 5 years without changing the battery. AWLR measures the water head above the pressure sensor together with an air-pressure, therefore, the depth of groundwater table must be compensated by air pressure near by the wells. Results of AWLR measuring are shown in Figure 4-3-3.4. These wells shown in the

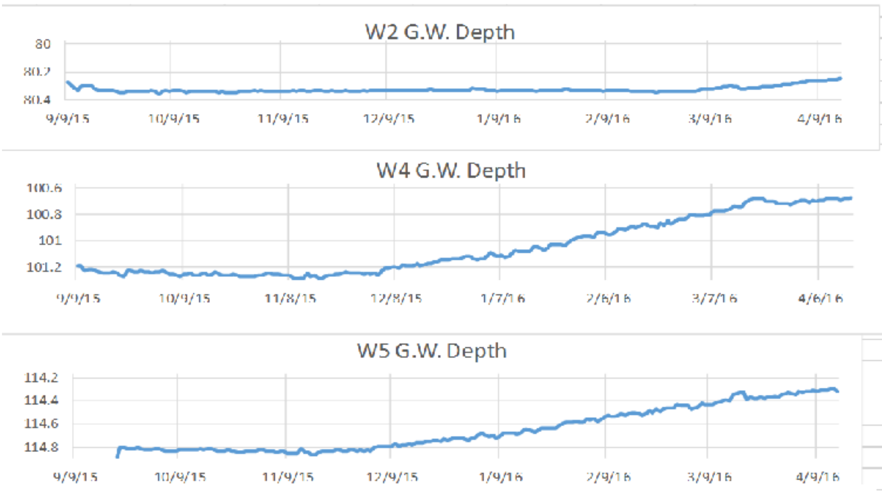


Figure 4-3-3.4 Groundwater Measurement by AWLR

figure were showing the heaviest groundwater movement among the five wells. However, the maximum fluctuation was only 56.7cm (in W5) for around a half year. Small fluctuations in each hydrograph are daily tidal fluctuations, and a long span movements of groundwater level, in W4 and W5, are large scale areal groundwater movements, and partly getting an influence of leaking water flow through the Arzuni-Shamiram canal.

Based on the results of monitoring well drilling, groundwater table near around the Yeghvard Reservoir area is illustrated as Figure 4-3-3.5. As shown in the Figure, groundwater table is almost flat but slightly tilted from north to south and east to west. Groundwater movement near the dam-site is, as shown in the contour map, flowing from north to south as a total, however, the maximum inclination is less than 14m for around 4km of distance. The results was almost consistent with the results of previous large scale Geo-electric Sounding (by ex-USSR), that total groundwater movement in the Yeghvard Highland is from NE to SW direction.

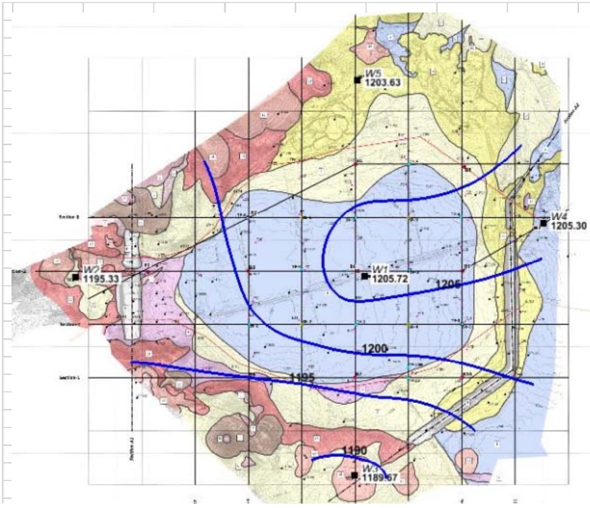


Figure 4-3-3.5
Groundwater Contour Map Of Yeghvard Basin

Figure 4-3-3.6 shows a wide range hydrogeological cross section of Yeghvard Basin, crossing the reservoir area from the opposite bank of the Kasakh to also the opposite side of the Hrazdan River. As shown in these figures, the groundwater table in and around the reservoir area is very flat, and very deep. The figures, together with the groundwater hydrograph, indicates that a) groundwater table in the reservoir area is very deep (more than 80m), b) permeability of the Yeghvard highland in between Kasakh and Hrazdan rivers are very high as a total, and 3) rainfall and snowmelt in the reservoir area gave almost no influence to the groundwater table.

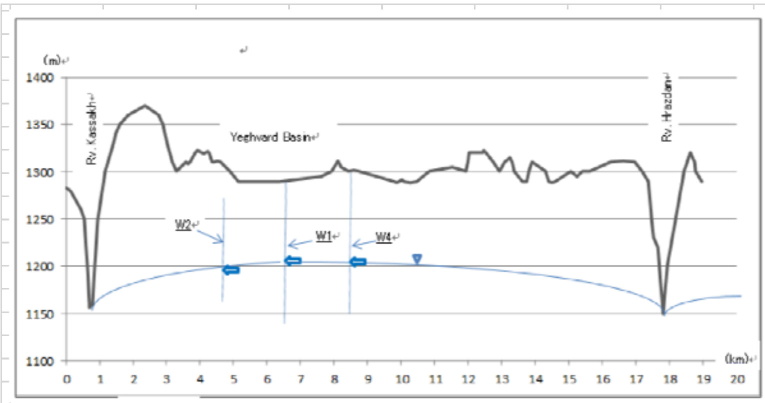


Figure 4-3-3.6 Hydrogeological Cross Section of Yeghvard

4-3-4 Investigation on Dam Body Materials and Laboratory Soil Test

(1) Investigation on impervious materials

(a) Outline of the survey

The ground of the reservoir area is widely covered by the thick soil layer so called "loamy sand or sandy loam" which was investigated and planned as the impervious materials for the dam body in the ex-USSR era. The excavation of ten test-pits were planned this time in the reservoir area and also the drilling of 10 hand-augers, defined as the spare borrow area, outside of the reservoir. The location map of the survey points is shown in Figure 4-3-4.1. In these test-pits, the field permeability tests by the pit method and by the cylinder method were carried out to grasp the differential between the horizontal permeability coefficient and the vertical one. The former, for the horizontal permeability, was the test done in the excavated pit where seepage through the pit wall is predominant; the latter, for the vertical permeability, was done to the soil column sculptured in the ground where seepage was forced to occur from the top of the column to its foot.

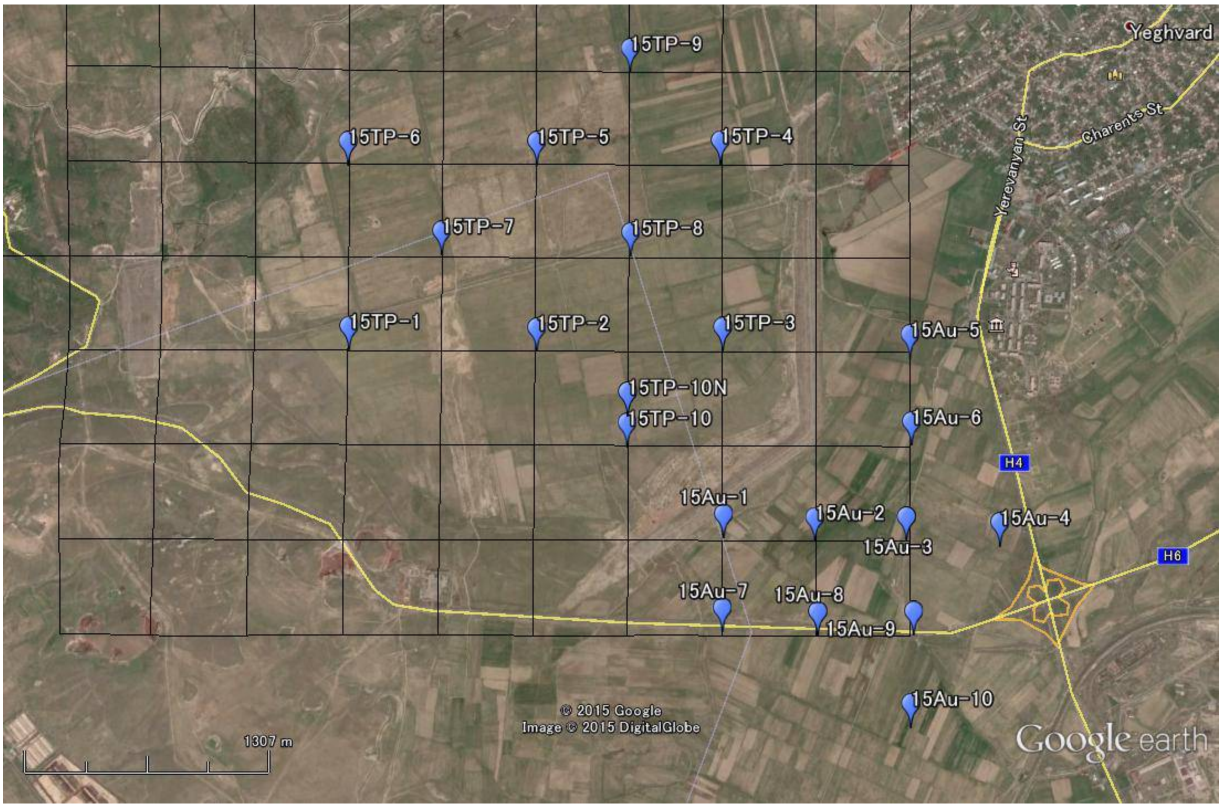


Figure 4-3-4.1 Location Map of Survey Points

(b) Typical features in the test-pit excavation

Test Pit ; 15TP-5

Depth (m)	Color	Classification etc.	Moisture content	Cohesion
	greyey black	top soil		
0.5	yellowish blown	silt	low	a little
		(SM)		
1.0				
1.5	black	coarse/volcanic sand		
2.0		sand-and-gravel	dry	
2.5				
3.0	yellowish blown	silty sand	low	almost non
3.5				
4.0				

Figure 4-3-4.2 Typical Test Pit Log and the Profile Photos

(c) Findings

1) The thickness of top soil ranges from 0.5m to 1.0m approximately, and the latter case is predominant. It takes on greyish black which comes from organic material.
2) Soil layer of silty sand with scarce cohesion to sandy silt with cohesion a little, which would be classified into SM in the unified soil classification system, is predominant in the soil so called "loamy sand or sandy loam".
3) Sometimes a thin sand-and-gravel layer or volcanic sand layer with the thickness of 0.5m to 1.0m is sandwiched; the continuity of them seems to be poor.
4) The soil layer of volcanic sandy silt/clay, which seems to be called "loam" in the ex-USSR investigation and of which characteristics is its light unit weight, appeared on rare occasions.
5) Any sedimentation formation could not be seen clearly in the soil layer. A soil clod with macro-porous vacant holes which suggested the eolian sediment formation was found only one time, and the alternation of thin deposits which suggested the aqueous sediment formation was found also only one time.
6) The soils on the test-pit wall were dried up except for the test-pit excavated in well-cultivated area or excavated in a vacant lot of borrow pit where the ground level was about 4 m below the ground surface around.
7) The location of test-pit 15TP-10 was shifted toward north by 100m approximately because of the rock formation appearing at the depth of 0.5m in excavation. This rock formation seems to be lava layer, which would be cracky so that considerations shall be requested in the reservoir planning.
8) The permeability coefficients by the pit method, the values of 10^{-3} cm/sec class, are larger apparently by 2 to 5 times than the ones, the values of 10^{-4} cm/sec class, by the cylinder method.
9) The same kind of soil layer was confirmed by the auger-drillings in the spare borrow area.

(2) In-situ falling test of sand-and-gravel

(a) Outline of the survey

Granular materials ranging from boulders/rocks to sand/soil such as sand-and-gravels or blasted weathered rocks segregate in granularity through being fallen down along a cliff slope; and there are deposits of sand-and-gravels on the northern slope outside of the reservoir that were used as the construction materials of existing dam bodies; and there exist cliffs as a vacant lot of quarry site. On the other hand, filter materials and rock/riprap materials are needed for the dam body materials of the zoned fill-type dam. Based on such circumstances and conditions, this in-situ falling test of sand-an-gravels was carried out in a manner of sand-and-gravels excavated from the vacant lot of quarry site being fallen down along the cliff left in the vacant lot. The location map of the survey point is shown in the Figure 4-3-4.3.

Figure 4-3-4.3 Location Map of the In-situ Falling Test

(b) Existing conditions of the sand-and-gravel

The sand-and-gravels exist as layers about 30 to 50 cm thick sandwiched by silty sand layers. Voids among gravels are filled completely by half-consolidated sand to silt, so that the sand-and-gravel layer can keep the overhang condition (refer to Figure 4-3-4.4).

Figure 4-3-4.4 Profile of the Sand-and-Gravel Layer

(c) Findings

1) Due to the alternate structure between the sand-and-gravel layers and silty sand layers, the prepared materials for testing were not uniform in gradational conditions. The first materials fallen were silty sands; next were sand-and-gravels. The sand-and-gravels did not roll down on the slope and not segregated because of the interruption of silty sands (refer to Figure 4-3-4.5).
2) While relatively uniform sand-and-gravels kept rolling down; and the segregation proceeded shown in Figure 4-3-4.6 and 4-3-4.7.

Figure 4-3-4.5 Conditions of Sand-and-Gravel

Figure 4-3-4.6 Mounded Sand-and-Gravels after Excavation

Figure 4-3-4.7 Segregation through Falling

3) Large size of cobbles suitable for the rip-rap materials with the grain size of 40 cm or so were few.
4) The materials to be fallen down should be uniform as the mixture of sand-and-gravel and silty sand excavated at the same time. A mass of silty sand interfere the segregation of sand-and-gravel.

(3) Test-pit excavation survey of sand-and-gravel

(a) Outline of the survey

According to the achievement of geological investigations done in the ex-USSR era, the area with the deposits of sand-and-gravel extends widely on the hills north side to the reservoir; and there extend widely the vacant lots of quarry site from where the dam body materials of existing dams were excavated. To obtain more information about these sand-and-gravels, 3 test-pits were excavated and samples for the sieving test were taken out. The locations of these test-pits are as shown in Figure 4-3-4.8.

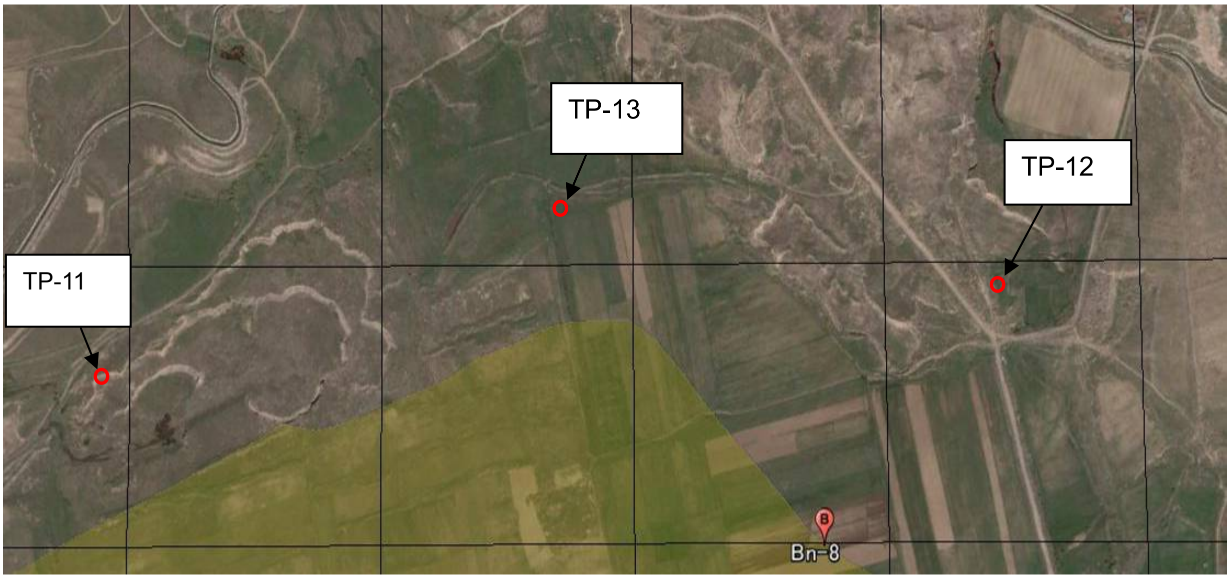


Figure 4-3-4.8 Location Map of Test-pits

(b) Conditions and findings

1) Area with the predominance of volcanic sand:

From the point excavated as TP-11 in the original plan, since thick layers of volcanic sand appeared with a thin sand-and-gravel layer at the top, sampling was canceled. The area which was classified to have the sand-and-gravel layer in the existing geological plane map must be carefully treated. The existing degree of sand-and-gravel differs much even if classified as the sand-and-gravel zone (This area is revised to be “Basaltic andesite lava” zone in the new geological plane map.) as shown in Figure 4-3-4.9 and 4-3-4.10

Figure 4-3-4.9 Test-pit Excavated into Volcanic Sand

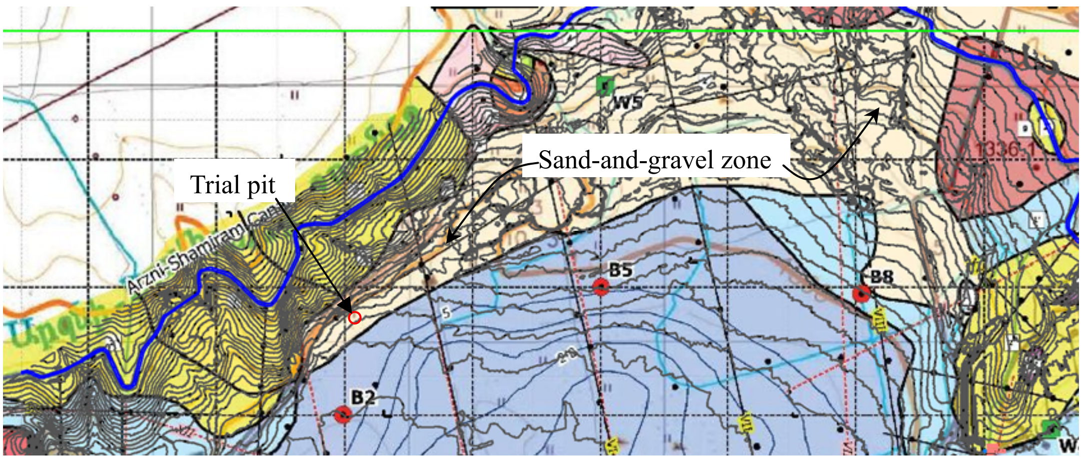


Figure 4-3.4.10 Sand-and-Gravel Zone and the Location of the Trial Test-pit

2) TP-11; Half-consolidated sand-and-gravel layer:

Under the naming of TP-11 to the cliff left in the old quarry site of sand-and-gravel, sampling was done out of the materials scraped down from the cliff surface. The sand-and-gravel layer was composed of cobbles to gravels and the silty sand and was half-consolidated totally as shown in Figure 4-3-4.11.

Figure 4-3-4.11
Half-consolidated sand-and-gravel

3) TP-12, TP-13; Sand-and-gravel layer rich with silty sand:

The layer was rich with silty sand. The maximum gravel size was 15 cm approximately as shown in Figure 4-3-4.12.

TP-12

TP-13

Figure 4-3-4.12 Sand-and-gravel with Rich Silty Sand

(4) Scoria with a possibility to be utilized as the filter material

There are reddish brown high cliffs along the regional road, H6 line, on the hill south side to the reservoir from where Scoria has been being mined for the use of pumice blocks to the fine portion and heat insulating layer of the building roof to the coarse portion. This scoria layer is estimated geologically to exist under the uppermost lava layer and extend widely with about 20 meter of the layer thickness. To examine the possibility of utilizing this scoria as the filter material, sampling was done in the mining site. The layer's feature and the locations of scoria cliffs around the reservoir are as shown in Figure 4-3-4.13 to 4-3-4.15.

Figure 4-3-4.13 Outcrop of Scoria

Figure 4-3-4.14 Mining Site of Scoria

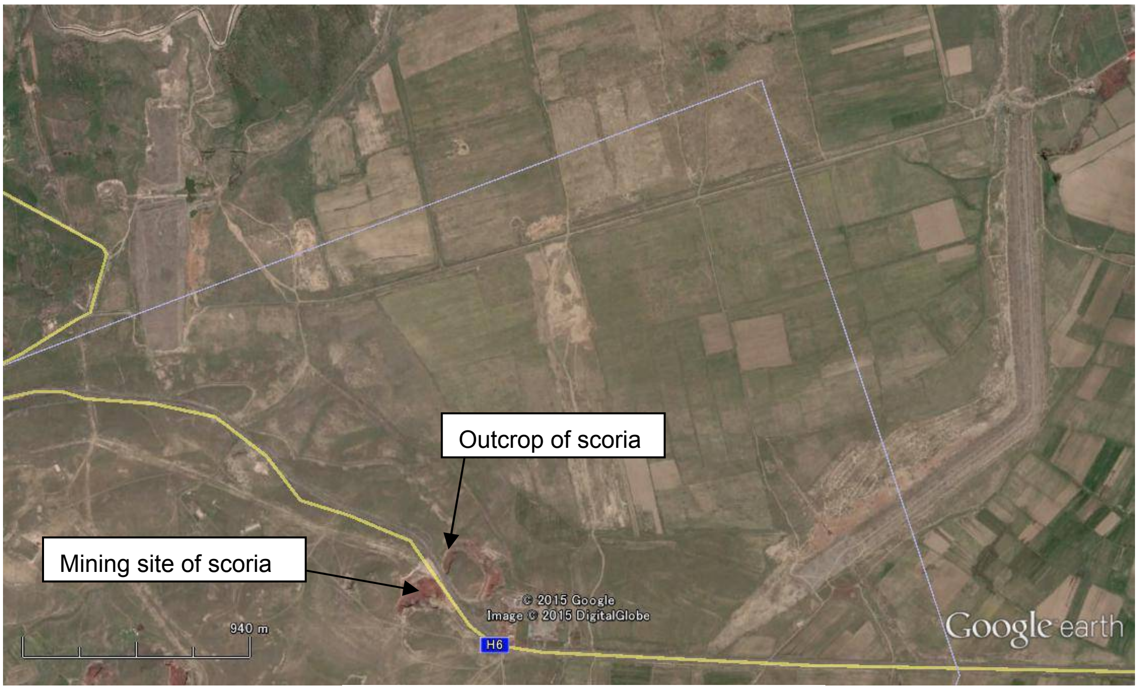


Figure 4-3-4.15 Location Map of Scoria Site

(5) Pit excavation survey on the slopes

(a) Purpose of the survey

The surveys and soil tests done in 2015 were the ones to the sandy loam or loamy sand lying thick in the reservoir basin area. On the other hand, the study result at the ITR was that constructing the suitable scale dikes at along the foot of the north and the south slopes became more economical than extending the anti-infiltration works with slope protection works wide and long on the gentle slopes of both the north and the south sides. This interim study result might change according to the cost of the anti-infiltration work, which would be decided through the additional soil tests to the bentonite-soil mixture and the soil-cement, but it is necessary to grasp the cover layers conditions as the dike materials to conduct the further study in terms of the reservoir shape or the way how to provide the reservoir with anti-infiltration works. Based on such recognition, the pit excavation surveys were conducted mainly on the slopes of both sides. The surveys are composed of three (3) phases.

Phase-1; Pit excavations ranging from TP.21 to TP.47 were done on the north and the south slopes or terraces in the reservoir to grasp the cover layers conditions.

Phase-2; Pit and trench excavations ranging from TP.48 to TP.55 were carried out on the south slope of the reservoir to observe the condition of the welded tuff stratum. The most impotent problem is how to design the anti-infiltration works against the back pressure caused by the ground water or seepage water and then how to provide the slope surface behind the anti-infiltration work with the drainage system; but if the welded tuff stratum is impervious, there is no way to release the water gathered by the drainage system. To this matter, the quantity of water that might be brought by the snow melting or heavy rain is related much. This survey was conducted in late February, which was the snow melting season, and the condition of welded tuff stratum, snow melting condition on the south slope of the reservoir and the seepage condition of melted water on to the welded tuff surface were observed.

Phase-3; Pit excavations ranging from TP.56 to TP.71 were done on the slopes and the terraces of the north side of the reservoir to grasp the lying conditions of sand-and-gravel as its too much disposal left in the old quarry site made the engineer unconfident in the available quantity of sand-and-gravel for the future construction works.

(b) Findings

[Phase-1 survey]

1) From the upstream area of Dam No.1 to the northern slope composed of low hills, the geological formation of the ground surface is made of welded tuff. On the reservoir basin, the surface is fresh; on the slope, weathered materials lie. (TP.21 - TP.23)

2) Along the foot of the north slope of the reservoir, the road made of sand-and-gravel is provided as the temporary work for construction. (TP.24, TP.26, TP.29, TP.30)

3) The north side slope to this road has the rock formation in case of the ground having no trees (TP.25, TP.28), a thick soil layer in case of the fruit farm existing (TP.27) and sand-and-gravel deposits or gravelly soil layers in other case even though the ground surface is full of lava rocks (TP.30, TP.31).

4) On the low terraces at the north-eastern corner of the reservoir, the sand-and-gravel layer appears at the depth of 2m to 3m (TP.32 - TP.38).

5) The low hill in front of Dam No.2 is covered with “Surface Gravel” geologically of which content is made of soil and gravel mixture originated from lava and welded tuff (TP.39).

6) The ground surface of the south slope of the reservoir is covered with “Surface Gravel” geologically of which content is made of soil and gravel mixture with the layer’s thickness to be 2m to 3m, where gravels are predominant usually except the area cultivated as the farmland. Gravels are originated mainly from welded tuff (TP.40 - TP.47).

7) As the conclusion to say, it is possible to construct the pervious embankment anywhere at the foot of the slope or on the slope by gathering gravelly soils from its surrounding area.

[Phase-2 survey]

1) From the bottom of all the pits or trenches excavated, welded tuff stratum appeared at the depth of 0.5m to 3m.

2) Any seams or cracks were not found on the surface of the welded tuff stratum, so that the welded tuff stratum supposed to be impervious due to the massive and consolidated condition in spite of the composition of sandy particles.

3) The top soil layer 0.3m thick seemed to be wet; the lower layer of “Surface Gravel” was dry and dusty in spit of the snow melting had already started (date of survey; 22/2/2016).

[Phase-3 survey]

1) On the low terraces at the north-eastern corner of the reservoir, the sand-and-gravel layer appears at the depth of 2m to 3m (TP.56 - TP.61).

2) On the slopes north side of the temporary road, the fundamental geological formation is composed of the base layer of pyroclastic flow or lava and the its coverage layer of moraine deposit, so that the existence of sand-and-gravel, i.e. moraine deposit, seems to be unstable (TP.62 - TP.68).

3) At TP.67, the excavated material was wet and damp due to high moisture content condition and the water seeping out on to the bottom of the pit was observed. The water was supposed to be originated from the snow melted water gathered to the swamp below the water-way bridge of the

Arzni-Shamiram canal. This fact must be emphasized to the design of anti-infiltration work.

4) From beneath the ground left in the old quarry site, a layer of pyroclastic flow, a thick sand layer and a volcanic sand layer appeared. It would be supposed to be difficult to obtain sand-and-gravel from the old quarry site area.

5) As the conclusion to say, the area extending from the gentle slope to the low terrace between the eastern and the western old quarry sites are preferable as the new quarry site for sand-and-gravel than the hilly area extending north side to the old quarry sites.

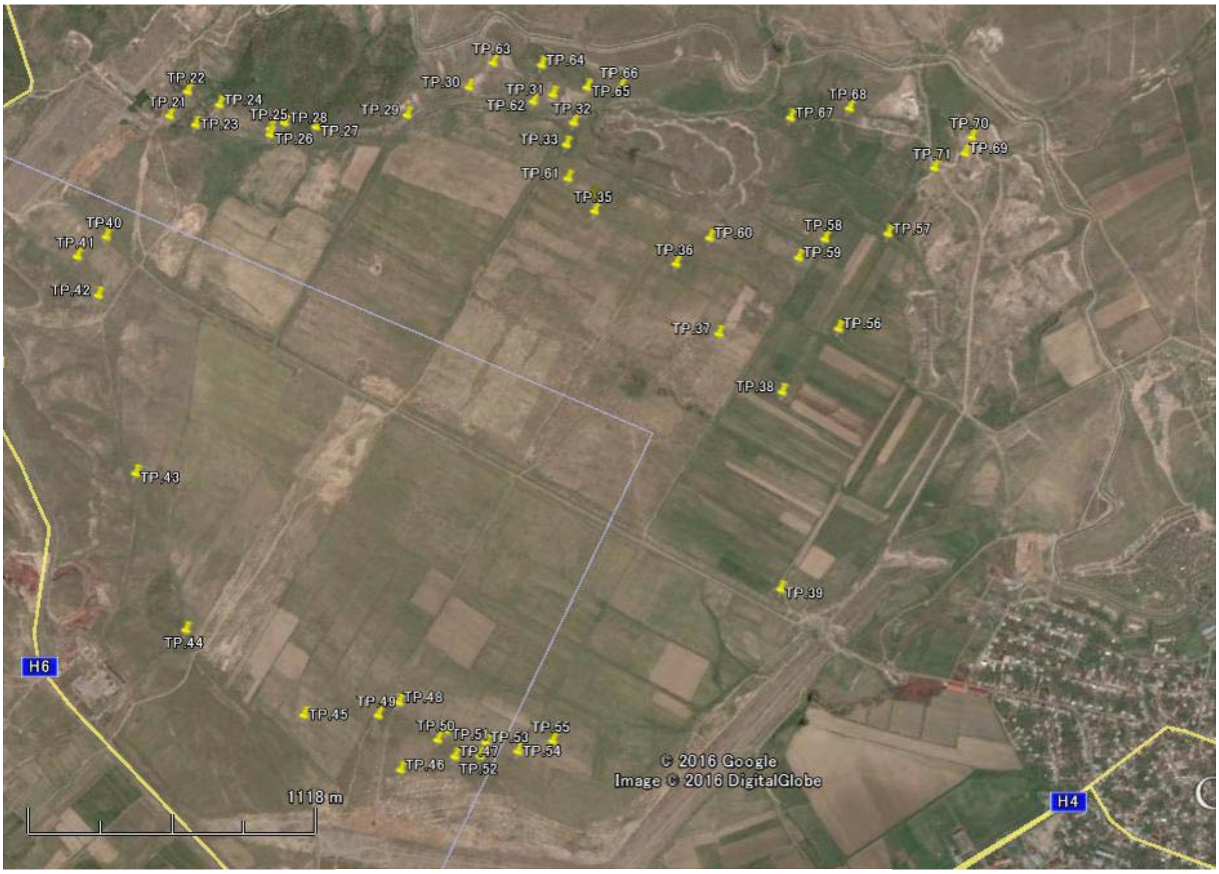


Figure 4-3-4.16 Location Map of the Pit Excavation

Welded tuff in front of Dam No.1 (TP.21)

Surface gravel on the foot slope of north hill (TP.24)

Basaltic Andesite lava on the north slope (TP.28)

Sand-and-gravel composing the construction road lying along the foot of the north slope (TP.29)

Sand-and-gravel on the northern low terrace (TP.33)

Surface gravel on the south-eastern end of the reservoir (TP.40)

Surface gravel on the south slope (TP.44)

Welded tuff on the south slope (TP.48)

Figure 4-3-4.17 Representative Profiles of the Excavated Material

4-3-5 Laboratory Soil Test

(1) Outline

Two (2) series of laboratory soil tests were conducted in this preparatory survey stage. One was to the disturbed soil samples of sandy loam and sand-and-gravel obtained from the test-pits excavated in the reservoir bottom and surrounding area, of which locations are shown in Figure 4-3.4.1 and Figure 4-3.4.8, under the purpose of grasping the characteristics of impervious materials and sand-and-gravels and examining the possibility of the soil's imperviousness being improved by adding and mixing bentonite or cement. The other was the ones conducted additionally to study the details about the imperviousness improvement by mixing sandy loam or sand-and-gravel with bentonite or cement. The former one shall be called "laboratory test phase-1" in this report and the latter "laboratory test phase-2".

(2) Laboratory test phase-1

(a) Tests to impervious materials (sandy loam)

1) Physical soil test and standard compaction test

The test results are summarized on the Table 4-3-5.1.

Table 4-3-5.1 Summary of Physical Soil Tests and Standard Compaction Test to Sandy Loam

	Specific Gravity ρs (g/cm3)	Moisture Content Wn (%)	Atterberg Limit (%)			Grain Size Distribution (%)				Standard Compaction	
			Liquid Limit WL	Plastic Limit Wp	Plastic Index Ip	Gravel 2~75mm	Sand 0.075~ 2mm	Silt 0.005~0.075mm	Clay <0.005 mm	Maximum Dry Density (g/cm3)	Optimum Moisture Content (%)
15TP-1u	2.64	13.11	22.5	17.1	5.4	0.9	34.9	31.2	33.0	1.60	21.2
15TP-1d	2.59	19.50	28.5	24.5	4.0	0.0	17.4	40.5	42.1	1.53	26.0
15TP-2u	2.58	16.48	33.9	23.9	10.0	0.2	7.7	32.8	59.3	1.56	23.0
15TP-2d	2.55	17.83	28.6	25.3	3.3	0.1	34.0	46.1	19.8	1.45	26.3
15TP-3u	2.57	15.15	30.0	20.2	9.8	0.6	44.3	19.5	35.6	1.60	22.2
15TP-3d	2.66	8.97	-	-	-	1.0	47.8	38.8	12.4	1.70	16.5
15TP-4u	2.57	22.56	-	-	-	6.2	29.8	39.0	25.0	1.60	20.8
15TP-4d	2.55	28.73	-	-	-	0.6	30.2	45.6	23.6	1.41	24.8
15TP-5u	2.63	12.30	21.9	17.5	4.4	4.5	31.5	41.9	22.1	1.71	17.6
15TP-5d	2.67	8.01	-	-	-	6.6	44.9	35.8	12.7	1.66	19.2
15TP-6u	2.64	8.51	20.1	16.8	3.3	2.2	28.4	47.7	21.8	1.73	16.4
15TP-6d	2.60	14.63	-	-	-	7.0	43.9	31.5	17.5	1.81	13.0
15TP-7u	2.58	25.20	30.2	27.6	2.6	0.3	21.9	45.1	32.7	1.42	22.7
15TP-7d	2.49	25.56	34.1	29.5	4.6	1.3	9.5	45.3	43.9	1.45	25.5
15TP-8u	2.59	19.12	38.5	22.2	16.3	0.0	3.4	39.2	57.4	1.49	24.0
15TP-8d	2.64	13.38	24.5	20.5	4.0	0.5	13.1	44.6	41.8	1.65	18.7
15TP-9u	2.60	10.28	25.0	20.0	5.0	0.5	13.6	53.5	32.4	1.64	20.5
15TP-10u	2.53	8.08	23.8	20.0	3.8	17.4	36.1	21.9	24.5	1.66	18.2
15TP-10d	2.52	12.37	-	-	-	1.6	39.8	42.7	15.9	1.44	23.6

[Moisture content]

The moisture contents range from 8.01 % to 28.73%. Samples taken from the upper wall, u-group, indicate comparatively the lower moisture content percentage than the ones taken from the lower wall, d-group.

Most of the soils have the field moisture content lower than the optimum moisture content by 5% to 12% except for the some exceptional ones with the field moisture content higher than the optimum moisture content by 1% to 2%, so that to conduct the compaction work to the soils with optimum moisture content condition, a large amount of water shall be needed.

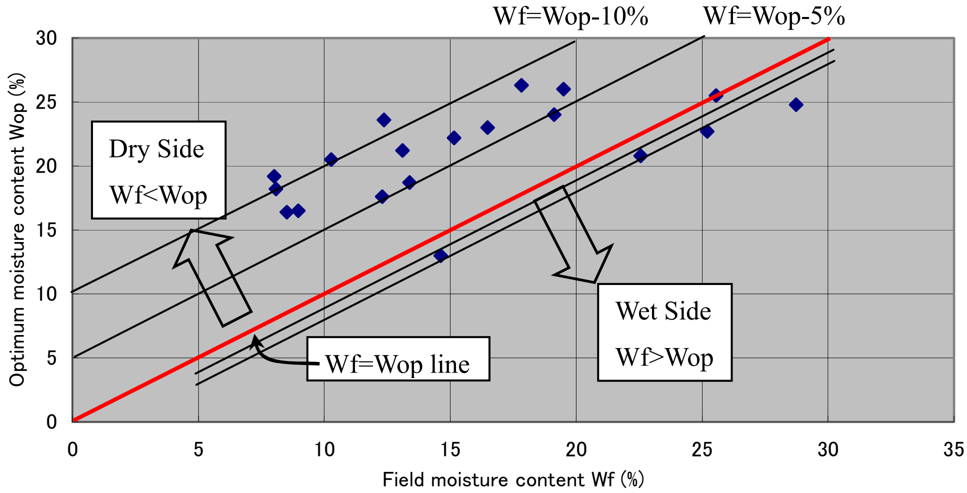


Figure 4-3-5.1 Relationship between Field Moisture Content and Optimum Moisture Content

[Specific gravity]

The specific gravities range from 2.49 to 2.67. Considering the value of common soil to be around 2.60 to 2.75, the low values of specific gravity around 2.49 or so would be related to its origin, i.e. volcanic ash. An obscure positive-relativity exists between the specific gravity and the maximum dry density in the standard compaction test according to Figure 4-3-5.2.

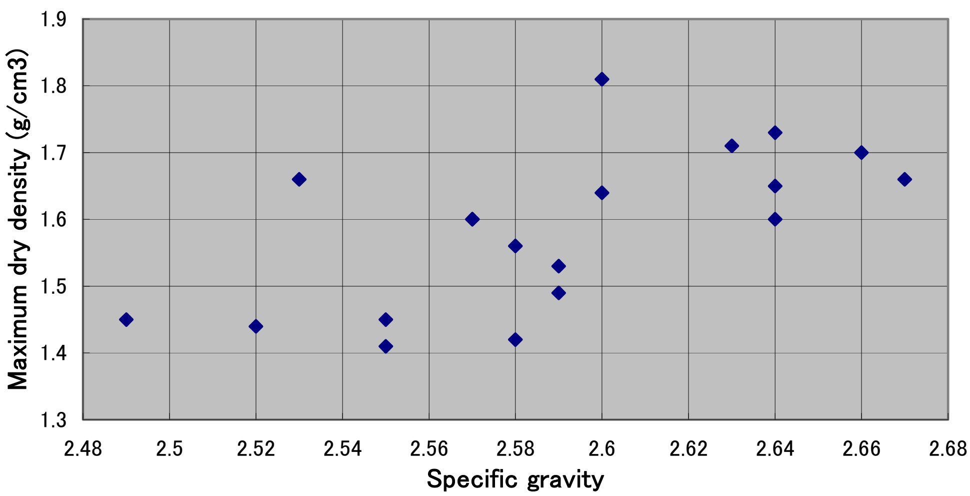


Figure 4-3-5.2 Relationship between Specific Gravity and Maximum Dry Density

[Grain size distribution test]

The results of the grain size distribution test are shown below. Most of the samples contain fine particles more than 50%, but it ranges wide from 50% to 95%.

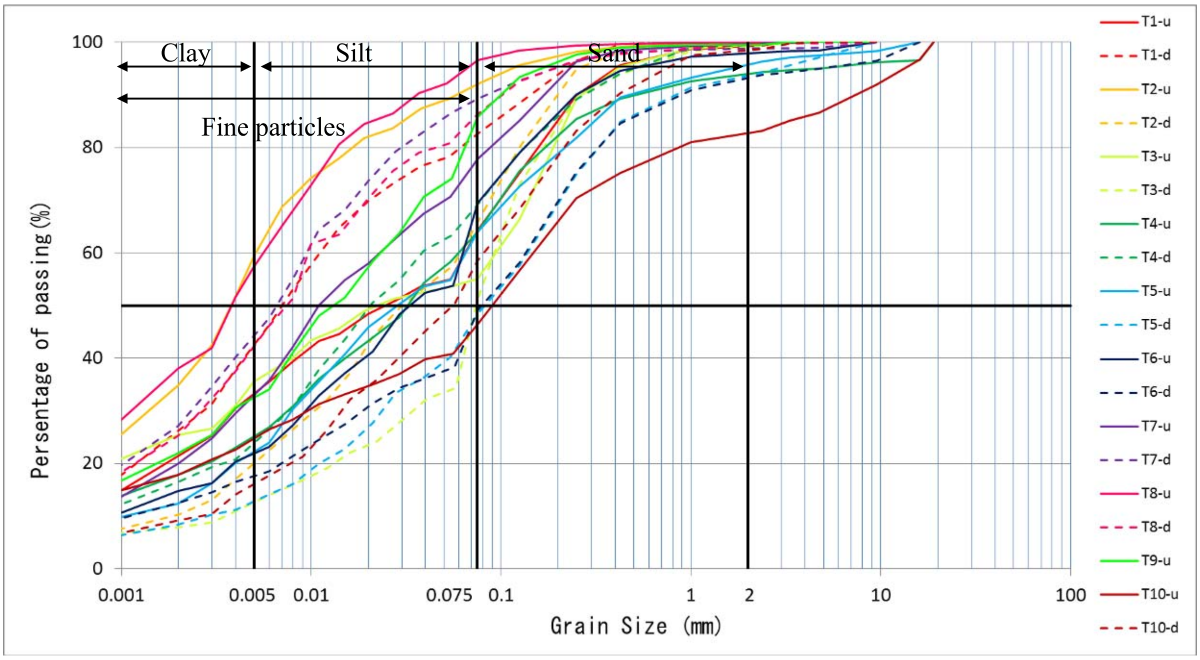


Figure 4-3-5.3 Grain Size Distribution Curve of Sandy Loam

[Atterberg limit test]

The values of liquid limit range from 20.1% to 38.5%; Plastic limit From 16.8% to 25.3%. Field moisture contents are situated lower than the plastic limits so that these soils are considered to be in "Semi solid" condition in the field. Therefore, water must be added when being used as the embankment materials; but careful work shall be required at that time because the small PI values ranging from 3.3 to 16.3 shall lead the soils into liquid condition under excessive water being added. The relationship between Atterberg limits and field moisture contents is shown in Figure 4-3-5.4.

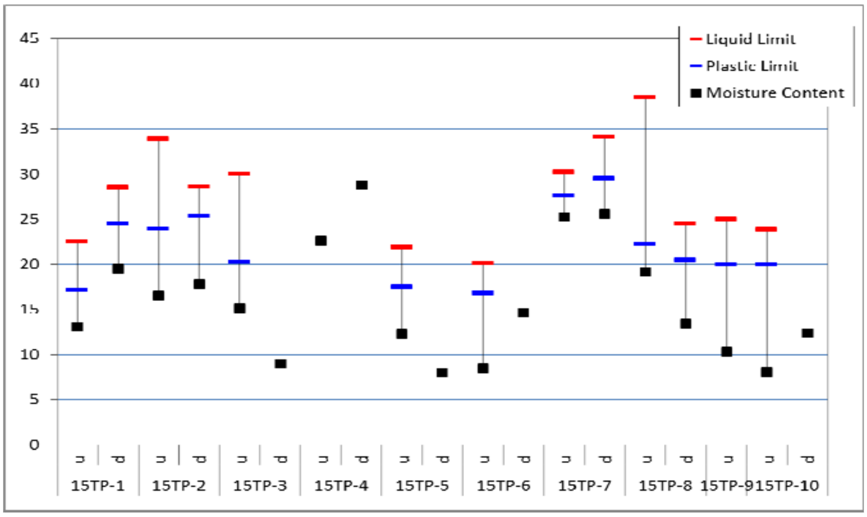


Figure 4-3-5.4 Relationship between Atterberg Limits and Field Moisture Contents

[Standard compaction test]

The compaction curves obtained as the results of the test are shown in Figure 4-3-5.5. The coarser soils with a wide range of particle size generally form sharp curves and tend to indicate higher maximum dry densities and lower optimum moisture contents. On the other hand, the finer soils with a narrow range of particle size form flat curves and tend to indicate lower maximum dry densities and high optimum moisture contents.

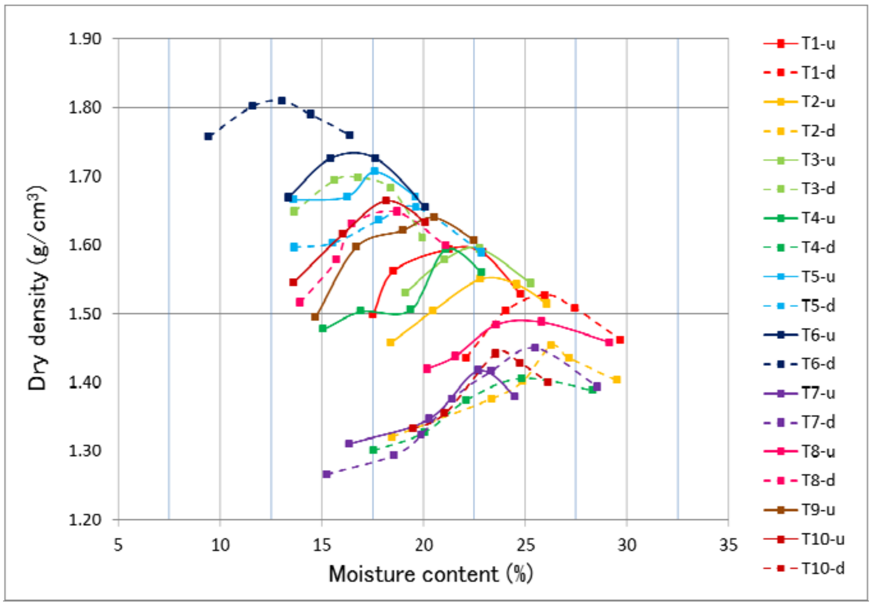


Figure 4-3-5.5 Compaction Curves of Sandy Loam

An obscure positive-relativity exists between the content percentage of sand and the maximum dry density as shown in Figure 4-3-5.6.

Sample number [u] indicates the sample to be taken from the upper wall at the depth of around 1.5 m. and Sample number [d] indicates the sample to be taken from the lower wall at the depth of around 3 m.

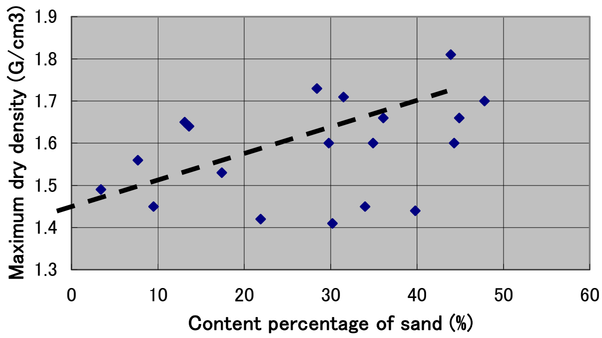


Figure 4-3-5.6 Relationship between Sand % and ρdmax

2) Mechanical soil test

The results of mechanical soil test done to the five samples are summarized as shown in Table 4-3-5.2.

Table 4-3-5.2 Summary of the Mechanical Soil Tests

Point	Sample name	Standard Compaction		Permeability			Direct shear test				Consolidation test						Triaxial test					
																			(UU)		CU-bar	
				Specimen condition		Result	Specimen condition		Result		Specimen condition		% of settlement				Specimen condition		Result		Result	
		OMC, %	ρ_{dmax}, t/m³	ρ_d, t/m³	M.C., %	K, cm/sec	ρ_d, t/m³	M.C., %	C, KN/m²	φ, °	ρ_d, t/m³	M.C., %	50 KPa	100 KPa	200 KPa	400 KPa	ρ_d, t/m³	M.C., %	C, KN/m²	φ, °	C, KN/m²	φ, °
A point	**T-1d**	26.0	1.53	1.53	26.0	**4.3 x 10^{-7}**	1.53	26.0	**12.7**	**23.3**	-	-	-	-	-	-	-	-	-	-	-	-
	T-2up	23.0	1.56	1.56	23.0	**3.2 x 10^{-7}**	1.56	23.0	**7.5**	**22.3**	-	-	-	-	-	-	-	-	-	-	-	-
	T-4d	24.8	1.41	1.41	24.8	**2.9 x 10^{-6}**	1.41	24.8	**11.9**	**23.4**	-	-	-	-	-	-	-	-	-	-	-	-
	T-5d	19.2	1.66	1.66	19.2	**2.3 x 10^{-6}**	1.66	19.2	**7.9**	**24.8**	-	-	-	-	-	-	-	-	-	-	-	-
	T-10up	18.2	1.66	1.66	18.2	**5.2 x 10^{-7}**	1.66	18.2	**23.9**	**25.5**	-	-	-	-	-	-	-	-	-	-	-	-
B point	**T-1d**	26.0	1.53	1.48	29.0	**3.5 x 10^{-7}**	1.48	29.0	**11.4**	**24.3**	1.48	29.0	**3.29**	**4.45**	**5.56**	**7.68**	1.48	29.0	**12**	**10.2**	**26**	**24.7**
	T-2up	23.0	1.56	1.51	26.0	**4.7 x 10^{-7}**	1.51	26.0	**6.5**	**21.0**	1.51	26.0	**2.22**	**3.24**	**5.09**	**7.29**	1.51	26.0	**13**	**16.7**	**34**	**23.7**
	T-4d	24.8	1.41	1.37	29.0	**2.0 x 10^{-6}**	1.37	29.0	**8.6**	**22.4**	1.37	29.0	**2.38**	**3.25**	**5.50**	**6.67**	1.37	29.0	**13**	**24.7**	**35**	**27.9**
	T-5d	19.2	1.66	1.61	22.0	**1.7 x 10^{-6}**	1.61	22.0	**7.7**	**24.8**	1.61	22.0	**2.30**	**3.16**	**4.77**	**7.29**	1.61	22.0	**3**	**17.2**	**10**	**33.8**
	T-10up	18.2	1.66	1.61	21.0	**1.9 x 10^{-6}**	1.61	21.0	**15.6**	**23.9**	1.61	21.0	**2.04**	**3.25**	**4.87**	**6.97**	1.61	21.0	**8**	**25.2**	**28**	**30.1**
C point	**T-1d**	26.0	1.53	1.40	19.0	**1.3 x 10^{-5}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-2up	23.0	1.56	1.37	17.8	**2.8 x 10^{-6}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-4d	24.8	1.41	1.33	23.0	**1.1 x 10^{-5}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-5d	19.2	1.66	1.64	15.5	**1.1 x 10^{-5}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-10up	18.2	1.66	1.54	13.5	**2.9 x 10^{-5}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[Grouping and selection of representative sample]

The samples obtained from the test-pits were grouped into five (5) groups according to the plasticity index (P.I.) and the content percentage of fine particles' portion as shown in Table 4-3-5.3 and one sample was chosen as the representative from each group.

Table 4-3-5.3 Grouping of the Samples and Selection of the Representative Sample

Group	Characteristics	Samples belonging to	Representative sample
G-1	Low P.I. Medium - Low percentage of 0.005mm content	1u, 2d, 5u, 6u, 10u	15TP -10u
G-2	Low P.I. High percentage of 0.005mm content	1d, 7u, 7d, 8d, 9u	15TP -1d
G-3	Medium P.I High-Medium percentage of 0.005mm content	2u, 3u, 8u	15TP -2u
G-4	Non Plastic Low percentage of 0.005mm content	3d, 5d, 6d	15TP -5d
G-5	Non Plastic Medium percentage of 0.005mm content	4u, 4d, 10d	15TP-4d

[Conditions of specimen to conduct the tests]

Three (3) conditions of soil specimen were defined as follows for the mechanical soil tests; and the density/mass and the moisture content of each specimen, which was made up through compaction, were adjusted to the defined value according to the compaction curve.

Point-A: Dry density condition = Maximum dry density, Moisture content condition = Optimum moisture content

Point-B: Dry density condition = Maximum dry density×0.97 (= relative density: D-97%), Moisture content condition = Moisture content corresponding to D-97% on the compaction curve in wet side

Point-C: Dry density condition = Maximum dry density×0.97 (= relative density:D-97%), Moisture content condition = Moisture content corresponding to the intersection point between the D-97% line and the saturation rate curve of 85%

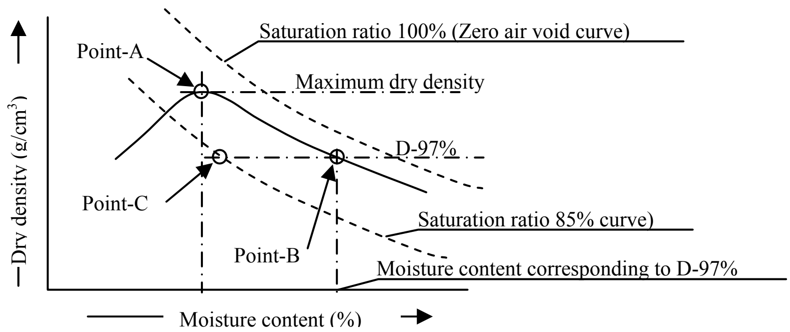


Figure 4-3-5.7 Testing Point (Specimen Conditions)

[Direct shear test]

Direct shear tests are conducted at two (2) testing points (Point-A and point-B) per one sample. In terms of shearing strength factors, the shear resistance angle (φ) ranges from 21.0° to 25.5° and cohesion (C) from 7.0 kN/m2 to 15.0 kN/m^2 approximately in Point B's case. In all of the samples, cohesion (C) at Point A tends to be higher than the one at Point B as shown in Figure 4-3-5.8

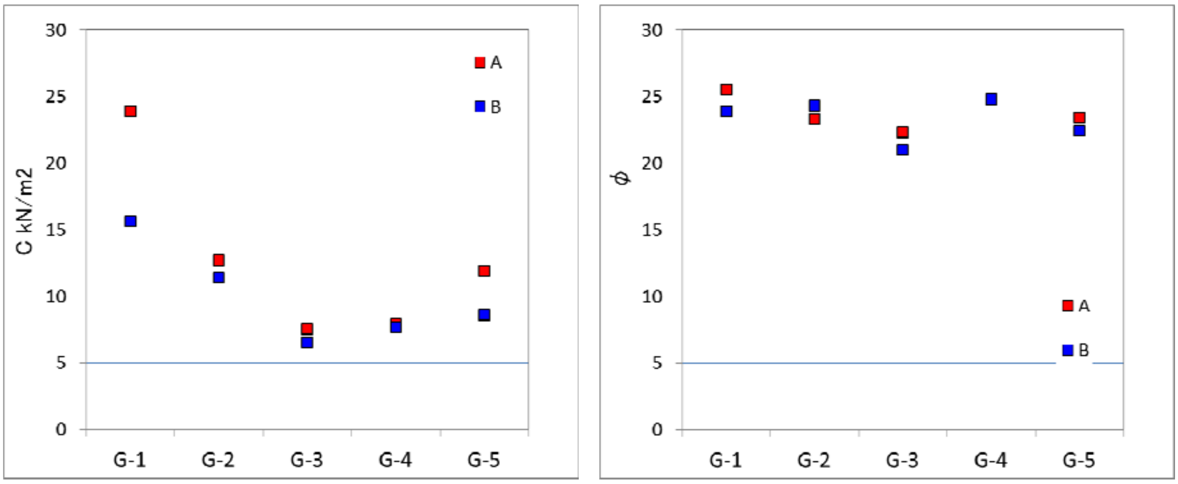


Figure 4-3-5.8 Result of Direct Shear Test

[Triaxial UU and CU-bar test]

Triaxial tests are conducted at one (1) testing point, Point-B, per one sample considering the wettest-side condition in moisture content making the specimen the weakest in shear strength comparing with other specimens with the same dry density level. The triaxial UU test is conducted to the specimen under unconsolidated and undrained condition, so that the shear strength factors obtained through this test are used for the stability analyses of dam body under unconsolidated condition, i.e. dam body just after completion. The triaxial CU-bar test is conducted to the specimen under consolidated and undrained condition, so that the shear strength factors obtained through this test are used for the stability analyses of dam body under consolidated and partially-saturated condition, i.e. the embankment under usual operation. Figure 4-3-5.9 shows the results of Triaxle UU test and CU-bar test where the shear strength factors of CU-bar test are dominantly larger than the ones of UU test.

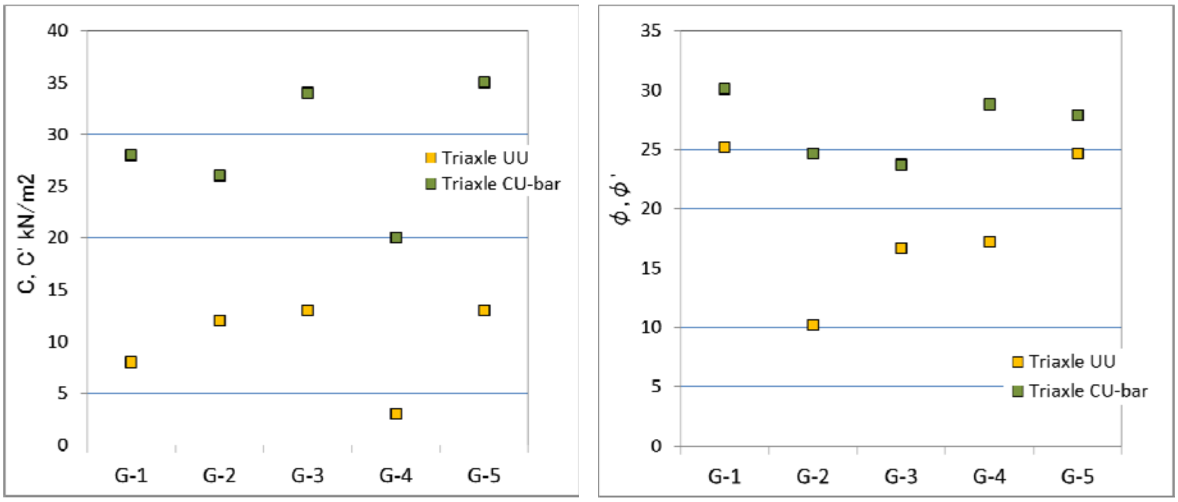


Figure 4-3-5.9 Results of Triaxial UU Test and Triaxial CU-Bar Test

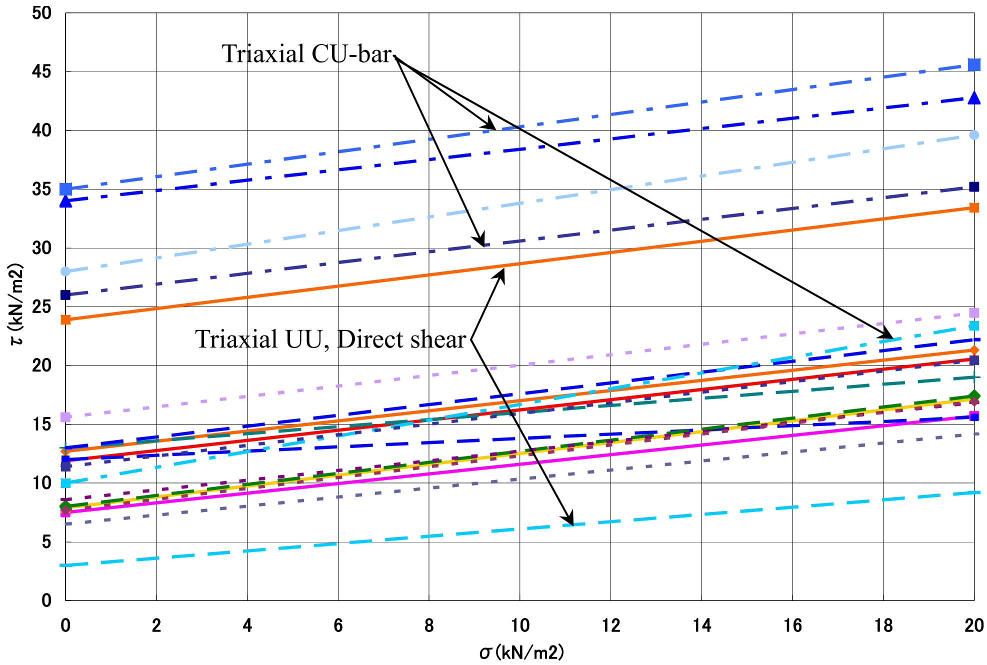


Figure 4-3-5.10 Summary of the Shearing Test Results

[Consolidation test]

Consolidation tests are conducted at one (1) testing point, Point B, per one sample considering the wettest-side condition in moisture content making the specimen's consolidation settlement maximum comparing with other specimens with other moisture content conditions and the same dry density level. In spite of the specimens having different void ratios, all specimens reach the consolidation yield stress at around 100 kPa and indicate almost the same compression index Cc as shown in Figure 4-3-5.11.

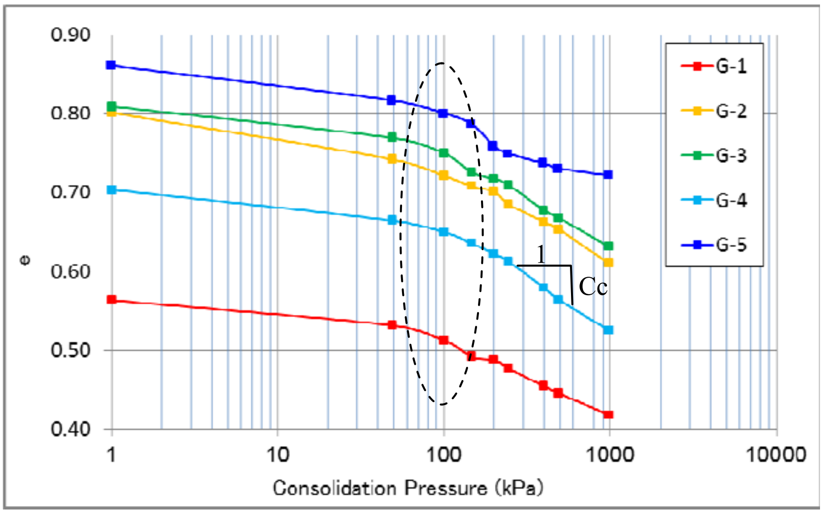


Figure 4-3-5.11 Result of the Consolidation Test

[Permeability test]

Permeability tests are conducted at three (3) testing points per one sample. The results are shown in Figure 4-3-5-12. As the impervious materials used to the core zone of the fill-type dams, the permeability coefficient required shall be in the order of 10^{-7} cm/sec or in the low level of 10^{-6} cm/sec order in the laboratory test considering the differential of permeability coefficient between in the laboratory and in the field. From this view point, the permeability coefficient values at C-point are insufficient. The compaction under high compaction energy by a heavy compactor shall be needed to prevent such circumstances from appearing.

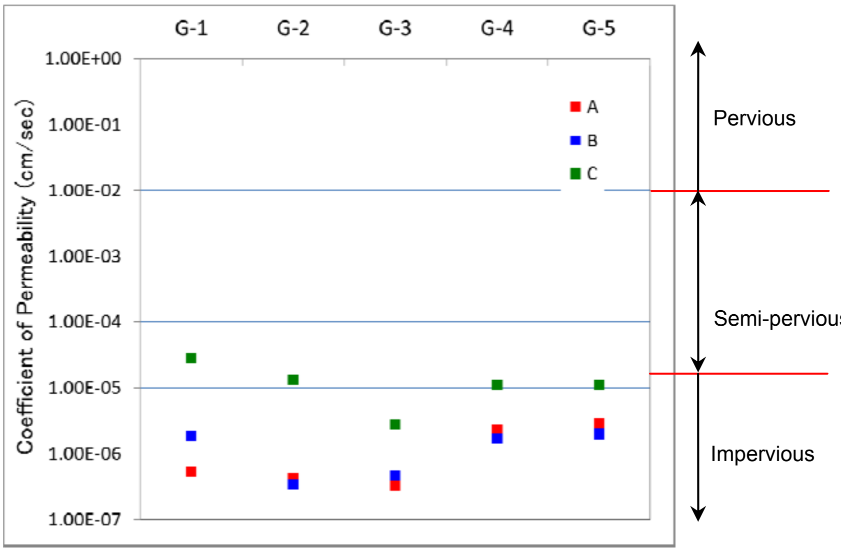


Figure 4-3-5.12 Results of the Falling Head Permeability Test

(b) Test to sand-and-gravels

In case of TP-11, the components are coarse sand, gravels and cobbles (refer to Figure 4-3-4.11). In case of TP-12 and TP-13, content percentage less or more than 10 % gives the observer the impression of fine, i.e. silt and clay, component being lower than the actual condition in the field (refer to Figure 4-3-4.12). This gap comes from the fact that the visual impression is caused by the volume ratio on one hand and the particle size distribution curve is drawn by the ratio of dry weight on the other hand. The fine portion of sand-and-gravels is composed of sandy loam which is volcanic soil and its dry weight is characteristically light. Therefore, we must be careful not to misunderstand the volume of fine portion to be merely 10 % or so based on the content percentage of the particle size distribution curve showing 10 % or so. Content percentage of 10 % of the particle size distribution curve might mean 30 % of fine portion in volume as shown in Figure 4-3-5.13.

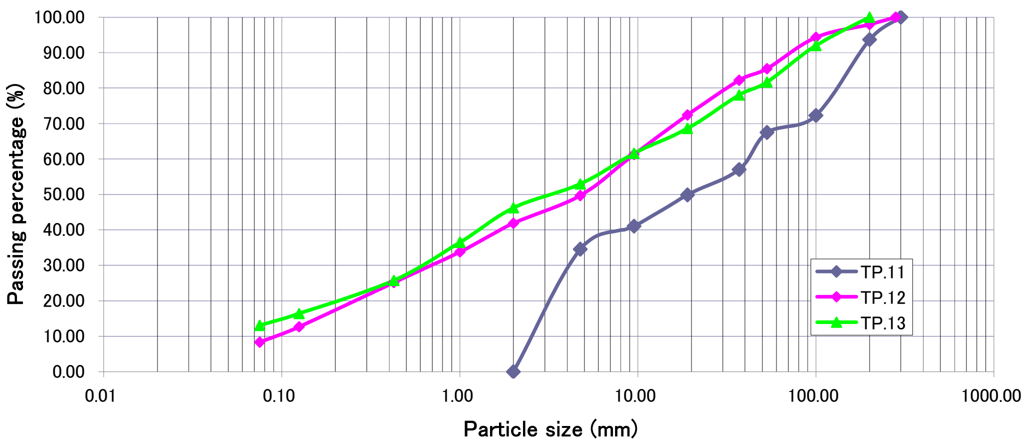


Figure 4-3-5.13 Particle Size Distribution of Sand-and-Gravels

(c) Possibility of the improvement of sandy loam's imperviousness

The possibility of the sandy loam being improved in its permeability coefficient by mixing cement or bentonite was confirmed as shown in Table 4-3-5.4.

Table 4-3-5.4 Result of Possibility Confirmation Test to be Improved by Mixing Cement/Bentonite

Sample name	k (cm/sec)	Sample name	k (cm/sec)
Soil + 3.4% cement	1.9×10^{-7}	Soil + 5.0% bentonite	3.9×10^{-7}
Soil + 6.8% cement	4.3×10^{-8}	Soil + 15.0% bentonite	8.3×10^{-7}
Soil + 10.0% cement	2.4×10^{-8}	Soil + 15.0% bentonite	4.3×10^{-7}

(3) Laboratory test phase-2

(a) Outline

Following the achievement of successful confirmation of the possibility for sandy loam's imperviousness to be improved by mixing with bentonite or cement as shown in Table 4-3-5.4, more detailed laboratory tests to the bentonite-soil mixture and the soil-cement were conducted aiming to determine the suitable soil's condition, the better additive substance and the appropriate mixing ratio of the additive substance. In case of soil-cement, the tests to estimate the durability such as the freezing/thawing test were conducted to judge the adequacy of soil-cement as the slope protection work. And also together with the pit-excavation survey (refer to 4-3-4 (5)), fundamental laboratory tests were conducted to the samples excavated from the pits. The contents of the laboratory tests planned and conducted are shown in Table 4-3-5.5 and the test results to the excavated materials are summarized in Table 4-3-5.6.

(b) Test results of bentonite soil mixture

The results are summarized in Table 4-3-5.7. Contrary to expectation, the permeability of sandy loam, sand-and-gravel fine and sand-and-gravel coarse could not be improved by mixing with bentonite. When recognizing that the mechanism of gravelly soils' permeability being improved by bentonite mixing depends on the swelling of bentonite powder that fills up the voids among gravelly soils' particle, it is assumed that the reason why bentonite mixing can not function is the voids among sandy loam's particle are too small for bentonite powder to intrude and swell. Room to pursue the permeability improvement by arranging the gradational conditions of sand-and-gravel is left but at this stage it has not yet been succeeded.

(c) Test results of soil-cement

The results are summarized in Table 4-3-5.8.

[Improvement degree in permeability by mixing with cement]

The permeability coefficients of raw materials are sandy loam: $k=3.3 \times 10^{-5}$ cm/sec, sand-and-gravel fine: $k=5.3 \times 10^{-4}$ cm/sec and sand-and-gravel coarse: $k=3.4 \times 10^{-5}$ cm/sec (refer to Table 4-3.5.6); and after being mixed with cement, all of them become $k=7.7\times10^{-7}$ cm/sec ~ 3.9×10^{-8} cm/sec (refer to Table 4-3.5.8) to the mixture ratio of cement 6 % - 10 % showing remarkable degree of improvement in imperviousness.

[Materials to be mixed with cement]

From the view point of the improvement degree and the stable test values in imperviousness, the material "sand-and-gravel coarse" is better than the others (refer to Figure 4-3.5.14). And also from the view point of unconfined compression strength, the material "sand-and-gravel coarse" is obviously superior to others (refer to Figure 4-3.5.15).

[Mixing ratio of cement]

The differential is small or not observed in the permeability coefficient between 8% and 10% of mixing ratio of cement all through the cases of “cured”, “not cured” and “freezing/thawing” of falling head permeability tests (refer to Figure 4-3.5.14) though clear differentials are recognized in unconfined compression strength (refer to Figure 4-3.5.15). It would be the safety side decision to adopt 10% of mixing ratio at this stage but the final answer shall be given considering the quality variation based on the further laboratory test in future.

[Importance of curing]

The influence of specimens being cured or not being cured appears as the differential of two orders, i.e. from 10^{-8} cm/sec order to 10^{-6} cm/sec order in the permeability coefficient (refer to Figure 4-3.5.14), so that it would be said that the curing is very important at the construction stage and that the design permeability coefficient of soil-cement shall be decided considering the deferential of curing conditions between in the laboratory and in the field.

[Durability of soil-cement]

Based on the test results of Slaking Test and Sodium Sulfate Soundness Test, soil-cement made of materials “sand-and-gravel fine” and “sand-and-gravel coarse” shall be estimated to have as stable enough quality as the coarse aggregate for concrete provided the mixing ratio 8% or 10% of cement is assured (refer to Figure 4-3.5.16, Figure 4-3.5.17). Therefore, it would be said that a series of test conducted this time could make it clear for the soil-cement to be available not only for the anti-infiltration work but also for the slope protection work though it is a matter to study what meaning the distinct differential in unconfined compression strength between 8% and 10% of the mixing ratio have in future.

Table 4-3-5.5 Contents of Laboratory Tests Planned and Conducted

Sample name / Test item	Pit	Sandy loam	Sand/ gravel	Bentonite-soil mixture									Soil-cement									Additional		Surface gravel			Total
				sandy loam mix			sand/gravel fine			sand/gravel coarse			sandy loam mix			sand/gravel fine			sand/gravel coarse			soil-cement		South		North	
				7.5*	10.0	12.5	7.5*	10.0	12.5	7.5*	10.0	12.5	6.0	8.0	10.0	6.0	8.0	10.0	6.0	8.0	10.0	Portland 8%,,7days	slag×2 type 8%,10%,7days	raw	cement mix	raw	
Excavations by a backhoe		1	4	(backhoe: 1 day)																							1
Sampling by big polyethylene bag		1	4																								5
Transportation by a truck with crane		1 lump-sum																									1
Observation-pit excavations by a backhoe	20	(backhoe: 3 days)																						31(backhoe: 2 days)			5
Moisture content		1	4																					5		8	18
Specific gravity		1	4																					5		8	18
Particle size distribution (full)		1																						5			6
Sieving test			4																							8	12
Spe. gravity & Water absorption			4																					5		8	17
Sample arrangement								1			1						1			1							4
Atterberg limit		1	4	1	1	1	1	1	1	1	1	1												5			19
Standard compaction		1	2																				12	5	5		25
Falling head permeability		1	2																					5			8
Modified compaction			4																								4
																											0
Apparatus preparation: Falling head permeability		1 lump-sum																									0
Apparatus preparation: Unconfined compression		1 lump-sum																									0
Standard compaction				1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1						16
Preparatory compaction test								5									5										10
Preparatory permeability test								3									3										6
Falling head permeability (cured)													1	1	1	1	1	1	1	1	1				5		14
Unconfined compression (cured)													1	1	1	1	1	1	1	1	1				5		14
Falling head permeability (not cured)				2	2	2	2	2	2	2	2	2		1	1		1	1		1	1						24
Unconfined compression (not cured)		1			2			2			2			1	1		1	1		1	1						13
Freezing/ thawing: Falling head permeability		1			2			2			2		1	1	1	1	1	1	1	1	1						16
Freezing/ thawing: Unconfined compression		1			2			2			2		1	1	1	1	1	1	1	1	1						16
Observation in water					2			2			2																6
Slaking test													1	1	1	1	1	1	1	1	1				5		14
Soundness of aggregate			2										1	1	1	1	1	1	1	1	1				5		16
Hexavalent chromium dissolution (Color comparison method)															2			2			2	3	12				21
Hexavalent chromium dissolution (IC-PC method)																						3	12				15

Table 4-3-5.6 Test Results to the Excavated Materials and the Aranged Samples of Sand-and-Gravel

N	Sample name	Moisture content, %	Specific gravity	Specific gravity & water absorption			Atterberg limits			Proctor test		Permeability, cm/sec.
				Bulk Specific Gravity	Apparent Specific Gravity	Water absorption	Liquid limit, %	Plastic limit, %	Plastic index	Max. Dry density, g/cm^3	OMC, %	
1.	Sandy loam	9.88	2.66	-	-	-	21.0	17.4	3.6	1.75	16.5	3.3E-05
2.	TP-17	9.31	2.59	2.23	2.30	2.41	Non-Plastic			1.77	14.5	-
3.	TP-18	4.69	2.59	2.35	2.41	2.06	Non-Plastic			1.56	10.5	-
4.	TP-19	16.16	2.62	2.32	2.38	1.82	33.1	20.6	12.5	1.79	17.0	-
5.	TP-20	16.77	2.60	2.32	2.40	2.42	Non-Plastic			1.83	15.8	-
6.	TP-22	11.04	2.41	1.42	1.52	15.16	Non-Plastic			1.31	17.0	3.1E-04
7.	TP-35	10.76	2.61	2.15	2.21	2.50	Non-Plastic			1.88	14.5	1.8E-04
8.	TP-41	24.79	2.75	2.17	2.36	7.14	32.2	20.9	11.3	1.59	22.7	1.5E-06
9.	TP-45	19.41	2.57	1.25	1.33	23.32	Non-Plastic			1.48	23.1	3.6E-05
10.	TP-50	22.44	2.78	2.06	2.39	12.98	Non-Plastic			1.57	24.0	1.8E-04
11.	TP-57	16.51	2.60	2.25	2.32	2.34	-	-	-	-	-	-
12.	TP-58	13.36	2.64	2.34	2.41	1.94	-	-	-	-	-	-
13.	TP-59	7.52	2.65	2.42	2.49	1.87	-	-	-	-	-	-
14.	TP-60	8.76	2.65	2.27	2.33	2.05	-	-	-	-	-	-
15.	TP-62	16.17	2.40	2.20	2.26	2.40	-	-	-	-	-	-
16.	TP-65	13.64	2.48	2.26	2.37	3.65	-	-	-	-	-	-
17.	TP-68	17.53	2.61	2.16	2.36	7.20	-	-	-	-	-	-
18.	TP-69	10.34	2.70	2.32	2.44	3.54		-	-	-	-	-
19.	Sand/gravel fine	-	-	-	-	-	Non-Plastic			1.65	14.5	5.3E-04
20.	Sand/gravel coarse	-	-	-	-	-	Non-Plastic			1.76	16.5	3.4E-05

Table 4-3-5.7 Test Results of Bentonite Soil Mixture

N	Mixture	Compaction	Standard compaction		Permeability, cm/sec.		Unconfined compression strength, KPa		Atterberg limits			Observation in water
			Max. dry density, g/cm^3	OMC, %	Not cured	After freezing/ Thawing	Not cured	After freezing/ Thawing	LL, %	PL, %	PI	
1.	Sandy loam	D-100	1.75	16.50	3.3E-05	5.1E-04	374.5	947.2	21.0	17.4	3.6	-
2.	Sandy loam+7.5 % bentonite	D-100	1.65	20.20	1.8E-06	-	-	-	34.5	17.0	17.5	-
		D-97			2.2E-06	-	-	-				-
3.	Sandy loam+10 % bentonite	D-100	1.65	19.00	1.7E-06	4.4E-06	276.9	531.8	38.2	17.4	20.8	Destroyed after 0.5-1 hour
		D-97			2.6E-06	2.3E-06	88.1	487.8				
4.	Sandy loam+12.5 % bentonite	D-100	1.53	23.00	2.9E-06	-	-	-	43.5	18.4	25.1	-
		D-97			2.0E-06	-	-	-				-
5.	Sand/gravel fine	D-100	1.65	14.50	5.3E-04	-			Non-Plastic			-
6.	Sand/gravel fine+7.5 % bentonite	D-100	1.61	21.00	2.2E-05	-	-	-	39.5	39.2	0.3	-
		D-97			1.1E-06		-	-				-
7.	Sand/gravel fine+10 % bentonite	D-100	1.62	21.00	7.0E-06	1.7E-05	239.2	207.7	43.5	42.2	1.3	Destroyed after 0.5-1 hour
		D-97			4.7E-07	3.0E-05	66.1	192.0				
8.	Sand/gravel fine+12.5 % bentonite	D-100	1.56	24.00	2.5E-06	-	-	-	46.5	45.0	1.5	-
		D-97			4.6E-07	-	-	-				-
9.	Sand/gravel coarse	D-100	1.76	16.50	1.6E-05	-			Non-Plastic			-
10.	Sand/gravel coarse+7.5 % bentonite	D-100	1.65	19.20	3.1E-06	-	-	-	41.0	39.0	2.0	-
		D-97			1.8E-06	-	-	-				-
11.	Sand/gravel coarse+10 % bentonite	D-100	1.63	20.30	1.4E-06	4.4E-06	129.0	119.6	46.0	39.3	6.7	Destroyed after 0.5-1 hour
		D-97			1.4E-06	2.9E-06	75.5	179.4				
12.	Sand/gravel coarse+12.5 % bentonite	D-100	1.57	23.00	1.9E-06	-	-	-	49.0	40.6	8.4	-
		D-97			1.4E-06	-	-	-				-

Table 4-3-5.8 Test Results of Soil-cement

N	Mixture	Standard compaction		Permeability, cm/sec.			Unconfined compression strength, MPa				Degree of slaking, %	Sound-ness, %	Hexavalent chromium content, mg/L	
		Max. dry density, g/cm^3	OMC, %	Cured	Not cured	After freezing/ Thawing	Cured 7 day	Cured 28 day	Not cured	After freezing/ Thawing			By color comparison method	By Ion Chromatog raphy
1.	Sandy loam + 6 % cement	1.67	19.00	3.6E-07	-	2.8E-07	1.7	2.7	-	2.3	4.1	11.3	0.11	-
2.	Sandy loam + 8 % cement	1.70	18.00	8.0E-08	2.2E-06	4.7E-07	2.4	3.1	3.4	3.5	3.5	6.4	0.10	0.1144
3.	Sandy loam + 10 % cement	1.71	17.61	7.0E-08	7.2E-06	3.0E-07	3.5	4.1	5.2	4.6	2.7	4.1	0.12	-
4.	Sand/gravel fine + 6 % cement	1.72	18.92	7.2E-07	-	1.0E-06	2.2	4.2	-	3.6	3.3	4.3	0.17	-
5.	Sand/gravel fine + 8 % cement	1.72	17.58	7.6E-08	3.0E-06	5.7E-07	3.5	4.3	4.3	4.5	2.6	2.8	0.094	0.092
6.	Sand/gravel fine + 10 % cement	1.70	18.95	7.7E-07	2.4E-06	2.6E-07	2.5	5.5	6.0	6.1	1.4	1.8	0.15	-
7.	Sand/gravel coarse + 6 % cement	1.77	17.42	5.9E-08	-	2.6E-07	3.1	4.0	-	4.0	3.6	4.1	0.12	-
8.	Sand/gravel coarse + 8 % cement	1.72	16.50	3.9E-08	2.8E-06	1.7E-07	4.6	4.9	5.3	5.8	2.2	2.8	0.056	0.057
9.	Sand/gravel coarse + 10 % cement	1.74	16.00	4.1E-08	2.4E-06	6.1E-08	2.4	5.8	6.3	6.9	1.9	2.1	0.13	-
10.	TP-22 + 8 % cement	1.35	19.00	4.5E-05	-	-	1.4	-	-	-	2.1	3.6	-	-
11.	TP-35 + 8 % cement	1.88	14.62	9.0E-08	-	-	4.5	-	-	-	3.6	6.1	-	-
12.	TP-41 + 8 % cement	1.52	24.00	9.5E-08	-	-	1.5	-	-	-	7.4	8.1	-	-
13.	TP-45 + 8 % cement	1.43	19.50	6.4E-08	-	-	2.9	-	-	-	6.4	10.6	-	-
14.	TP-50 + 8 % cement	1.49	20.90	3.2E-07	-	-	3.2	-	-	-	6.8	6.9	-	-
15.	Sandy loam + 8 % slag-cement 1	1.69	18.00	-	-	-	2.0	-	-	-	-	-	0.061	0.065
16.	Sand/gravel fine+8 % slag-cement 1	1.62	19.00	-	-	-	3.6	-	-	-	-	-	0.072	0.070
17.	Sand/gravel coarse+8 % slag-cement 1	1.67	15.80	-	-	-	4.6	-	-	-	-	-	0.066	0.064
18.	Sandy loam + 8 % slag-cement 2	1.62	17.40	-	-	-	2.0	-	-	-	-	-	0.062	0.0596
19.	Sand/gravel fine+8 % slag-cement 2	1.66	21.00	-	-	-	3.0	-	-	-	-	-	0.064	0.068
20.	Sand/gravel coarse+8 % slag-cement 2	1.70	16.00	-	-	-	3.9	-	-	-	-	-	0.050	0.051
21.	Sandy loam + 10 % slag-cement 1	1.70	18.00	-	-	-	2.5	-	-	--	-	-	0.052	0.065
22.	Sand/gravel fine+10 % slag-cement 1	1.69	21.00	-	-	-	3.6	-	-	-	-	-	0.066	0.068
23.	Sand/gravel coarse+10 % slag-cement 1	1.72	19.83	-	-	-	3.3	-	-	-	-	-	0.064	0.068
24.	Sandy loam + 10 % slag-cement 2	1.66	19.50	-	-	-	2.4	-	-	-	-	-	0.058	0.059
25.	Sand/gravel fine+10 % slag-cement 2	1.67	20.50	-	-	-	3.4	-	-	-	-	-	0.076	0.081
26.	Sand/gravel coarse+10 % slag-cement 2	1.77	18.50	-	-	-	3.5	-	-	-	-	-	0.070	0.071

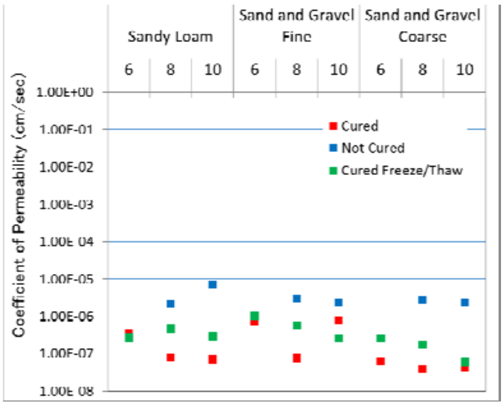


Figure 4-3.5.14 Result of Falling Head Permeability Tests to Soil-cement

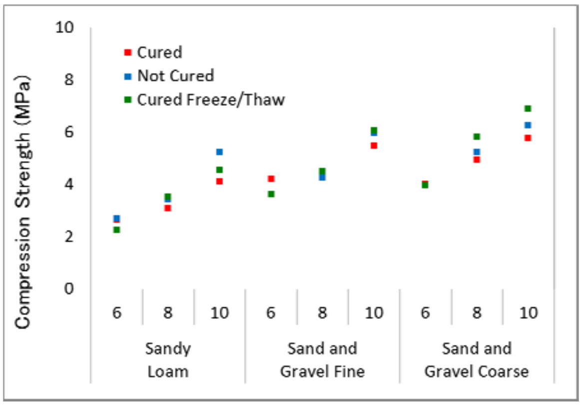


Figure 4-3.5.15 Result of Unconfined Compression Tests to Soil-cement

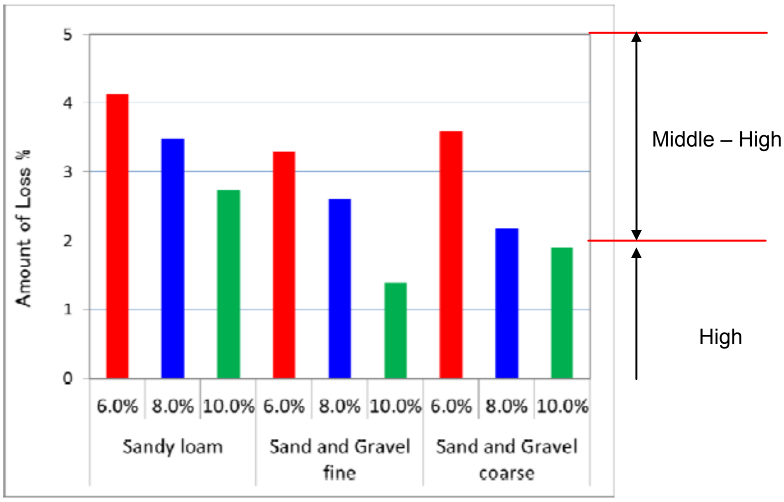


Figure 4-3.5.16 Result of Slaking Tests to Soil-cement

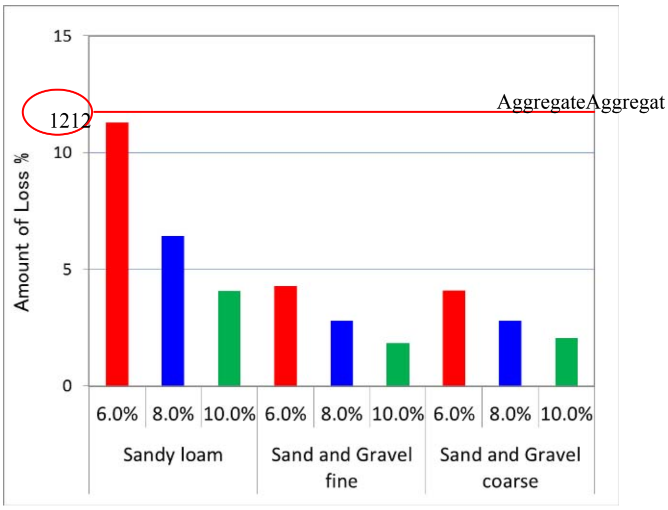


Figure 4-3.5.17 Result of Sodium Sulfate Soundness Tests to Soil-cement

4-3-6 Investigation for the Anti-infiltration Works to the Reservoir Basin

(1) Field survey of the existing range of sandy loam

(a) Outline of the survey

As the achievement of the geological investigations carried out in ex-USSR era, drawings of the geological cross-sections of the reservoir basement had been left. Based on these drawings, the geological plane map was drawn this time where the existing range of the sandy loam in the reservoir basin was shown. It is considered to be important to confirm this range of existence for studying the anti-infiltration method to the reservoir bottom/slope in case of the sandy loam having relatively low permeability, so that the field survey was conducted to the points set up beforehand corresponding to the boundary on the geological plane map. And later, the same kind of field survey was conducted to assume the range of the area with a thick coverage of sandy loam visually from the circumstances on the ground surface.

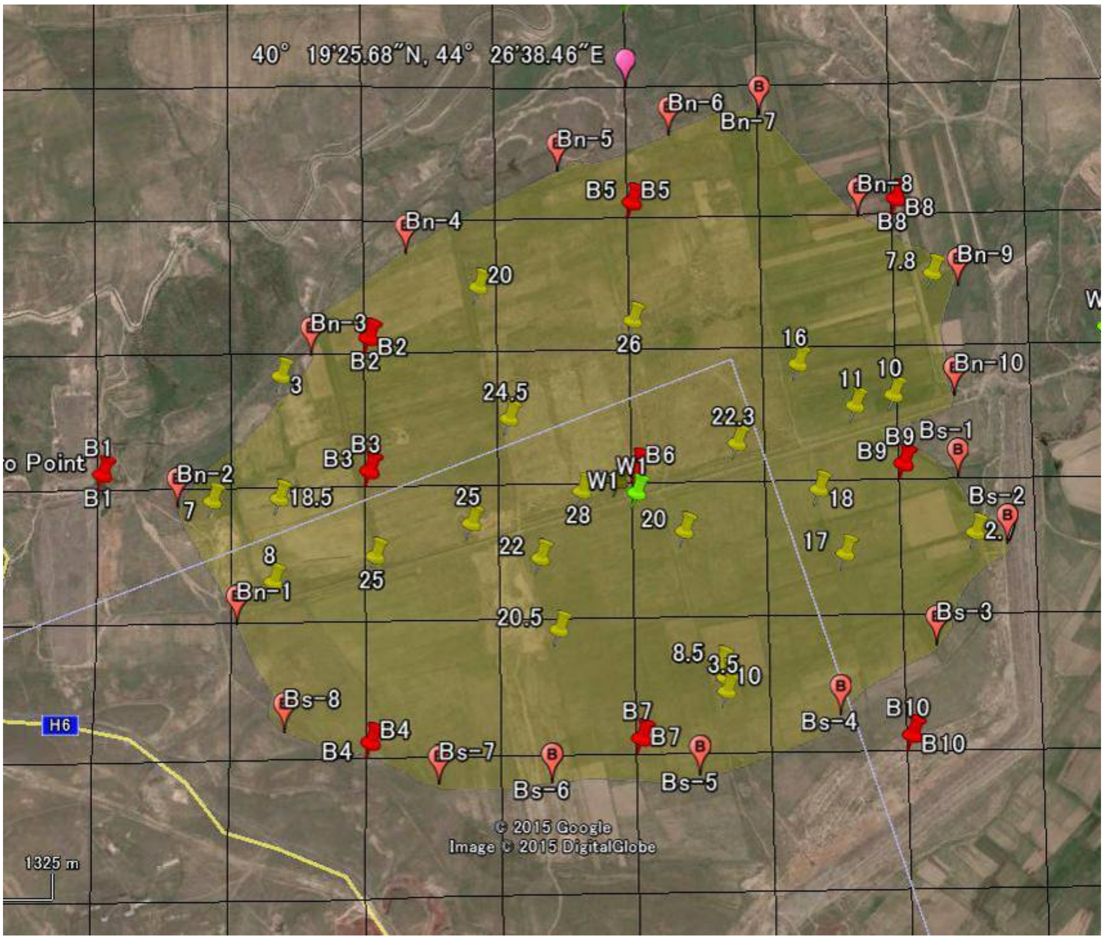


Figure 4-3-6.1 Existing Range of Sandy Loam (Yellow-colored Area) and the Confirmation Points

(b) Findings

1) At the north-western side where the slopes are relatively and comparatively steep among the slopes around the reservoir, the boundary between the sandy loam deposit and the sand-and-gravel deposit is clear and corresponds to the line of slope change.

2) At the north side, the low and flat terrace extends wide toward south which seems to be composed of the sand-and-gravel deposit.

3) At the north-eastern side where the relatively steep slope goes back to north and the wide area

with gentle slope extends, the boundary between the sandy loam deposit and the sand-and-gravel deposit is not clear; but the latter seems to occupy the main portion of the gentle slope area.

4) At the eastern side, the boundary between the sandy loam deposit and the volcanic deposit is clear and corresponds to the line of slope change.

5) At the south-eastern side, the ground is gently inclined from the hill top toward the central plain and the boundary between the sandy loam deposit and the volcanic deposit does not appear.

6) At the south side, the two lines of slope change appear. The slope beyond the upper line is composed of volcanic deposits and the sandy loam with rubbles. The lower line of slope change is the one between the central plain and the gentle slope; the slope below the upper line is composed of the sandy loam deposit, the thickness of which seems to be not so much.

7) At the south-western to the western side, the gentle slope is covered with the sandy loam with rubbles and the boundary is between this gentle slope and the central plain. The rubbles are volcanic produced from the foundation rock so that it is assumed that the thickness of the sandy loam with rubbles is thin.

8) Result of the field survey to assume the range of the area with a thick coverage of sandy loam

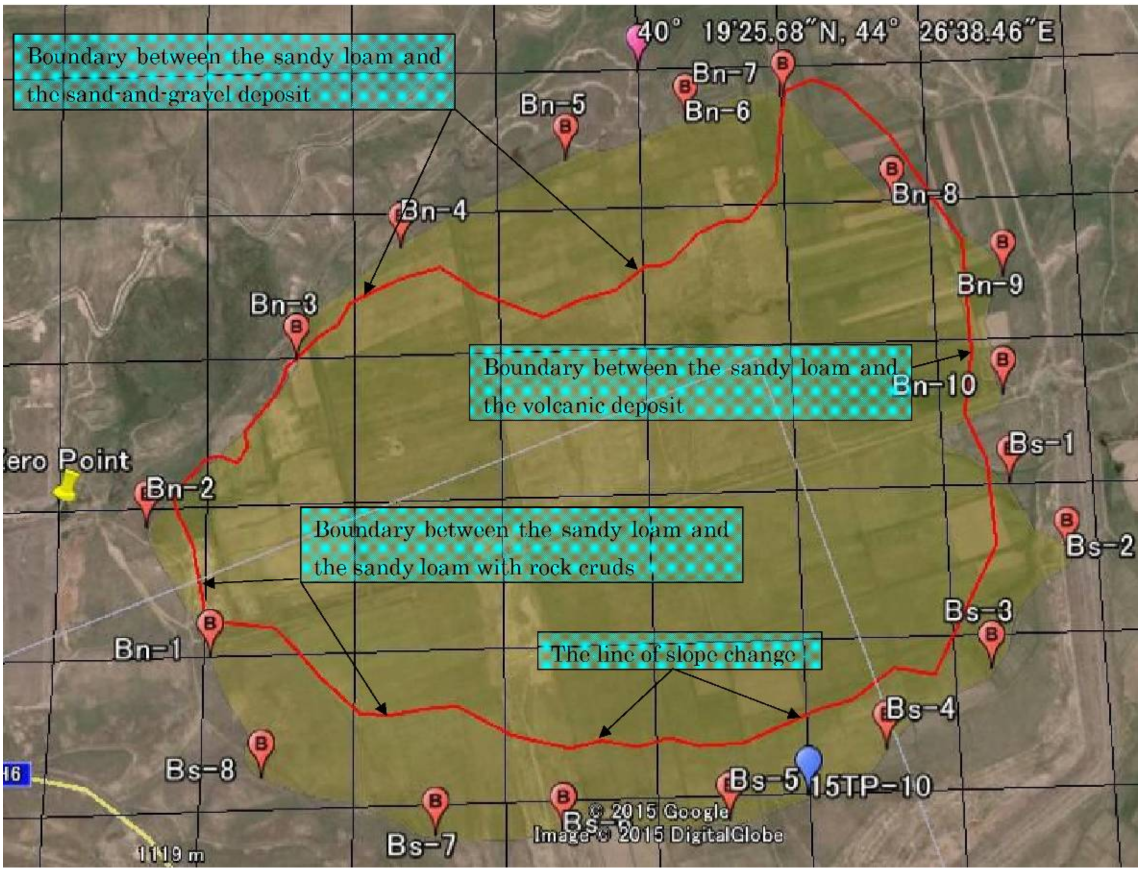


Figure 4-3-6.2 Boundary Survey Result

(2) Field survey to confirm the layer conditions in terms of piping phenomenon

(a) Outline of the survey

In case of the base layer being porous, cracky or rich in void and a high hydraulic gradient arising in the upper soil layer, soil particles of the soil layer might be sucked out into the base layer. This is the phenomenon called "piping"; and if the soil layer corresponds to the anti-infiltration work made of soil or an impervious zone of the dam, the occurrence of this phenomenon leads to the loss of function of the work/structure. To check the possibility of this phenomenon arising, the field survey by the visual observation was carried out. The target of the observation was the sand-and-gravel layers and the volcanic rock layers.

(b) Findings

1) There is no possibility of the piping phenomenon arising into the sand-and-gravel layers.

There lie widely sand-and-gravel layers on the slopes north-side to the reservoir. There are two kinds of sand-and-gravel layers. One is the layer with the clear alternation structure of the rounded gravel layer and the silty sand layer. The other is the layer of the mixture of gravels and silty sand.

In the former case, the gravel layers are half-consolidated by the gypsum-like materials that fill up the voids in the layer (refer to Ph-1, 2). Therefore, there are no spaces into which soil particles are sucked out.

In the latter case, silty soil is predominant and the gravels are compared to the balls floating in the ocean of silty sand, so that voids are filled up with silty sand (Ph-3), into which soil particles are not sucked out.

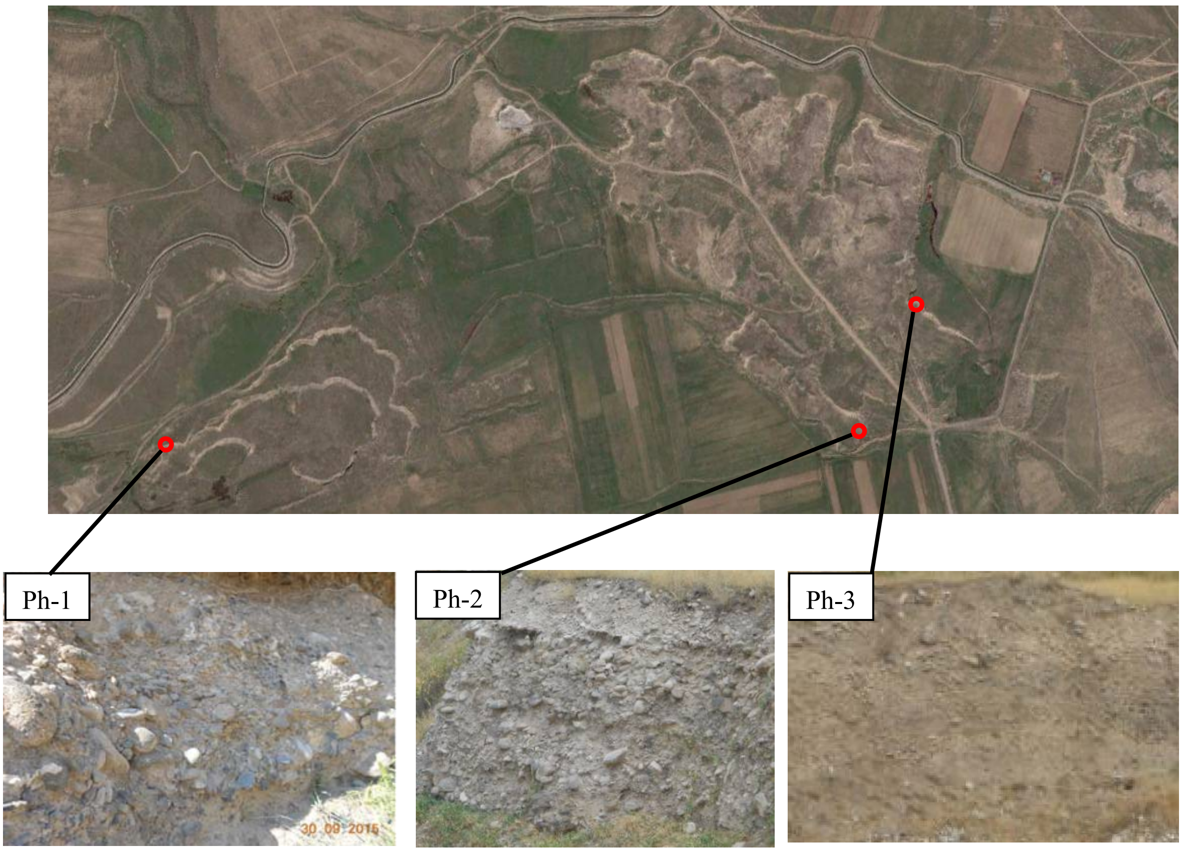


Figure 4-3-6.3 Conditions Observed on the Outcrop of Sand-and-Gravel Layers

2) There is a high possibility of the piping phenomenon arising into the volcanic rock layers.

The slopes south-side to the reservoir are composed of volcanic rock layers or volcanic layer of gravel and sand mixture, that is to say, lava layers (Ph-4), welded tuff layers and deposits of pyroclastic flow (Ph-5). There is the trench on the slope excavated for the intake pipe line in the Soviet era. There, the profile and conditions of these layers are observed as shown in Figure 4-3-6.4. These layers are recognized to be rich in cracks so that there is a high possibility of the piping phenomenon arising.

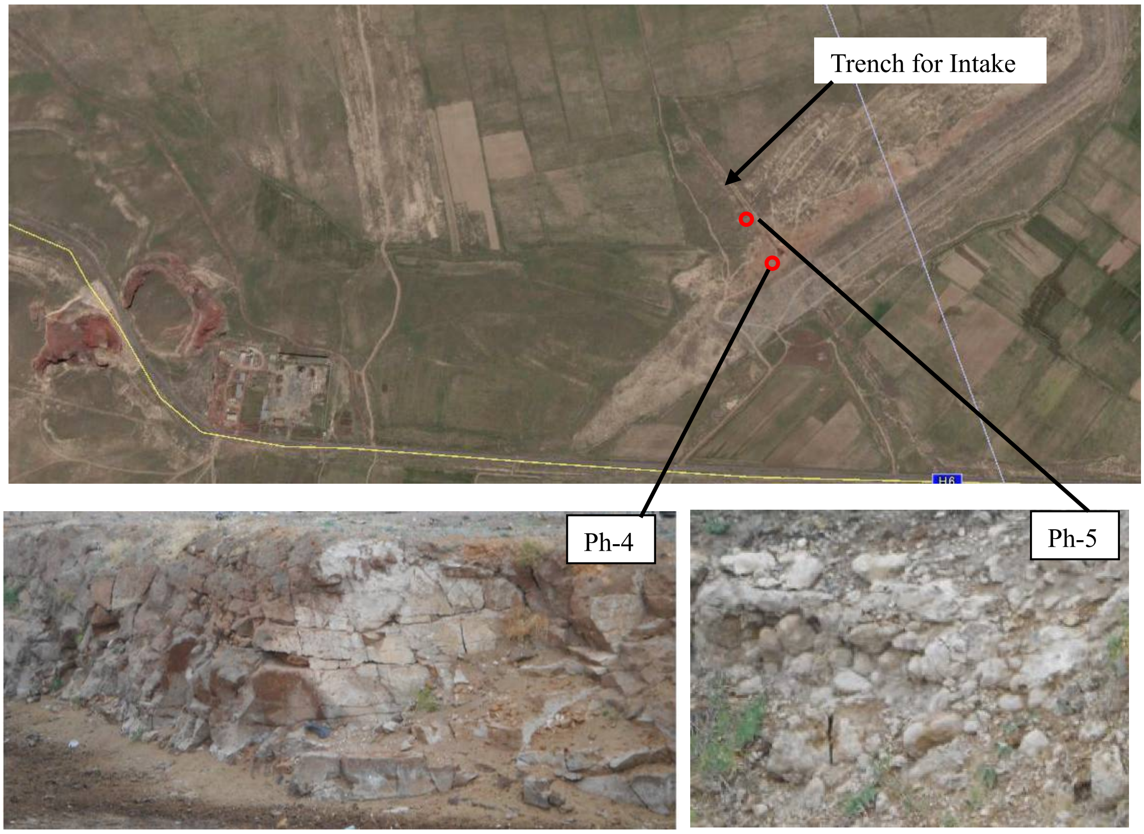


Figure 4-3-6.4 Conditions Observed on the Outcrop of the Lava Layer and the Deposits of Pyroclastic Flow Layer

(3) Field survey of ground water seeping out of the slope surface

(a) Aim

The anti-infiltration work constructed on the slope/ground surface prevents the reservoir water from seeping into the slope/ground but also prevents the ground water from seeping out from the slope/ground. If the ground water is prevented from seeping out and results in being pressurized when the reservoir is empty, the anti-infiltration work will be lifted up by the back pressure and destroyed. The field survey of ground water seeping out points on the slopes was conducted to judge if the geological conditions have the possibility of back pressure arising behind the anti-infiltration work.

(b) Finding

1) There are two ponds on the reservoir bottom just upstream side of the Dam No.1. Their long-term existences almost all through a year suggest a possibility of ground water flowing down toward the reservoir bottom in the hill-side areas. It must be noted that there might be a possibility of the back pressure arising against the bottom of the impervious zone of Dam-No.1 or from behind the anti-infiltration work in the upstream side of Dam No.1.


Figure 4-3-6.5 Ponds on the Reservoir Bottom at the Upstream of Dam-No.1

2) The points of ground water seeping out from the slopes or cliffs could not be found; but the leaked/discharged water from Arzni-Shamiram Canal was observed to keep falling down like a fall from along the upper surface of the silty soil layer of the cliff, composed of sand-and-gravel with alternation of gravel layers and silty sand layers, located on the hill north-side to the reservoir in early summer as shown in Figure 6-3-6.6. This fact suggests that the sand-and-gravel layer allows the existence of ground water along the upper surfaces of silty sand layers, that at present seeping points are not to be found due to the small quantity of ground water or the inclination of the layers (On the other day after rain, a part of the cliff with sand-and-gravel was found to be wet.), and that once the seeping out point is closed by the anti-infiltration work, the ground water might be stored up on along some silty sand layer, then pressurized, and act as the back pressure from behind the anti-infiltration work. It is necessary to consider the possibility of the back pressure arising on the slopes composed of sand-and-gravel layers.


Figure 4-3-6.6 Conditions Observed on the Cliff Slope of Sand-and-Gravels

3) On the slope south-side to the reservoir, the stratified structure of volcanic products is assumed to be inclined toward the reservoir based on the observation to the existing trench and the outcrops of lava on the south hill slope of Dam No.1 as shown in Figure 4-3-6.7. And an unconformity surface, which is not rare to function as an impervious plane, exists between the uppermost lava layer and the lower pyroclastic flow deposits. It is probable for the water stored on an unconformity surface to become pressurized and act as the back pressure against the anti-infiltration work because of its inclined stratified structure.

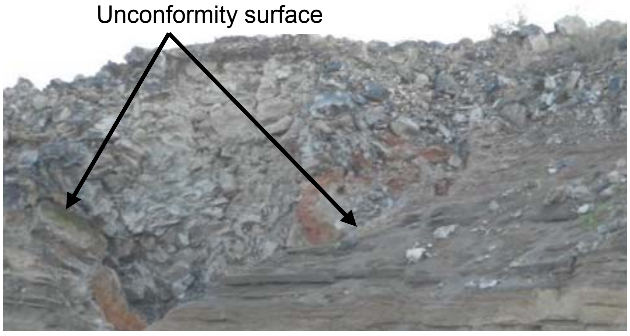


Figure 4-3-6.7 Unconformity Surface on the Lava cliff

(4) Snow melting condition survey

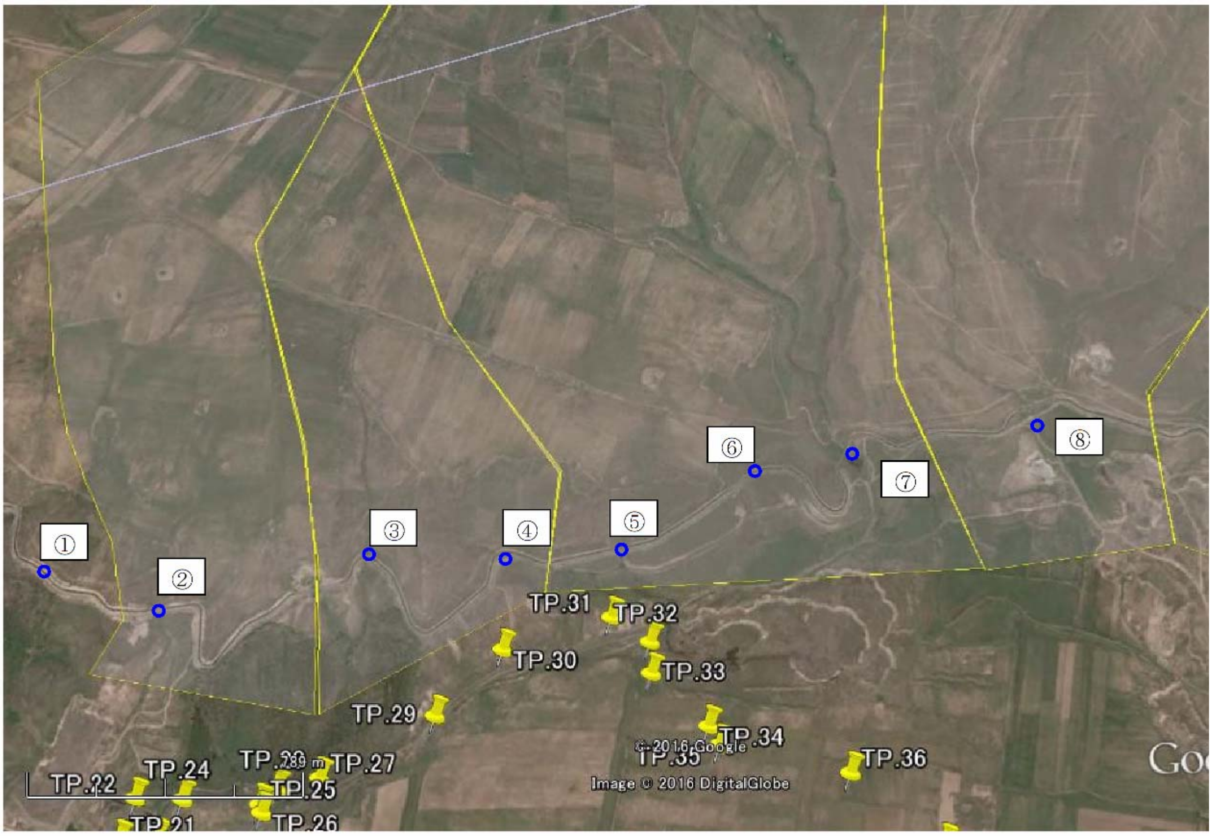


Figure 4-3-6.8 Location Map of the Observation Points

(a) Survey on 16th of February, 2016, clear and sunny, 5 ℃± as summarized in Table 4-3-6.1 and Figure 4-3-6.9

Table 4-3-6.1 Survey on 16th of February, 2016

Survey point	Catchment area (km2)	Depth of snow (cm)	Existence of stream (volume of stream)
①		10cm	No water under the water-way bridge and in front of the culvert pipe (Ph-1), Small pond on the road (Ph-2)
②	2.1	10cm	No water. The canal wall is wetted partly. (Ph-3)
③	1.0	20cm	No water under the water-way bridge A partial wetting on the cut slope (Ph-4), but totally seepage of water cannot be seen on the cliff. (Ph-5)
④		15cm	No water comes to the cutout mouth of the canal wall. (Ph-6)
⑤	0.5	10cm	No water under the water-way bridge. (Ph-7)
⑥		10cm	No water under the water-way bridge. (Ph-8)
⑦	18.1	15cm	Small pond under snow, no move, no stream(Ph-9,10)
⑧	7.2	10cm	No water under the water-way bridge. (Ph-11)

Ph-1

Ph-2

Ph-3

Ph-4

Ph-5

Ph-6

Ph-7

Ph-8

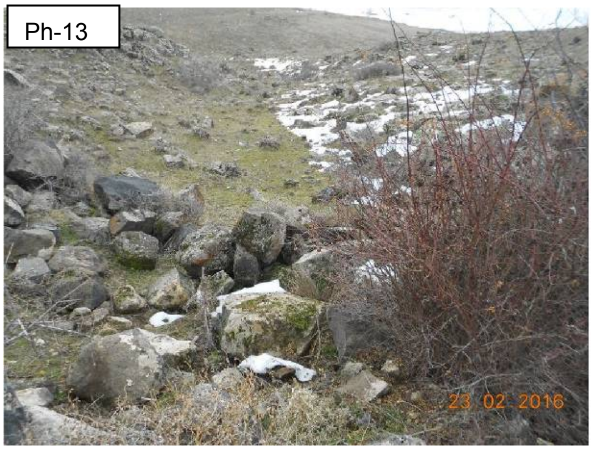
Figure 4-3-6.9 Photo of the Survey on 16th of February, 2016

(b) Survey on 24th of February, 2016, cloudy, 7 ℃± as shown in Table 4-3-6.2

Table 4-3-6.2 Survey on 24th of February, 2016

Survey point	Catchment area (km2)	Depth of snow (cm)	Existence of stream (volume of stream)
①		0 cm	Wet ground but no water in front of the culvert pipe (Ph-12), No water in the downstream valley(Ph-13)
②	2.1	0 cm	No water. The canal wall is dry. (Ph-14)
③	1.0	0 cm	No water is seen under the water-way bridge, but the ground surface corresponding to the watercourse is eroded. (Ph-15) Now water in the watering pond for cow. (Ph-16)
④		0 cm	No water comes to the cutout mouth of the canal wall. (Ph-17)
⑤	0.5	0 cm	Wet but no water (Ph-18)
⑥		0 cm	No water under the water-way bridge. (Ph-19)
⑦	18.1	0~5 cm	Small stream, In-flow volume under the water way bridge is 20 ~ 30 ℓ/sec. (Ph-20) Water is led by a earth canal (Ph-21, 22) and disappears in a meadow (Ph-23). This water shall be increased in early summer and makes a swamp around the foot of the north slope (Ph-24).
⑧	7.2	10cm	Small ripple and swamp under the water-way bridge. (Ph-25) Quantity is uncountable.


Ph-12


Ph-13


Ph-14


Ph-15


Ph-16


Ph-17


Ph-18


Ph-19

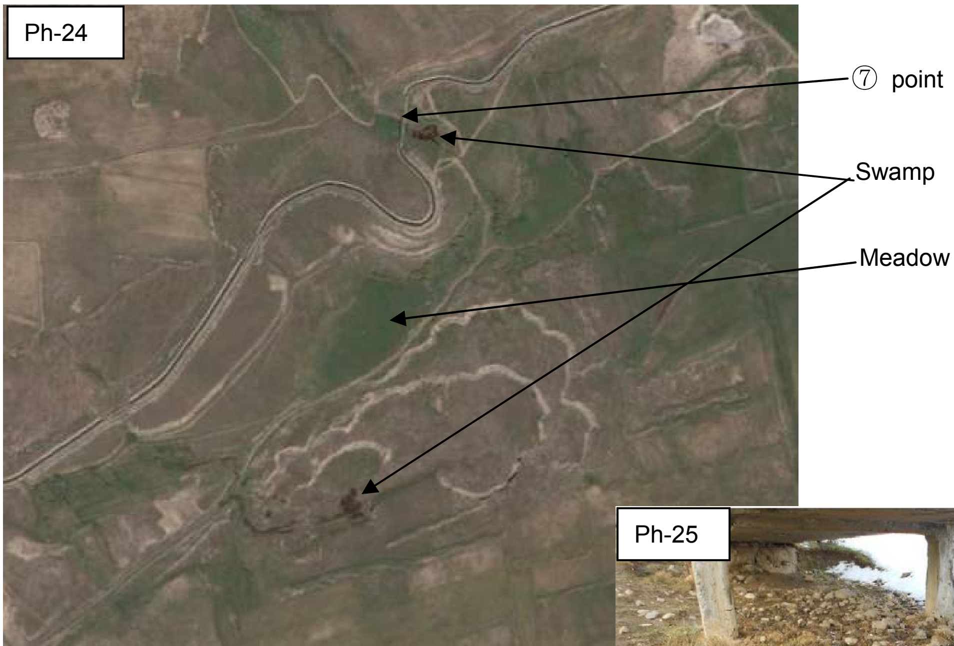
Ph-20

Ph-21

Ph-22

Ph-23

Ph-24



Ph-25

Figure 4-3-6.10 Photo of the Survey on 24th of February, 2016

(c) Survey on 18th of March, 2016, fine, －3 ℃± shown in Figure 4-3-6.11

Snow disappeared from the ground surface in and around the reservoir except the slope of Mt. Ara (Ph-27). There is no water under the water-way bridge at ⑧ point. At ⑦ point, a small swamp is left (Ph-26) under the water-way bridge but the stream last time we saw is not seen. The snow melting season seems to have finished already.

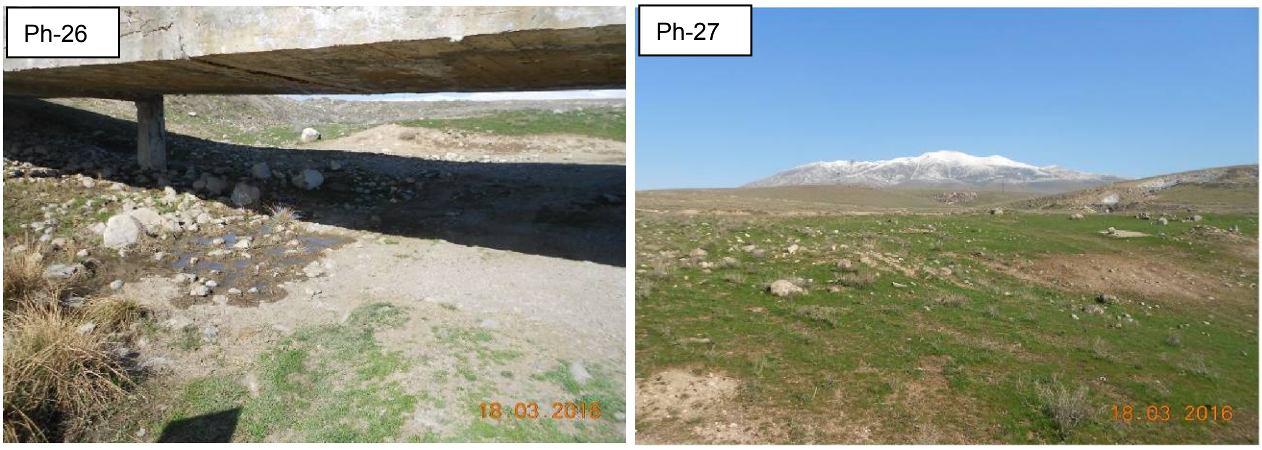


Figure 4-3-6.11 Photo of the Survey on 18th of March 2016

(d) Suspended water / ground water on the north-eastern slope

TP.67 was excavated on 30th of March in the pit excavation survey. At that time, it was found that the sand-and-gravel layer was muddy and the groundwater table appeared on the pit bottom about 3m deep. It is assumed that this groundwater was borne and brought from the snow-melt water at point-⑦. If this groundwater has the same origin as the observation well W-5 where it is said sound of water dropping into the observation well is audible, a relatively wide expansion of high groundwater table shall be required to take account of in the reservoir design.

Figure 4-3-6.12 High Groundwater Table in the North Eastern Slope

(5) Wind velocity survey

(a) Aim

In summer, 2015 geological investigations by borehole drilling were carried out in the reservoir bottom. On the way of works, a beach-parasol with tough structure and heavy basement was provided to protect technicians and engineers from the strong sunshine. But the attempt was failed "twice" due to the strong wind blowing off the parasol and breaking its bones. These incidents left a sharp impression of strong wind to the engineer's mind; and here wind velocity survey was carried out under the recognition that the sheet covering method was one of the alternatives for the anti-infiltration works to the reservoir bottom/slope and its laying work might be much affected by wind.

(b) Result of the survey

Wind velocity observations for ten (10) minutes have been conducted at the Yeghvard observation station 8 times a day at every 3 hours interval. From these observations, 8 records of mean wind velocity for ten minutes and 8 records of the instantaneous maximum wind velocity during ten minutes are reported. The contents of the report in 2014 are summarized as in 4-3-6.13.

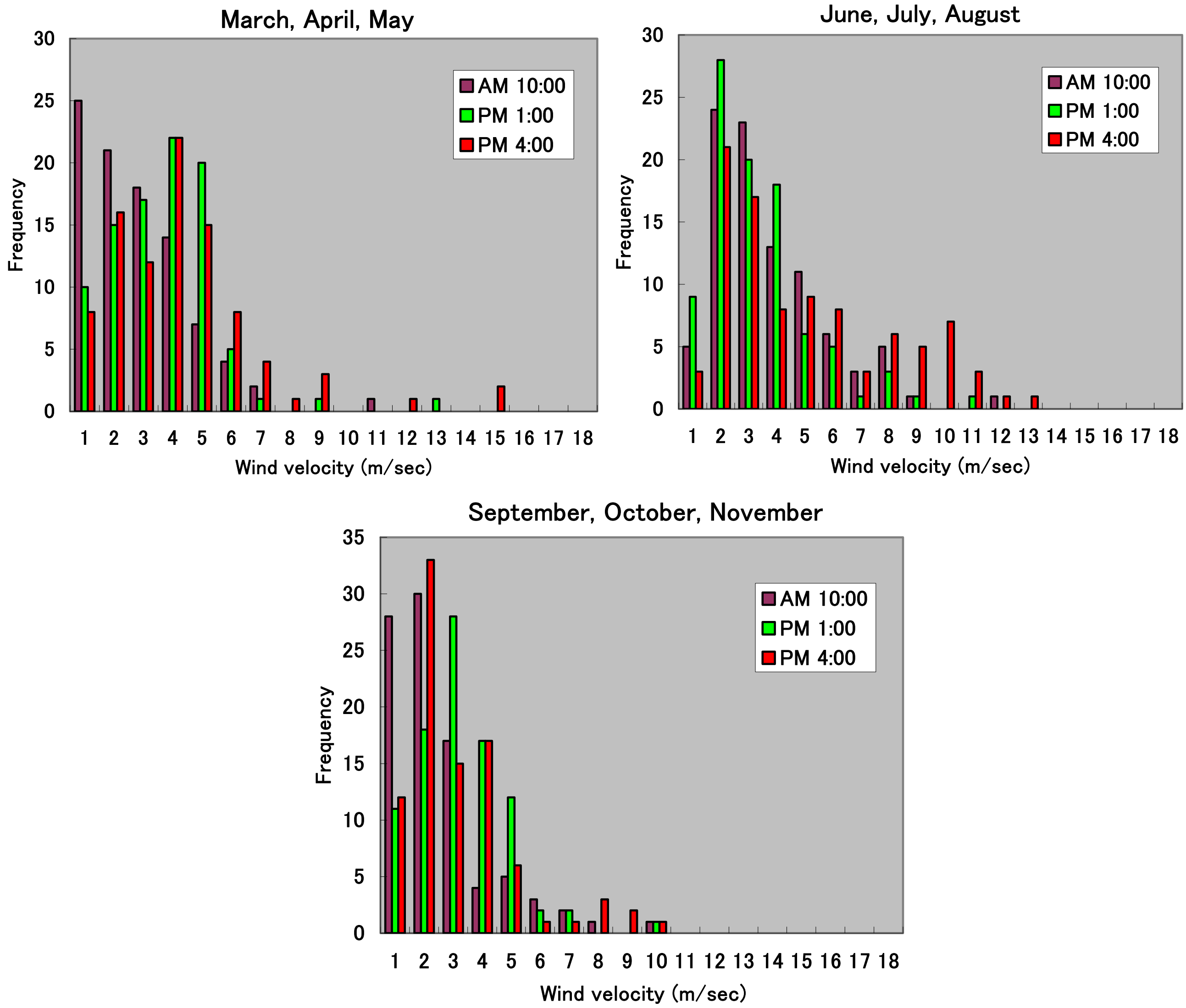
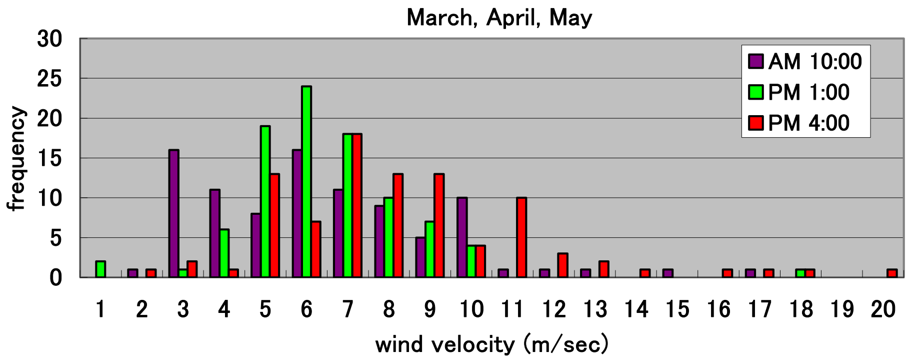
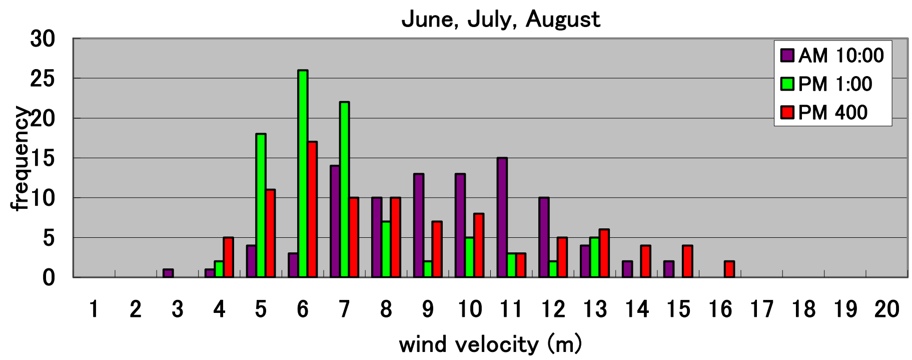


Figure 4-3-6.13 Mean Wind Velocity for Ten Minutes Observed in 2014





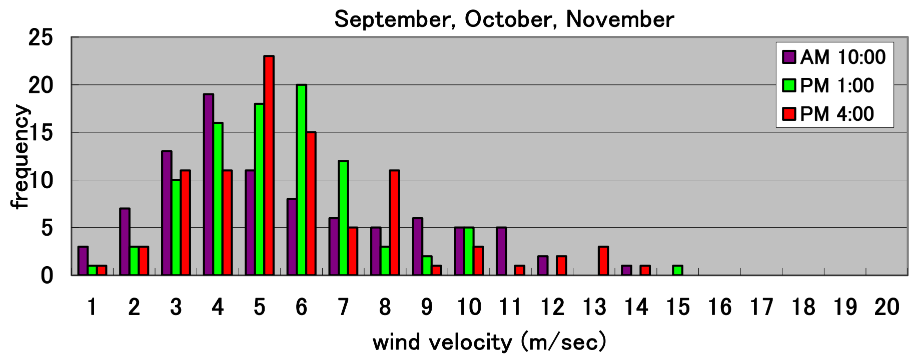


Figure 4-3-6.14 Instantaneous Wind Velocity during Ten Minutes Observed in 2014

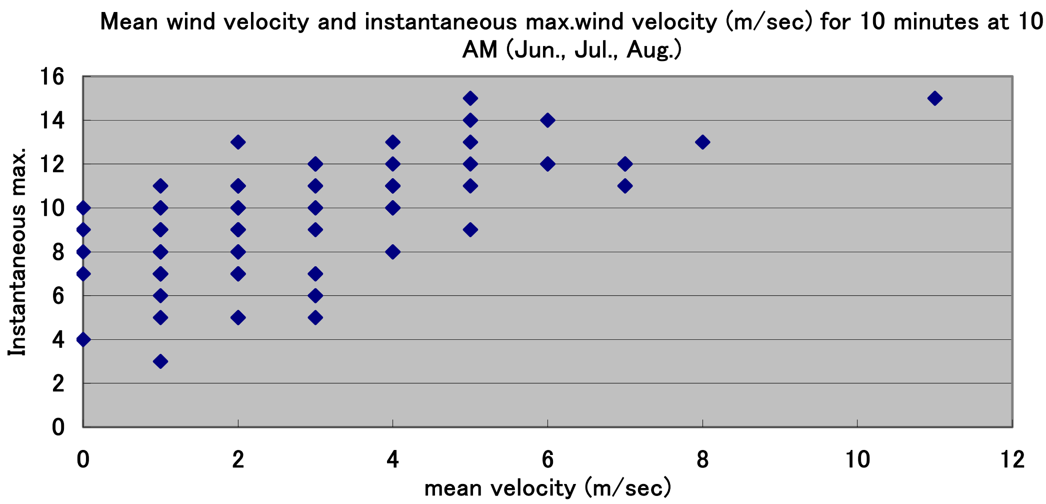


Figure 4-3-6.15 Relationship between Mean Wind Velocity and Instantaneous Wind Velocity

(c) Findings

1) In terms of the mean wind velocity, frequency of mean wind velocity around 3 m/sec is highest all through a year.
2) Occurrence of high mean wind velocity becomes more frequent in June, July and August.
3) In terms of the instantaneous maximum wind velocity, the peak of occurrence frequency is the velocity around 5 to 6 m/sec all through a year.
4) Occurrence of high instantaneous maximum wind velocity becomes more frequent in June, July and August.
5) Occurrence frequency of high instantaneous maximum wind velocity is lowest around 1:00 PM compared to 10:00 AM in the morning and 4:00 PM in the late afternoon all through a year.
6) Even under the breeze conditions, a gusting wind blows down.

4-3-7 Conditions of Existing Dam Bodies

(1) Site survey and information collection

The existing dam bodies consist of sand-and-gravel materials only. The vacant lots where these materials were obtained are left on the hills or gentle slopes north-eastern side to the reservoir as shown in Figure 4-3-7.1 and 4-3-7.2.

Figure 4-3-7.1 Existing Dam Body (Dam No.1)

Figure 4-3-7.2 Vacant Lots of the Sand-and-Gravel Quarry

The information obtained regarding the construction works is shown in Table 4-3-7.1.

Table 4-3-7.1 Construction Specifications of the Existing Dam Body

Item		Contents
Quality control criteria	Embankment density	2.0~2.1 t/m3 in wet density
	Grain size	
	Rock quality	
Frequency of control test	Embankment density	
	Grain size	
	Rock quality	
Specifications of construction works	Compaction machine	Vibratory roller
	Spreading machine	Bulldozer
	Compaction passing times	
	Layer’s thickness before compaction	45 cm
	Arrangement of moisture content	spraying

(2) In-situ investigations and tests

(a) In-situ investigations

1) Test-pit excavation

Test-pit excavations were conducted on the existing dam bodies, TP-1 and TP-16 on the Dam No.1 and TP-4, TP-14 and TP-15 on the Dam No.2, to confirm their actual conditions. The depth of test-pits was decided to be 1.5 m considering the disappearance of dried-up condition brought from the surface. Test-pit conditions of each are shown as Figure 4-3-7.3 and 4-3-7.4.

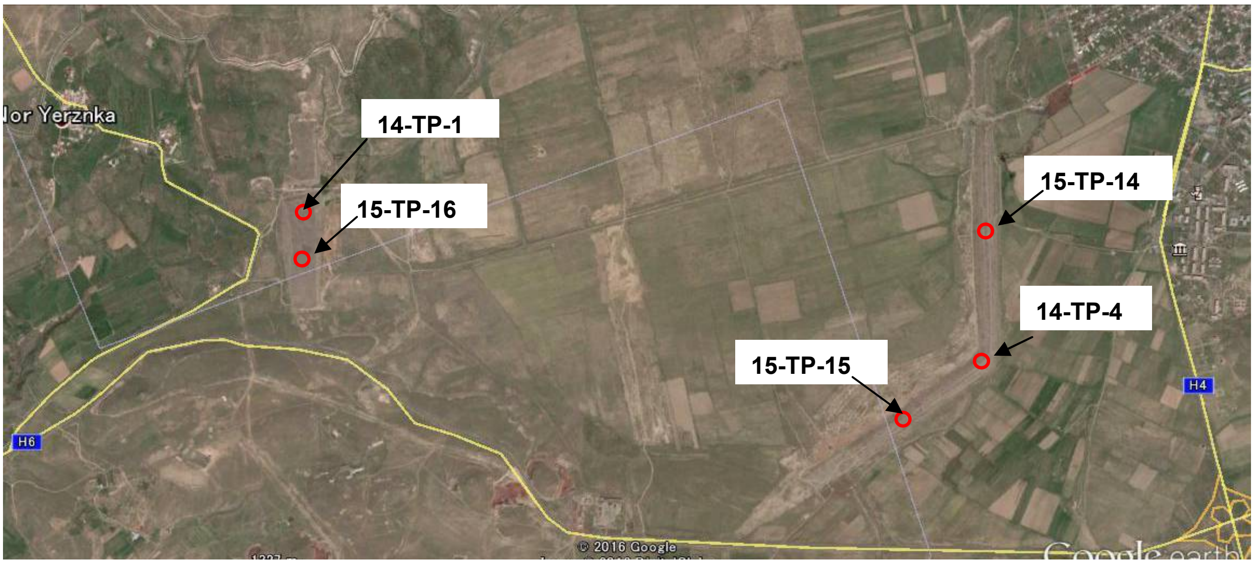


Figure 4-3-7.3 Test-pit Location for the Investigation of Dam Bodies

Figure 4-3-7.4 Test-pit Profiles after Excavation

[Findings]

a. The maximum grain size of cobbles is about 40 cm.
b. The rock sort of cobbles and gravels is basalt.
c. The quality of cobbles is hard and not weathered so that the metallic sound is emitted from them by the hitting of the geologist hammer.
d. The compacted layers are rich with fine particles composed of sand and silt that fills up almost completely and densely voids among gravels and cobbles.

2) Field density test

The field density tests by the water-replacement method were carried out on the bottom surface of the test-pits. The size of the testing hole was 60 cm in diameter and 40 cm in depth as shown in Table 4-3-7.2.

Figure 4-3-7.5 Circumstances in the Field Density Test

Table 4-3-7.2 Field Density of the Existing Dam Bodies

Pit No.	Dry weight of extracted soil (kg)	Weight of replaced water (kg)	Dry density (g/cm3)
TP-1	141.85	66.7	2.13
TP-4	164.45	79.7	2.06
TP-14	156.2	80.1	1.95
TP-15	203.6	108.3	1.88
TP-16	237.2	114.6	2.07
		Average	2.02

3) Field permeability test

Table 4-3-7.3 Field Permeability Coefficient of the Existing Dam Bodies

Pit No.	Trial No.	Poured Q (cm3)	Time passed minute	Time passed second	Unit Q (cm3/sec)	h (cm)	r_0 (cm)	k (cm/sec)	k-mean (cm/sec)
TP-14	1	31000	3	2	170.33	40	56	5.8×10-3	5.8×10-3
	2	31000	3	5	167.57	40	56	5.7×10-3	
	3	31000	3	1	171.27	40	56	5.9×10-3	
TP-15	1	12600	34	34	6.08	42	57.5	1.9×10-4	1.9×10-4
TP-16	1	35750	63	0	9.46	55	60	2.2×10-4	2.5×10-4
	2	3575	5	0	11.92	55	60	2.7×10-4	

Figure 4-3-7.6 Circumstances in the Field Permeability Test

4) Repose angle of sand-and-gravel materials

Repose angles were measured on the natural slope caused by the backhoe's dumping work of excavated materials.

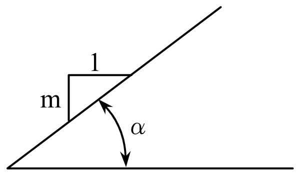
Table 4-3-7.4 Result of Repose Angle Measurement

Pit No.	TP-1	TP-4	TP-14	TP-15	TP-16
Repose angle (°)	33, 35, 38	35, 41	36.8	40.1	41.2

Figure 4-3-7.7 Circumstances in the Repose Angle Measurement

The repose angle is defined as the internal friction angle of sand, sand-and-gravel and rock materials under the unconfined and loosest condition. It is easy to understand through the relationship between the definitional identity of safety factor to the surface sliding of rock slope and the slope inclination.

$$Fs = \frac{1 - m * k}{m + k} * \tan \phi '$$



Fs; safety factor
m; slope inclination
m=tanα α; repose angle of the slope
k; seismic coefficient (percentage to the gravitational acceleration×1/100)
φ'; internal friction angle

When Fs=1.0 and k=0.0 are inserted as the safety factor reflecting the critical slope inclination and the normal condition, m=tanφ', tanα=tanφ' and then α=φ' is obtained. In case of the slope being stamped by foot, the repose angle increases. Therefore, the internal friction angle of the compacted materials is understood to be larger than the repose angle.

(b) Laboratory test

Table 4-3-7.5 Summary of the Laboratory Tests to Sand-and-Gravels From the Existing Dam Bodies

pit No.	Field moisture	Spe. gravity	Spe. Gravity/absorption		praticle size distribution			Compaction test	
	Wf (%)	(-37mm)	Bulk density	absorption (%)	fine (%)	sand (%)	gravel (%)	D_{max}(t/m3)	W_{opt}(%)
TP-1	5.97	2.69	2.34	1.87	5.00	23.26	71.74	1.95	11.0
TP-4	7.04	2.57	2.34	1.67	7.88	22.78	69.34	1.73	14.6
TP-14	9.50	2.59	2.25	2.52	10.20	24.98	64.82	1.77	16.0
TP-15	11.48	2.53	2.17	1.91	11.50	23.38	65.13	1.65	17.2
TP-16	7.81	2.64	2.35	1.68	6.87	23.99	69.14	1.95	12.7

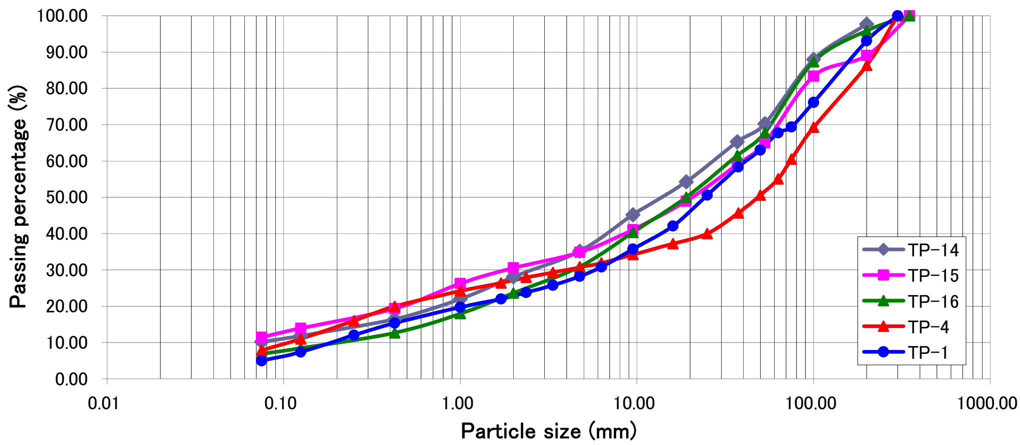


Figure 4-3-7.8 Particle Size Distribution Curve of Sand-and-Gravels from the Existing Dam Bodies

[Finding]

a. Moisture content; Field moisture contents are lower than the optimum moisture content by 5% to 7% approximately.
b. Water absorption; Water absorption is low enough to suggest the freshness, i.e. not weathered condition, of the gravels and cobbles.
c. Bulk density; Bulk density is relatively small; it would be affected by the mineral composition of rocks.
d. Gradational condition; Content percentage of the fine portion, i.e. silt and clay, ranging from 5% to 10% approximately suggests the permeability coefficient of the compacted layer ranging from $n \times 10^{-3}$ cm/sec to $n \times 10^{-4}$ cm/sec, which is consistent with the values obtained in the field permeability test.
e. Evaluation of the compaction degree; Relative density ranging from 91.6% to 93.7% shall be expressed to be “not loose but not so dense”.

Table 4-3-7.6 Summary of the Laboratory Test

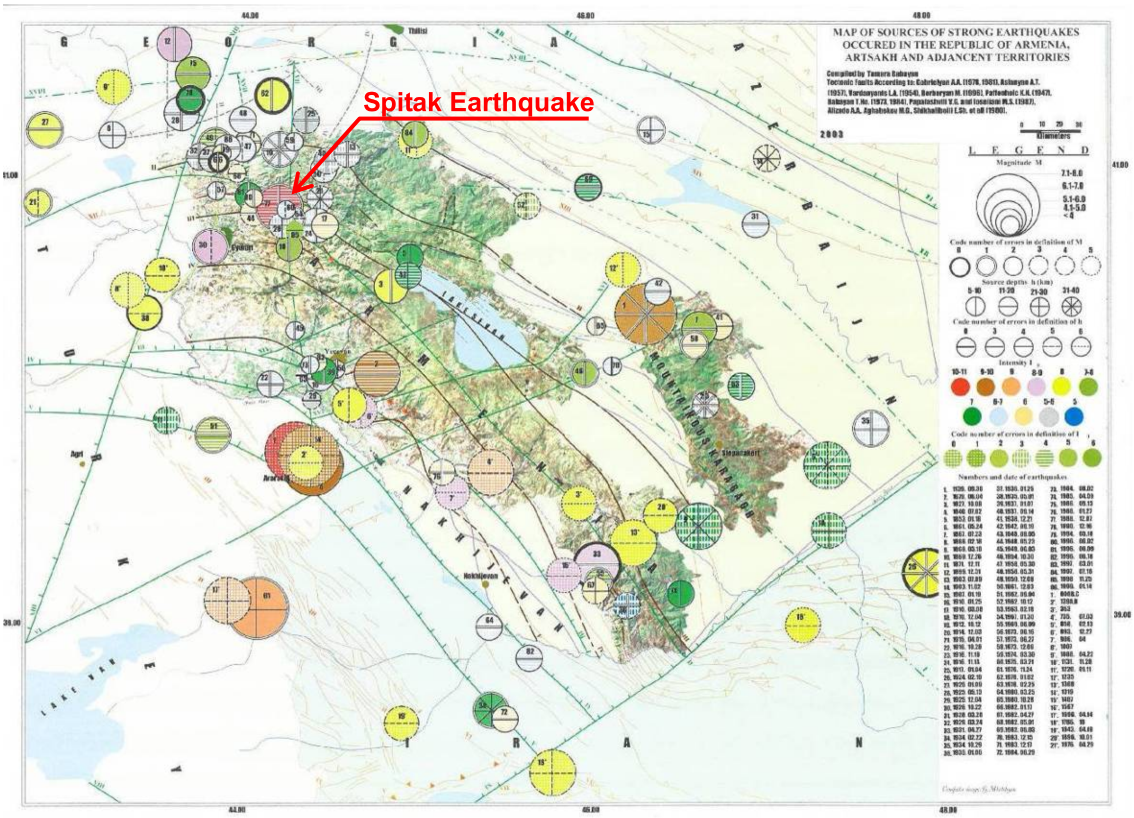
Item	Calculation formula	TP-14		TP-15		TP-16	
		Value	unit	Value	unit	Value	unit
①Total volume of the excavated material		80,100	cm3	108300	cm3	114600	cm3
②Total weight of the excavated material		156.2	kg	203.6	kg	237.2	kg
③Weight of the coarse portion (+37mm)	②×(100-65.25)/100	54.3	kg				
	②×(100-59.50)/100			82.5	kg		
	②×(100-61.48)/100					91.4	kg
④Weight of the fine portion (-37mm)	②－③	101.9	kg	121.1	kg	145.8	kg
⑤Bulk density of the coarse portion	from laboratory test	2.25					
				2.17			
						2.35	
⑥Volume of the coarse portion	③／⑤×1000	24124	cm3	37999	cm3	38881	cm3
⑦Volume of the fine portion	①－⑥	55976	cm3	70301	cm3	75719	cm3
⑧Wet density of the fine portion	④×1000／⑦	1.82	g/cm3	1.72	g/cm3	1.93	g/cm3
⑨Moisture content of the fine portion	from laboratory test	9.5	%				
				11.48	%		
						7.81	%
⑩Dry density of the fine portion	⑧／(1+⑨/100)	1.66	g/cm3	1.55	g/cm3	1.79	g/cm3
⑪Max. dry density in the compaction test	from laboratory test	1.77	g/cm3				
				1.65	g/cm3		
						1.95	g/cm3
⑫Compaction degree (relative density D)	⑩／⑪×100	93.9	%	93.7	%	91.6	%

4-3-8 Situations Related to the Safety of Facilities

(1) General situation of earthquakes in and around Armenia

Armenia national land is located at the northern edge of Arabia plate which is surrounded by Eurasia, Africa and India/Australia plates and Armenia has suffered from earthquakes caused by the movement of these plates.

Figure 4-3-8.1 shows the epicenters of main earthquakes until 2003. Epicenter is shown by circle symbol and size of that shows the scale of magnitude. One of the devastating earthquakes is Spitak earthquake happened 7th December 1988 with its magnitude 7.0. According to the records, this earthquake caused more than 25,000 fatalities, 365 damaged villages (from which 58 ones were fully ruined) and 13.3 billion Ruble of total physical damage. Spitak earthquake became a turning point to review policies to mitigate disaster damage.



Source) Atlas of Strong Earthquakes of the Republic of Armenia, Artsakh and Adjacent Territories from Ancient Times through 2003

Figure 4-3-8.1 Epicenters of Main Earthquake in and around Armenia until 2003

(2) Development situations of earthquake resistant design standards

Taking into account the lessons and learned from experiences through Spitak earthquake, the earthquake resistant design standard was reviewed and new standard was issued in 1994. This reviewed standard required severe earthquake resistant capacity for facilities. From the view point to mitigate damage by earthquake, this standard was well developed, in the other hand, however, industrial development activities had been limited because construction cost of facilities designed by this standard was high and some projects could not be feasible.

In 2006, the standard was reviewed and revised again in conformity with the actual situation, and renewed one namely "EARTHQUAKE RESISTANT CONSTRUCTION DESIGN CODES RABC II-6.02-2006" was issued. This standard is the latest standard as of May 2016.

(3) Assessment of PGA (Peak Ground Acceleration) coefficient k for design

Inertial force caused by earthquake (Fe) is calculated by the formula below in Armenian standard.

$$Fe = k \times m$$
$$k = A \times k_0 \times k_1 \times k_2$$

Where;

Fe: Inertial force caused by earthquake
k: PGA coefficient
m: Weight of target part of structure
A: Seismic impact coefficient
k_0: Soil condition coefficient
k_1: Permissive damage coefficient
k_2: Importance coefficient

1) Seismic impact coefficient (A)

Seismic impact coefficient A shows the peak acceleration[1] of the earthquake, which reoccurrence interval is 500 year, at the surface of engineering bedrock[2].

A at the target site is examined taking into consideration i) distance from target site to a target active fault and 2) scale of earthquake caused by a target active fault.

Detailed Seismic Zoning survey is conducted to estimate value of A at Yeghvard reservoir site. Outline procedure of this survey is shown as below.

i) Collection of information about historical earthquakes around reservoir site
ii) Collection of information about faults around reservoir site
iii) Modeling of geological conditions and faults
iv) Calculation of peak acceleration which occurred at the reservoir site (past earthquake) (*utilizing historical earthquake data)
v) Calculation of peak acceleration which will occur at the reservoir site (future earthquake) (*utilizing fault data)
vi) Selection of A for design

Figure 4-3-8.2 shows epicenters of historical earthquakes and model of faults around reservoir site.

As a result, 0.33 is calculated as maximum A and 0.298 is as reoccurrence period 500 year's value. According to Armenian standard, 0.298 can be selected as design value. However there is a village namely Nor Yerznka at the downstream of Dam No.1 and this village will be seriously damaged by flood in case Dam No.1 collapses. Therefore taking into consideration safety, maximum value **<u>0.33</u>** is selected as design value. This means designed facility has resistant capacity against maximum scale of scientifically predictable earthquake.

[1] A= Peak acceleration(gal) / 9.8m/s^2
[2] Soil layer with Vs= 700m/s

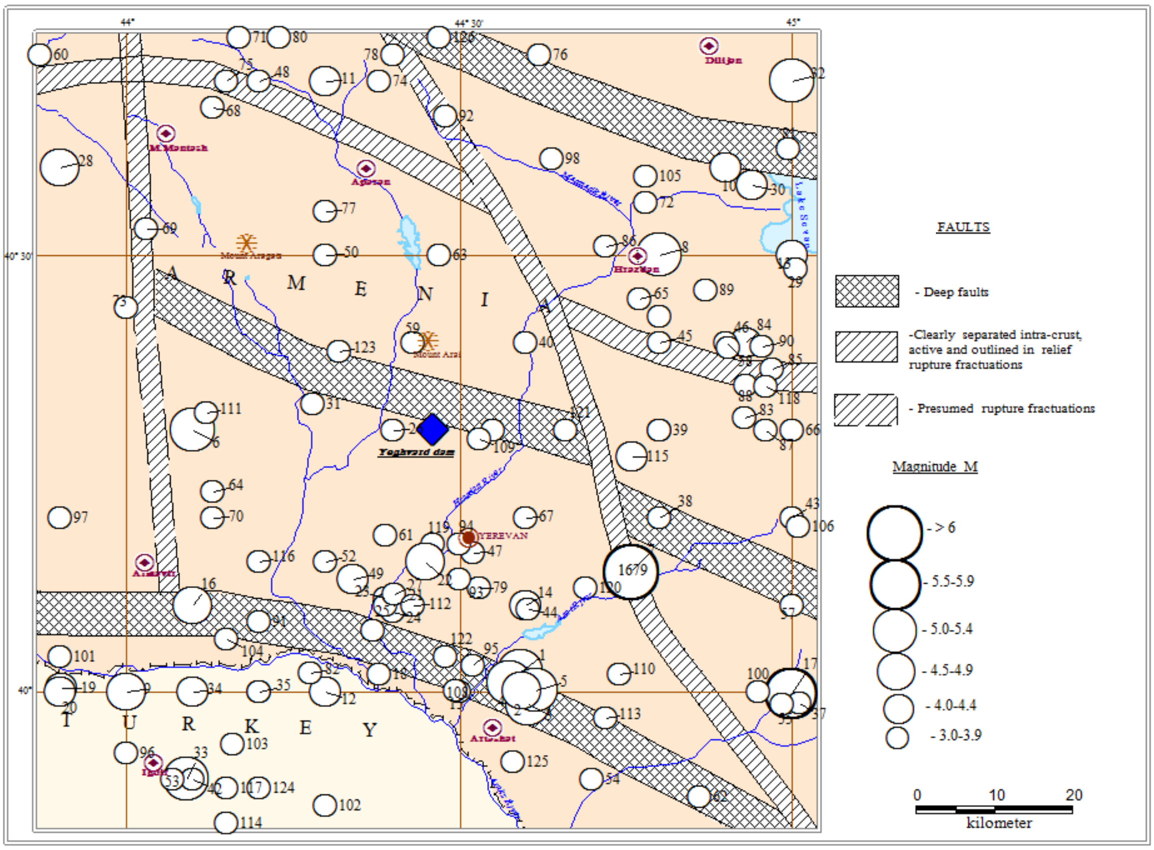


Figure 4-3-8.2 Epicenters of Historical Earthquakes and Model of Faults around Reservoir Site

2) Soil condition coefficient (k_0)

Peak acceleration at ground surface (PGA) is bigger than that at the surface of engineering bedrock surface because earthquake wave becomes higher during passing through soil layer lying between engineering bedrock and ground surface. Soil condition coefficient k_0 shows this increasing ratio.

Since k_0 highly depends on the vertical variation of soil layers between engineering bedrock and ground surface, Seismic Micro Zonation (SMZ) survey is conducted to grasp the vertical variation of soil layers and to estimate k_0. Outline procedure of survey is shown as below.

i) Collection of existing geological survey results
ii) Conducting additional geological drilling surveys
iii) Measurement of the response of each geological condition against artificial shake caused by small blustering or dropping large stone
iv) Modeling of geological condition at reservoir site
v) Analysis of k_0 and calculation of PGA (=A × k_0)

Figure 4-3-8.3 shows the seismic hazard map (contour map of PGA value (=$A \times k_0$))within reservoir area. According to this map, maximum PGA within reservoir area is 0.36 however at Dam No.1 is 0.32 and 0.31 at Dam No.2. Taking into consideration safety, **0.32**, bigger one at dam bodies location, is selected as design value for both Dam No.1 and No.2.

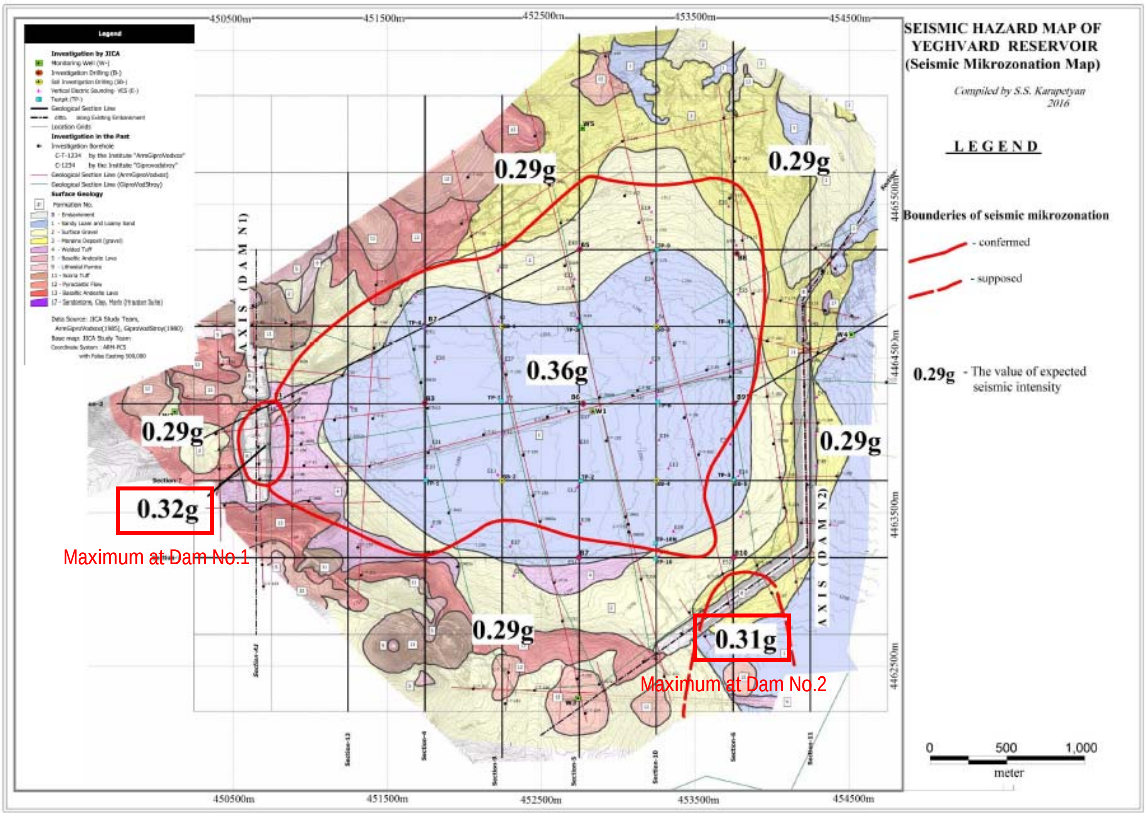


Figure 4-3-8.3 Seismic Hazard Map of Yeghvard Reservoir

3) Permissive damage coefficient (k_1)

Permissive damage coefficient k_1 is prescribed according to the class of facility and its structure as shown in Table 4-3-8.1. Since Yeghvard reservoir is earth-fill structure, **0.30** is applied to k_1.

Table 4-3-8.1 Permissive Damage Coefficient (k_1)

Class and Type of Structure	k_1
For Class I water-retaining hydrotechnical structures	0.40
For other concrete and reinforced concrete hydrotechnical structures	0.35
For earth-fill structures	0.30

4) Importance coefficient (k_2)

Importance coefficient k_2 is prescribed according to the class of facility and its structure as shown in Table 4-3-8-2. Since Yeghvard reservoir is classified as Class-I, **1.20** is applied to k_2.

Table 4-3-8.2 Importance Coefficient (k_2)

Class and Type of Structure	k_2
For Class I water-retaining hydrotechnical structures	1.20
For other concrete and reinforced concrete hydrotechnical structures	1.00

*Classification of reservoir is described in "6-5-6 Basic Design of Dams and Reservoir."

5) PGA coefficient (k) for design

According to examined results above, PGA coefficient k for design is calculated as below.

$$k=(A \times k_0) \times k_1 \times k_2 = 0.32 \times 0.3 \times 1.2 = 0.1152 \rightarrow \underline{\mathbf{0.12}}$$

Reference

In Japanese present standard, value of k for fill dam constructed on the rock basement is prescribed from 0.10 to 0.18. Also basement of Dam No.1 and No.2 of Yeghvard reservoir is judged as soil category I, rock basement. Since calculated value of k is almost same as Japanese standard, Yeghvard reservoir designed with k=0.12 will have almost same safety against earthquake as Japanese dams designed under present standard, which have no experience of collapse by earthquake.

(4) Concerning matters for emergency discharge after earthquake

In case an emergency situation happens on a reservoir, fast water level lowering by emergency discharging is required to avoid condition becomes worse or to mitigate flood damage in case dam collapse. It is said that main emergency situations on a dam are the following 3 cases. c) is supposed to be the main case for Yeghvard reservoir.

i) Extraordinary increasing of leakage expected to lead efflux of dam body material
ii) Land sliding around the reservoir
iii) Damage on the reservoir by earthquake

Dam body is designed taking into account the inertial force caused by earthquake so that dam body has resistant capacity against predictable scale earthquake. However there is a possibility that unpredictable scale earthquake happens and dam body is damaged. Therefore emergency discharge structure is required even if dam body is designed by earthquake-resistant design.

1) Regulation in Armenian standard

The only description about emergency discharging in Armenian standard “Main Provisions for Hydro Technical structures, RACN 33-01-2014” is shown as below.

The operation regimes of hydro technical structures such as filling and discharging orders shall be realized in accordance with reservoir operation rules, which include rules on water utilization, technical operation and rehabilitation rules agreed with interested organizations in defined order for each reservoir.

According to the description above, there are no common regulation and own emergency discharging rules for Yeghvard reservoir shall be defined taking into account its specific conditions.

2) Specific condition of Yeghvard Reservoir

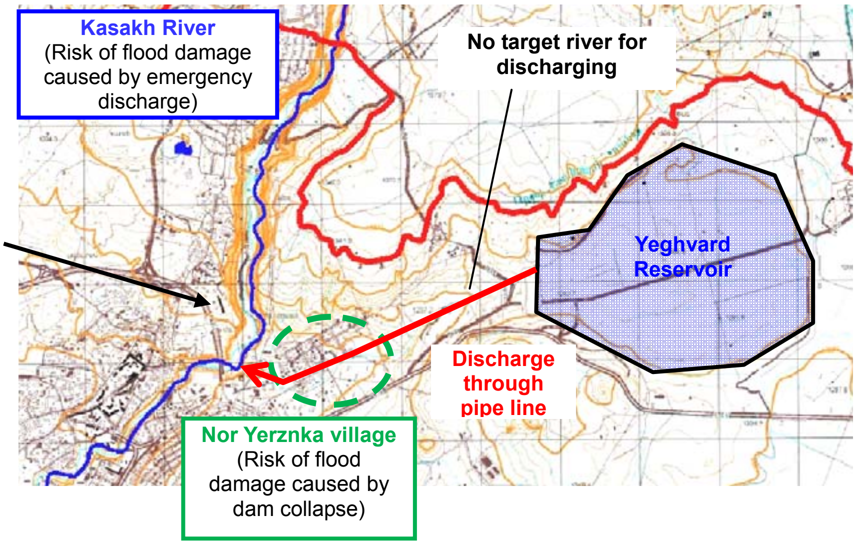
There is no river just downstream of dam bodies which can be a destination of discharging from Yeghvard reservoir because Yeghvard reservoir is planned not across the river but closing plane land by two (2) dam bodies. The nearest river from Yeghvard reservoir is Kasakh River and this river is only the destination of discharging. It is planned to discharge from Yeghvard reservoir through pipeline.

There locates Nor Yerznka village between Yeghvard reservoir and Kasakh River. In case of dam collapse, this village will be seriously damaged by flood. Therefore if dam body is damaged by earthquake, water level shall be lowered as fast as possible (emergency discharge volume shall be as much as possible) to mitigate risk of dam collapse and damage in case dam collapse.

While there are some facilities along Kasakh River and these facilities will suffer from flood damage in case huge volume of water is discharged from Yeghvard reservoir.

Therefore flood damage risk caused by dam collapse at Nor Yerzunka village and caused by huge volume discharging along Kasakh River has tradeoff relation as shown in the Figure 4-3-8.4. Target discharge volume shall be examined taking into account this trade off relation.

A facility just besides Kasakh River



Emergency Discharge Volume	Damage Risk along Kasakh River (= Risk of flood damage caused by emergency discharge)	Damage Risk on Nor Yerznka village (= Risk of flood damage caused by dam collapse)
Huge Small	High Low	Low High

Figure 4-3-8.4 Trade off Relation of Risk along Kasakh River and Nor Yerznka Village

4-4 Current Conditions of Irrigation Network System with Related Structures

4-4-1 Overview of Current Irrigation System

Current irrigation system which distributes water to 8,391 ha through Arzni-Shamiram canal, Lower Hrazdan canal and Ranchpar pump station, is divided into two (2) parts. First part is the east side of Kasakh River before Arzni-shamiram canal crossing the Kasakh River, which area irrigated by Arzni-shamiram canal. And the second part is the west side of Kasakh River after Lower Hrazdan canal passing the Kasakh River, which are irrigated by Lower Hrazdan canal.

The Ranchpar pump station consists of two (2) pumps; i.e. No.1 in Ararat Marz and No.2 in Armavir Marz. The station No.1 lifts up the collected drain water near lower part of Hrazdan River to pump station No.2, and lifted water is distributed to Lower Hrazdan canal through the No.2. These pump stations are operated by Water Supply Agency (WSA).

Table 4-4-1.1 lists the cultivated crops and those area under current irrigation plan. Those areas are located in Yeghvard WUA in Kotayk Marz, Ashrarak WUA in Aragatsotn and Armabvir Marzes, Vagharshapat WUA in Armavir Marz, and Khoy WUA in Armavir Marz respectively.

Table 4-4-1.1 Current Irrigation Area and Crops

Crop	Area (ha)
Wheat	1,560
Vegetable	2,819
Potato	669
Grape	1,110
Alfalfa	910
Fruit	831
Others	492
Total	8,391

Source) MOA

Most of the areas are irrigated by furrow irrigation method. However, the area lower part of Lower Hrazdan canal has issues about water shortage. It is caused by difficulty of pump's water distribution due to deficit of ground water, conveyance water loss and so on. The current situation of ground water level and amount of collected water volume by drain canal for irrigation use becomes worse year by year, especially in Akanalich and Metsamor pump stations, which located in Ararat Plain.

As a countermeasure to the water shortage, especially in Khoy and Vagharshapat WUAs, those WUA install a lot of wells and tackle with water shortage issues by themselves. Consequently, WUA strongly hope to shift from pump-based irrigation to gravity system. Figure 4-4-1.1 shows the scattered pump facilities which located in Khoy WUA and Vagharshapat WUA, Table 4-4-1.2 lists the number of pump facilities in those WUAs, and Figure 4-4-1.2 shows the current situation of schematic diagram of irrigation network.

Table 4-4-1.2 Pump Facilities in Khoy and Vagharshapat WUA

WUA	Deep Well	Pump Station
Khoy	61	10
Vagarshapat	72	3
Total	133	13

Note) Except for WSA of PS are. Akanalich, Metsamor, Ranchpar No.1, 2 pump stations
Source) JICA Study Team

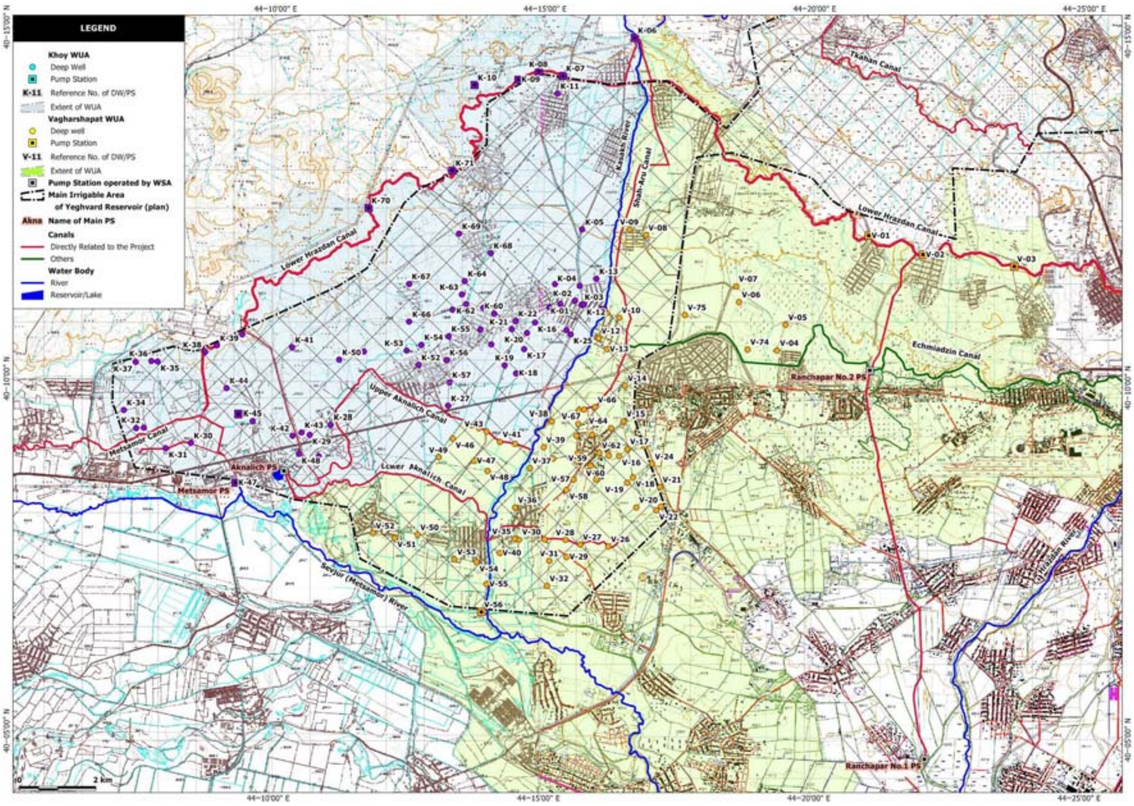
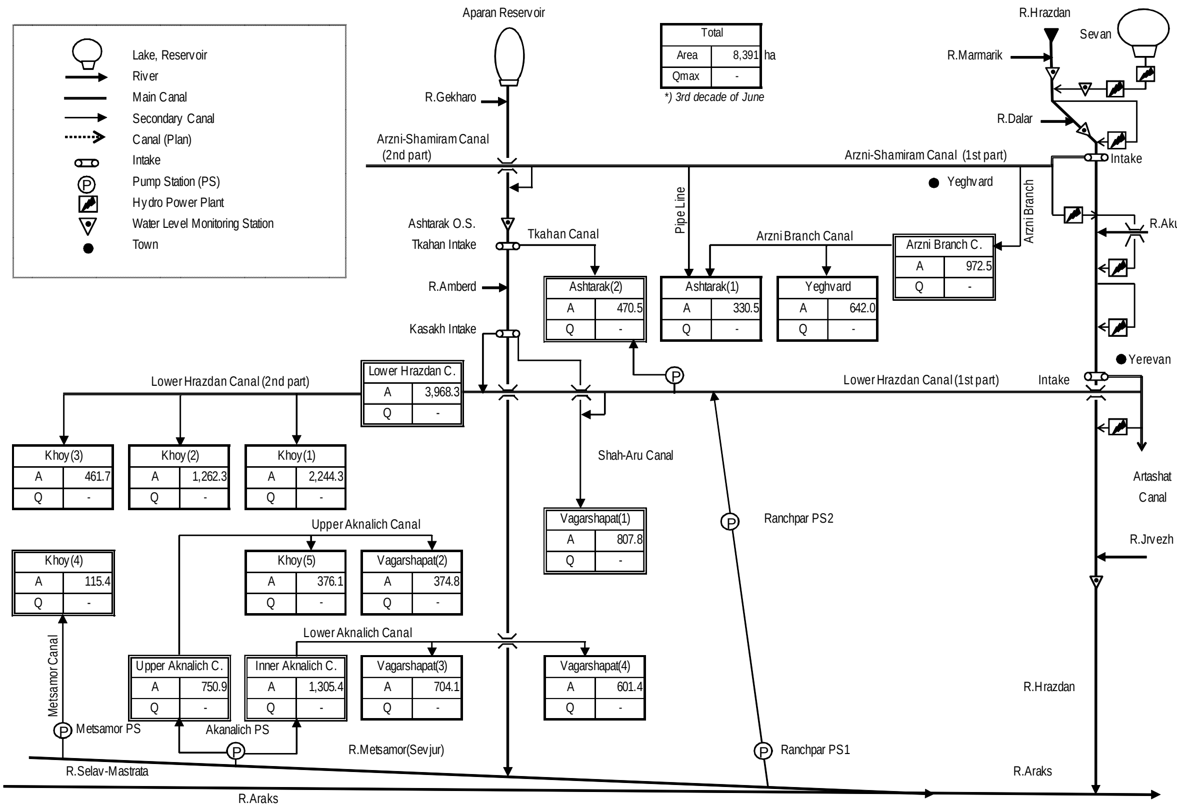


Figure 4-4-1.1 Scattered Pump Facilities Located in Khoy WUA and Vagharshapat WUA



Schematic Diagram of Irrigation Network (Current State)

Figure 4-4-1.2 Current Situation of Schematic Diagram of Irrigation Network

4-4-2 Current Conditions of Irrigation Network System

Irrigation areas targeted by the Yeghvard irrigation system are divided into two(2) areas, namely;

1) The area is composed of Yeghvard and Ashtarak WUAs which are located at east of Kasakh River and are irrigated by a) Arzni-Branch canal and b) Takahan canal through Kasakh River.

2) The other area is composed of Vagharshapat and Khoy WUAs which are located at west of the Kasakh River and are irrigated by c) Shah-Aru and d) Lower Hrazdan canals through Kasakh intake and Ranchpar pump station No.1 and No.2. These area, also, are irrigated by e) Upper Akhnalich, f) Inner Aknalich and g) Metsamor canals sourced by two (2) pump stations (Aknalich and Metsamor PSs).

The aim of the irrigation facility survey is to understand current irrigation situation for the targeted areas including the above seven (7) canals, "a)" to "g)", by field surveys as well as interviews to related WUAs and organizations.

A survey for target facilities are carried out for major irrigation facilities in the areas, of which location map is shown in Figure 4-4-2.1.

Responsibility	Facility and structure	Location
Yeghvard WUA	Arzni-Branch canal, BP. to PK120	
Ashtarak WUA	Arzni-Branch canal, PK120 to EP.	
	Takahan canal	
Vagharshapat WUA	Shah-Aru canal	
	Kasakh Intake at right bank	
Khoy WUA	Upper Aknalich canal	
	Inner Aknalich canal	
	Metsamor canal	
	Kasakh Intake at left bank	
Water Supply Agency (WSA)	Lower Hrazdan canal	
	Aknalich PS.	
	Metsamor PS	
	Ranchpar PS. 1	
	Ranchpar PS. 2	

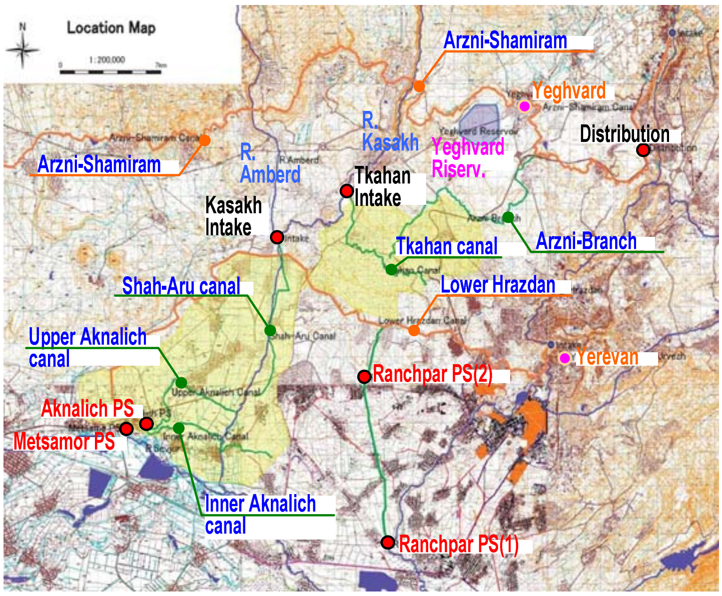


Figure 4-4-2.1 Location Map of Irrigation Facilities

Inventory survey for the facilities in target area is conducted as followings;

a) Survey on main canal in the Project areas
  ・Condition of irrigation and facilities (Deterioration and damage)
  ・Diversion from other water source

b) Survey on Kasakh Intake and main pump stations
  ・Condition of facilities and pump stations

(1) Result of inventory survey for targeted canal

a) Arzni-Branch canal system

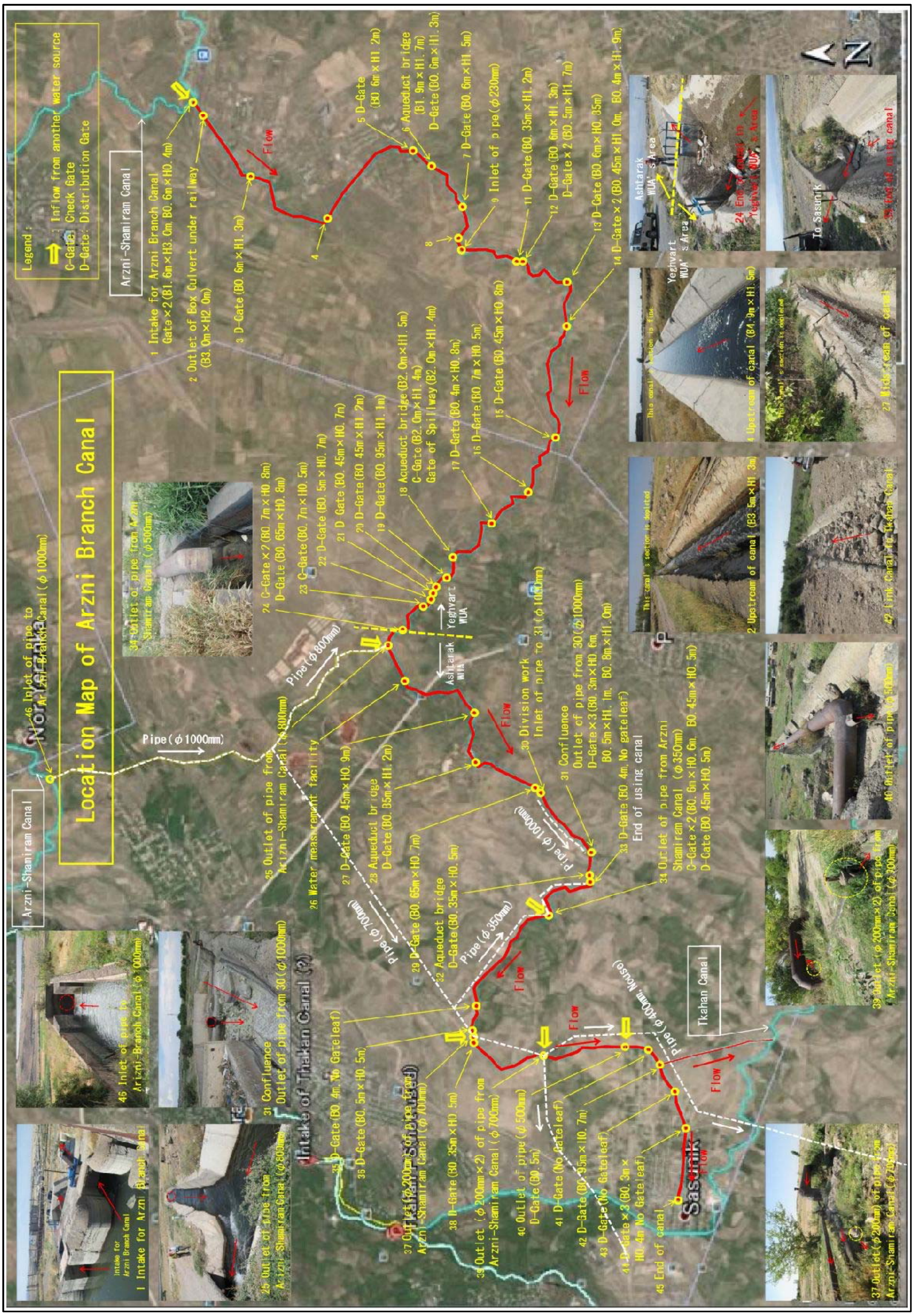


Figure 4-4-2.2 Location of the Irrigation Facilities of Arzni Branch Canal

b) Takahan canal system

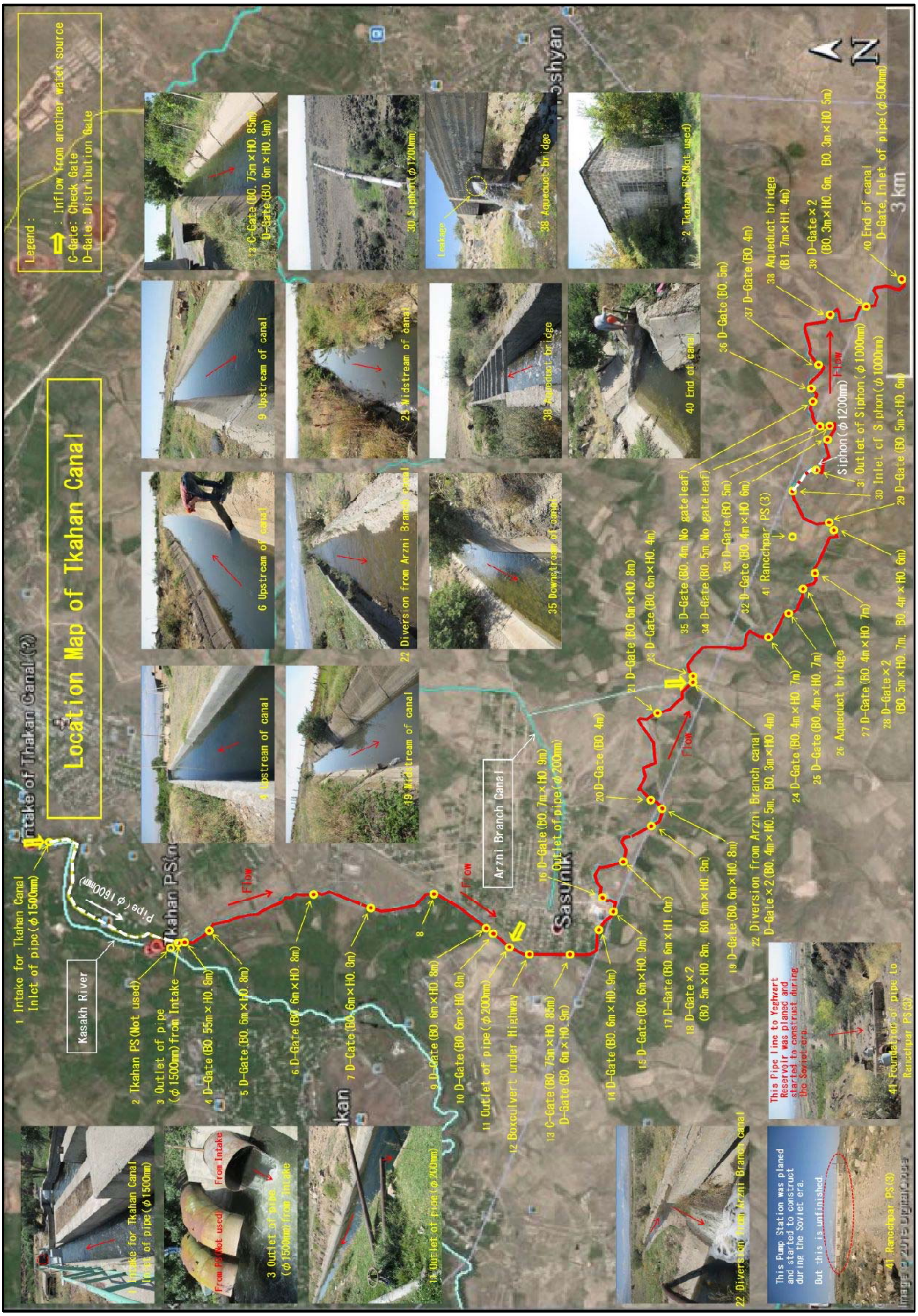


Figure 4-4-2.3 Location of the Irrigation Facilities of Takahan Canal

c) Shah-Aru canal system

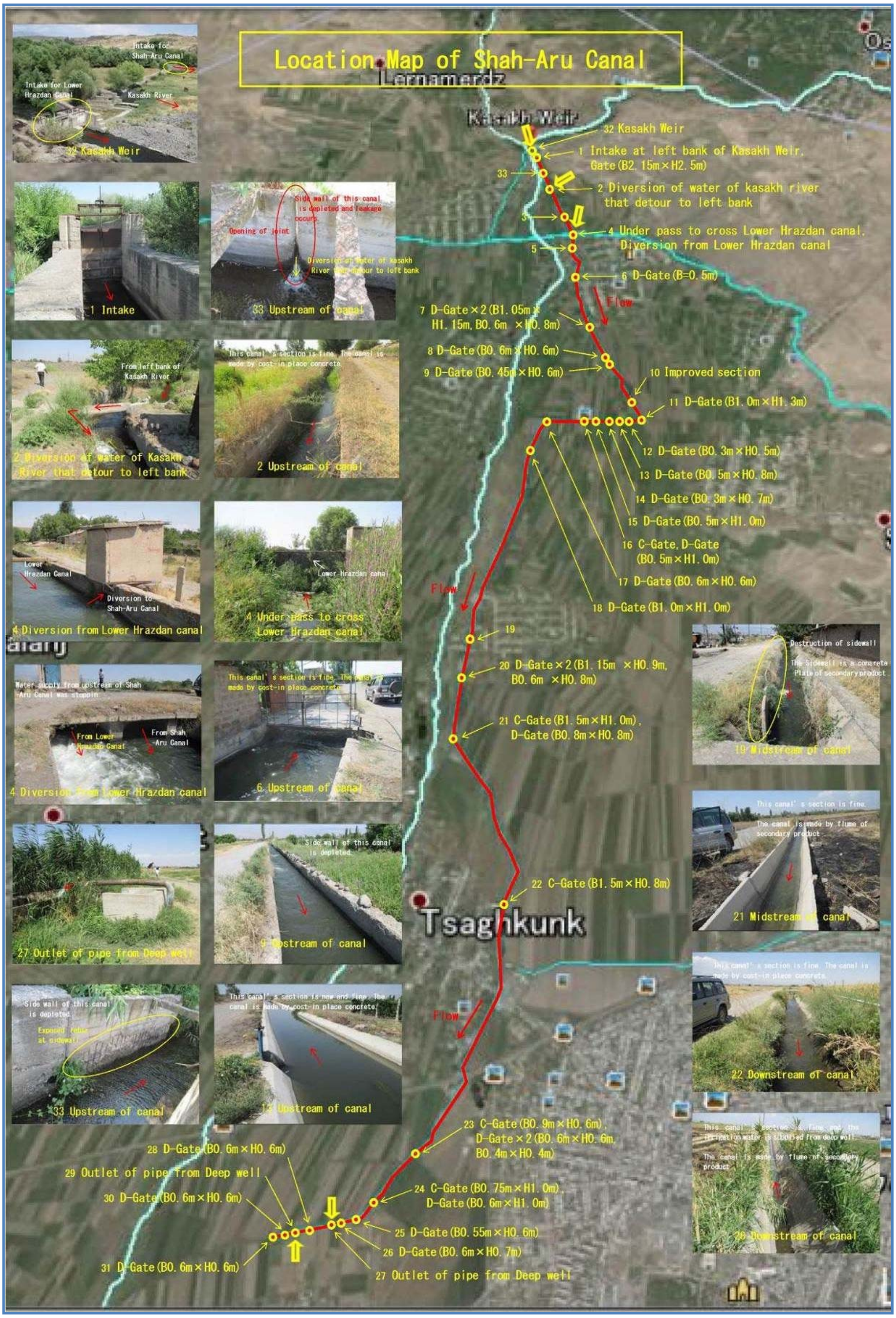


Figure 4-4-2.4 Location of the Irrigation Facilities of Shah-Aru Canal

d) Upper Aknalich canal

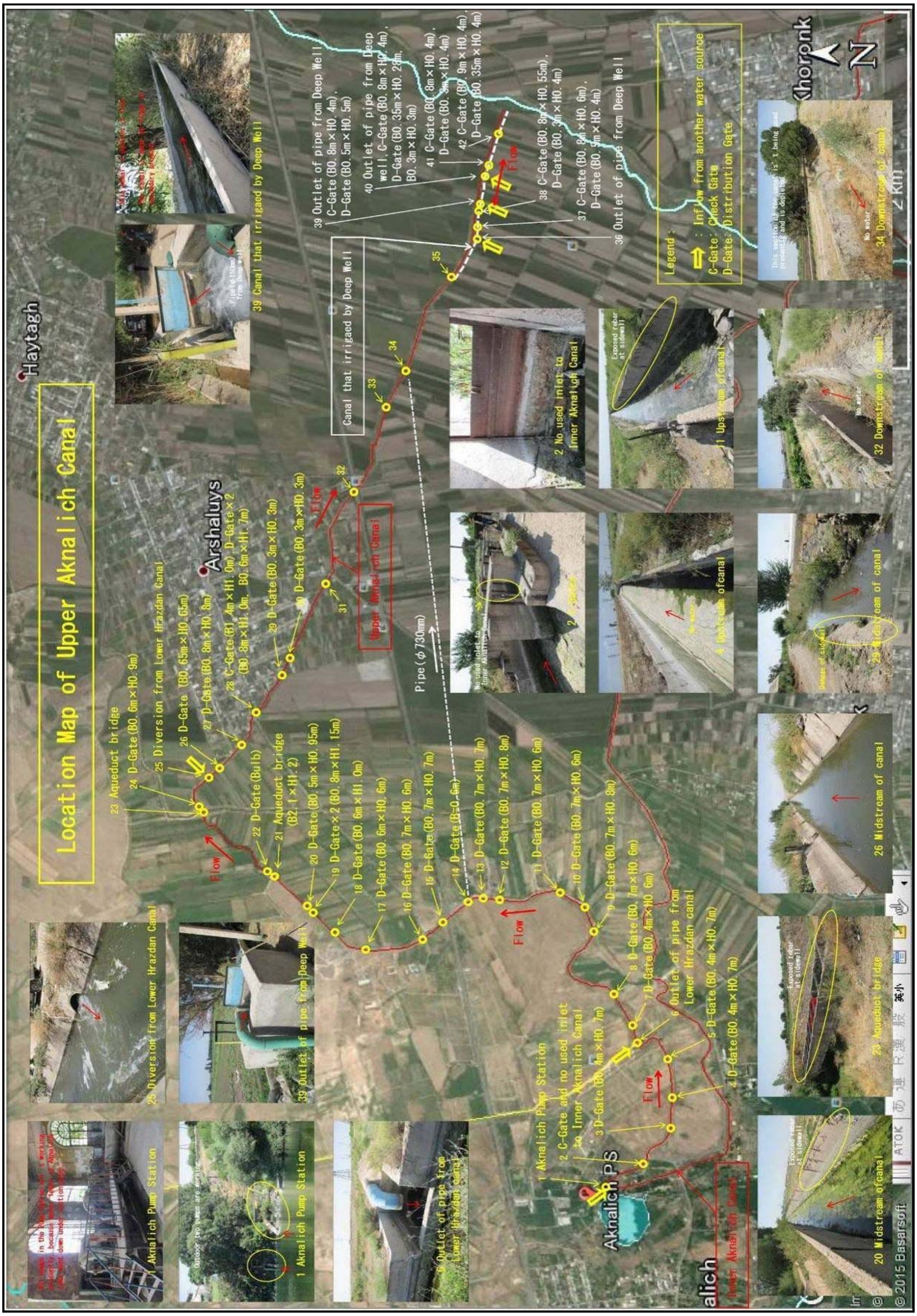


Figure 4-4-2.5 Location of the Irrigation Facilities of Upper Aknalich Canal

e) Inner Aknalich canal

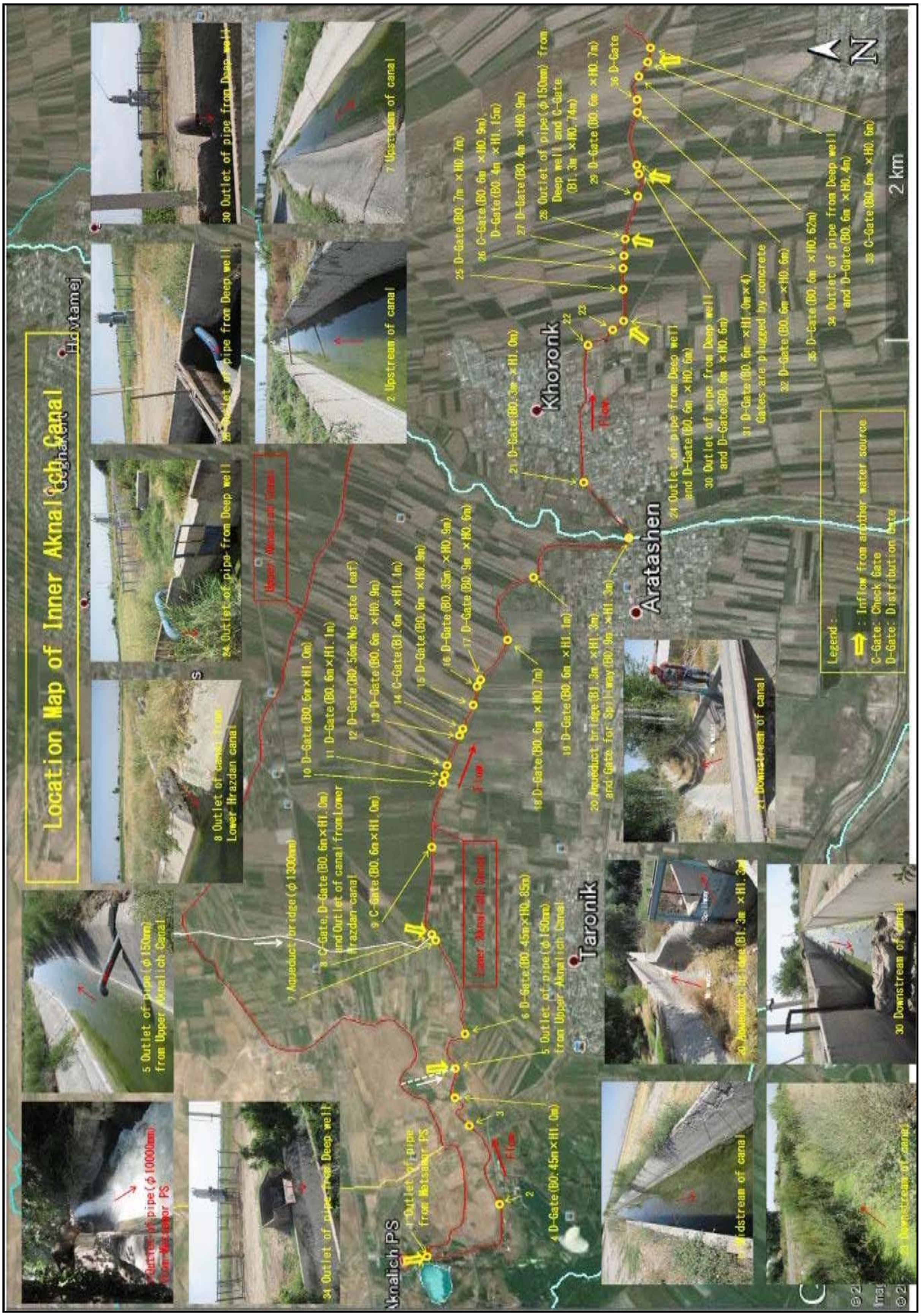


Figure 4-4-2.6 Location of the Irrigation Facilities of Inner Aknalich Canal

f) Upper Metsamor canal

Figure 4-4-2.7 Location of the Irrigation Facilities of Metsamor Canal

g) Lower Hrazdan canal

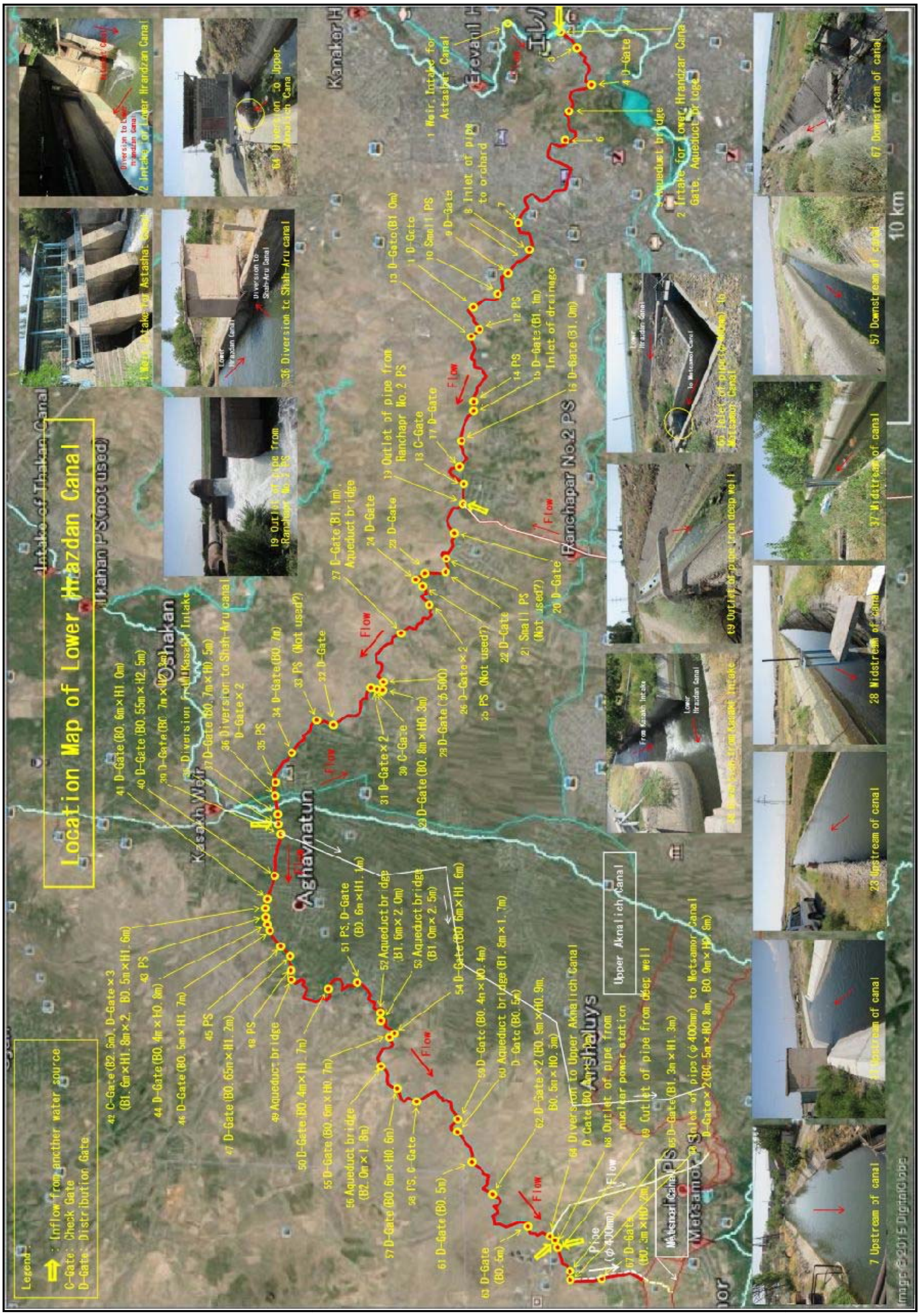


Figure 4-4-2.8 Location of the Irrigation Facilities of Lower Hrazdan Canal

(2) Structural dimensions and conditions of canal

According to the survey by WB Rehabilitation Program, structural dimensions and conditions of targeted canals are shown in Table 4-4-2.1 to 4-4-2.5.

Table 4-4-2.1 Arzni Branch Canal's Structural Dimensions and Conditions

Arzni branch canal							
NN	D/M	Length	Conser Code	b, m	B, m	H_{st}, m	Discharge Q, m^3/s
1	0+00 0+90	90	C	1.0	2.5	1.5	7.0
2	0+90 2+00	110	C	1.0	2.5	1.5	7.0
3	2+00 2+35	35	C	0.7	2.2	1.5	7.0
4	2+35 4+95	260	C	0.6	2.1	1.5	7.0
5	4+95 6+00	105	C	0.7	2.5	1.8	7.0
6	6+00 10+20	420	C	0.8	2.8	2.0	7.0
7	0+25		B				7.0
8	3+50		B				7.0
9	8+80		B				7.0
10	9+10		B				7.0
11	10+00	–	G				–
12	10+20 11+20	100	C	0.8	2.6	1.8	7.0
13	11+20 11+50	30	C	2.5	2.5	2.5	7.0
14	11+50 29+00	1750	C	1.0 2.5	3.0 5.0	2.0 2.5	7.0
15	11+70	–	OUT				–
16	29+00 32+00	300	C	1.8	4.3	2.5	7.0
17	37+60	–	OUT				–
18	32+00 37+90	590	C	1.3	3.8	2.5	7.0
19	37+90 38+25	35	C	2.0	2.0	2.5	7.0
20	38+25 38+75	50	A	2.0	2.0	2.5	7.0
21	38+75 39+10	35	C	2.0	2.0	2.5	7.0
22	39+10 49+10	1000	C	1.5	4.0	2.5	7.0
23	46+00	–	OUT				–
24	49+10 52+00	290	C	8.0 1.5	3.1 4.5	2.5 3.0	7.0
25	52+00 56+00	400	C	1.2	3.8	2.6	6.0
26	56+00 56+50	50	C	1.3	3.9	2.6	6.0
27	56+50 61+00	450	C	1.3	3.9	2.6	6.0
29	59+00, 59+30; 59+40	3	OUT				–
30	61+00 64+50	350	C	1.2	3.6	2.4	6.0
31	64+50 69+00	450	C	1.2	3.7	2.5	6.0
32	69+00 72+80	380	C	1.3	3.3	2.0	4.3
33	72+80 88+00	1520	C	1.3	3.3	2.0	4.3
34	88+00 97+00	900	C	1.3	3.6	2.3	4.3
35	97+00 105+00	800	C	1.2	3.9	2.7	4.3
36	105+00 107+50	250	C	1.2	3.9	2.7	4.0
37	107+50	–	OUT				–
38	107+50 107+90	40	A	2.0	2.0	2.0	3.6
39	107+90 123+00	1510	C	1.5	4.1	2.6	3.6
40	123+00 130+00	700	C	0.8	2.0	1.2	2.8
41	130+00 136+00	600	C	1.0	2.7	1.7	2.8
42	136+00	–	OUT				–
43	136+00 137+50	150	C	0.8	2.3	1.5	2.8
44	137+50 143+00	550	C	0.8	2.3	1.5	2.8
45	143+00 143+80	80	C	1.5	1.5	1.5	2.8
48	143+80 144+50	70	C	0.4	1.6	1.2	2.8
49	144+50 145+00	50	A	1.5	1.5	1.2	2.8
50	145+00 145+50	50	C	0.8	2.3	1.5	2.8
51	145+50 148+50	300	C	0.5	2.0	1.5	2.0
52	148+50 152+50	400	C	0.5	1.9	1.4	2.0
53	152+00		S				2.0
54	152+50 170+50	1800	S		d = 700		2.0
55	145+50		B				2.8

Constraction Code
C – Canal
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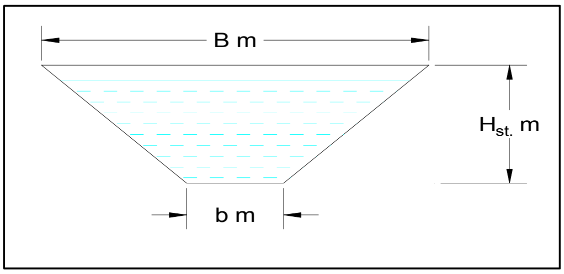

Table 4-4-2.2 Takahan Canal's Structural Dimensions and Conditions

Tkahan Canal							
NN	D/M	Length m	Conser Code	b, m	B, m	H_{st}, m	Discharge Q, m^3/s
1	2	3	4	5	6	7	8
1	0+00 3+50	350	C	2.5	2.5	1.5	4.3
2	3+50 5+00	150	C	2	4.5	2	4.3
3	5+00	1	B				
4	5+00 9+50	450	C	2	4.7	1.8	4.3
5	9+50 20+00	1050	C	2	5	2.1	4.3
6	20+00 22+50	250	C	1.8	4.6	1.9	4.3
7	22+50 25+50	300	C	2.8	2.8	1.5	4.3
8	25+50 27+50	200	C	2.8	2.8	1.5	4.3
9	27+50 28+60	110	C	2.8	2.8	1.5	4.3
10	28+00	1	OUT				–
11	28+60 32+60	400	C	1.6 2.0	4.2 5.0	1.7 2.0	4.3
12	32+60 50+00	1740	C	1.0 1.4	3.2 3.6	1.5	4.3
13	50+00 61+00	1100	C	0.6 1.0	2.8 3.2	1.5	4.0
14	61+00 82+00	2100	C	1	4	2	4.0
15	68+80; 80+00	1	OUT				–
16	82+00 83+00	100	C	1	3.2	1.5	3.0
17	83+00 83+50	50	A	1.5	1.5	1.8	3.0
18	83+50 84+50	100	C	1	3.2	1.5	3.0
19	84+50 86+00	150	C	1	3.4	1.6	3.0
20	86+05	1	OUT				–
21	86+00 95+00	900	C	1	3.5	1.7	3.0
22	90+05; 91+00	1	OUT				
23	95+00 96+00	100	C	1	3.5	1.7	2.1
24	96+00 98+50	250	S	d=1200mm			2.1
25	98+50 120+00	2150	C	0.9	2.9	1.3	2.1
26	120+00 130+00	1000	C	0.8	2.6	1.2	2.1
27	20+00; 22+50; 31+50; 40+00; 41+00; 80+05; 86+00; 90+00		B	–	–	–	–
28	33+50; 50+00; 83+55		OUT	–	–	–	–

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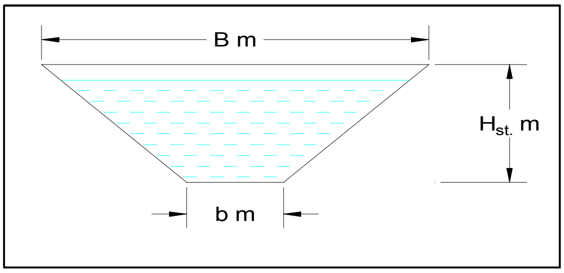

Table 4-4-2.3 Shah-Aru Canal's Structural Dimensions and Conditions

Shah-Aru Canal							
NN	D/M	Length	Conser Code	b, m	B, m	H_{st}, m	Discharge Q, m^3/s
1	0+00 2+00	200	C	1.5	1.5	1.8	2.0
2	2+00 3+40	140	C	1.5	1.5	1.0	2.0
3	3+40 4+00	60	C	1.5	1.5	0.8	2.0
4	4+00 9+50	550	C	1.5	1.5	1.0	2.0
5	9+50 11+00	150	C	1.5	1.5	1.0	2.0
6	11+00 28+00	1700	C	2.2	2.2	1.0	3
7	28+00 34+00	600	C	2	2	1.0	3
8	34+00 41+00	700	C	1.5	3.5	1.0	2.0
9	41+00 50+00	900	C	1.0	3.0	1.0	2.0
10	50+00 56+00	600	C	1.0	3.0	1.0	2.0
11	56+00 59+00	300	C	1.0	3.0	1.0	1.5
12	59+00 67+00	800	C	1.0	3.0	1.0	1.0
13	67+00 68+50	150	C	1.0	3.0	1.0	1.0
14	68+50 70+00	150	C	1.0	3.0	1.0	1.0
15	70+00 84+00	1400	C	1.0	3.0	1.0	1.0
16	84+00 93+00	900	C	1.0	3.0	1.0	0.7

Table 4-4-2.4 Lower Hrazdan Canal's Structural Dimensions and Conditions (1/2)

Lower Hrazdan Main canal II stage							
NN	D/M	Length	Conser Code	b, m	B, m	H_{st}, m	Discharge Q, m^3/s
1	0+00 3+00	300	S	3	3	1.5	7
2	3+00 6+50	350	C	2	6	2	7
3	6+50 21+50	1500	C	2	6	2	7
4	21+50 26+00	450	C	2	2	2.5	8
5	26+00 37+50	1150	C	2	6	2	8
6	37+50 40+00	250	C	2	6	2	5
7	40+00 46+70	670	C	2	6	2	5
8	46+70 47+70	100	A	3.5	3.5	2.5	3
9	47+70 80+35	3265	C	1.5	7.5	3	3
10	80+35 107+35	2700	C	1.5	7.5	3	3
11	107+35 159+35	5200	C	1.5	6.5	2.5	3
12	159+35 218+70	5935	C	1.5	5.5	2	3

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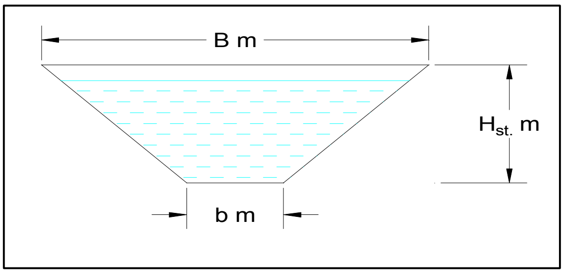

Table 4-4-2.5 Lower Hrazdan Canal's Structural Dimensions and Conditions (2/2)

Lower Hrazdan Main canal I stage							
NN	D/M	Length	Conser Code	b, m	B, m	H_{st}, m	Discharge Q, m^3/s
1	0+00	0	IN	5	5	3	13
2	0+00 1+13	113	A	3	3	3.5	10
3	1+13 4+15	302	C	3	6.5	3.5	10
4	4+15 4+80	65	C	6.5	3	3.5	10
5	4+80 12+00	720	C	3	10	3.5	10
6	12+00 12+50	50	C	3	10	3.5	10
7	12+50 14+80	230	C	3	10	3.5	10
8	14+80 15+80	100	C	3	10	3.5	10
9	15+80 34+20	1840	C	3	10	3.5	10
10	34+20 38+20	400	C	3	10	3.5	10
11	38+20 57+20	1900	C	3	10	3.5	10
12	57+20 61+00	280	C	3	10	3.5	10
13	61+00 64+80	380	C	3	10	3.5	10
14	64+80 73+10	830	C	4	4	2.5	10
15	73+10 77+20	410	C	4	4	2.5	10
16	77+20 77+70	50	C	4	4	2.5	10
17	77+70 83+44	574	C	3	10	3.5	10
18	83+44 84+05	71	A	3.5	3.5	3.5	10
19	84+05 88+05	400	C	3	10	3.5	10
20	88+05 90+50	245	C	3	10	3.5	10
21	90+50 93+40	290	C	3	10	3.5	10
22	93+40 98+00	460	C	3	10	3.5	10
23	98+00 98+70	7	A	3.5	3.5	3.5	10
24	98+70 107+00	830	C	3.5	3.5	3.5	10
25	107+00 118+00	1100	C	3	10	3.5	10
26	118+00 132+00	1400	C	3	10	3.5	10
27	132+00 144+50	1250	C	3	9	3	10
28	144+50 146+50	200	C	3	9	3	10
29	146+50 188+40	5650	C	3	9	3	10
30	188+40 203+00	1460	C	2	7	2.5	9
31	203+00 227+00	2400	C	3	9	3	9
32	227+00 248+00	2100	C	3	9	3	8
33	248+00 254+00	600	C	3	9	3	8
34	254+00 271+50	1750	C	3	8	2.5	8
35	271+50 273+50	200	C	2	7	2.5	8
36	273+50 282+12	862	C	2	7	2.5	8
37	282+12 282+60	48	C	4	4	3	7
38		35	OUT				

Constraction Code
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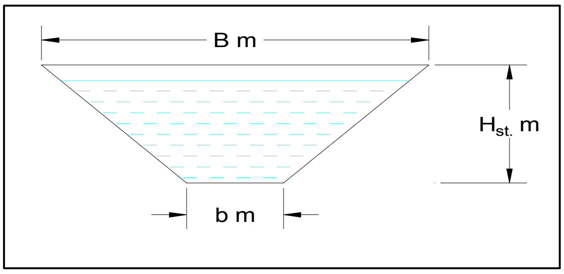


(3) Major pump station

The situation of existing pump stations is shown in Figure 4-4-2.9;

Responsibility	Facility and structure	Picture
Khoy WUA	Aknalich PS. Constructed in 1926 yr 3pumps at outside are installed P1 :0.065m^3/s P2: 0.265m^3/s P3 :0.75m^3/s 4pumps at house are installed P1 :0.4m^3/s P2: -m^3/s (expired) P3 :-m^3/s (expired) P4 :-m^3/s (expired)	 Inside pump station  Outside pump station
	Metsamor PS Constructed in 1960yr 4pumps are installed P1 :0.32m^3/s P2: 0.55m^3/s P3 :0.95m^3/s P4 :0.35$m^{3/}$s P2 is only to operate in once per 2days. others are suspended.	 Inside pump station  Pipeline from pump station
Water Supply Agency (WSA)	Ranchpar PS. 1 Constructed in 1985 yr Major rehabilitation in 2011 by Millennium Challenging Cooperation(MCC) 4pumps made in Turkey are re-installed. P1 :1.75m^3/s P2: 1.75m^3/s P3 :1.75m^3/s P4 :1.75$m^{3/}$s ※ Normally 5.3m^3/s discharge of 75% Max.	 Pump station (out view)  Pump station (inside)
	Ranchpar PS. 2 Constructed in 1985 yr Major rehabilitation in 2011 by Millennium Challenging Cooperation(MCC) 4pumps made in Turkey are re-installed. P1 :0.92m^3/s P2: 0.92m^3/s P3 :1.30m^3/s P4 :1.30$m^{3/}$s	

Figure 4-4-2.9 Situation of Existing Pump Stations

(4) Kasakh intake

Existing Kasakh Intake has following situations by visual survey and interview.

- ✓ Construction in 1950s as headworks with intakes at both sides with length of 130m.
- ✓ Water taken from right bank reaches to Khoy WUA which is linked with Lower Hrazdan canal.
- ✓ Water taken from left bank reaches to Shah-Aru canal by earth canal which is connected at 70m upstream of headworks. It irrigates Vaghashapat WUA.

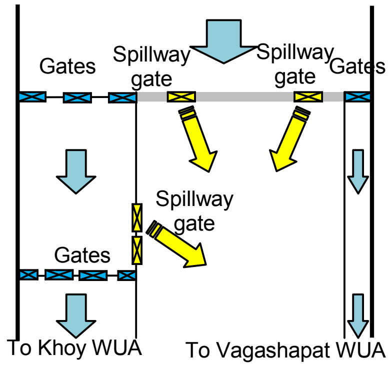


Figure 4-4-2.10 Kasakh Intake

- ✓ River discharge in peak is in March to April which is caused by melted snow. In these seasons, the fixed weir is sometimes submerged.
- ✓ 165m downstream at right side, four irrigation gates and two spillway gates are existed
- ✓ During flood season, all of irrigation gates are closed to prevent the water into canals. Two of radial gates at headworks are simultaneously opened to keep safe irrigation
- ✓ **Although the concrete structures are old, the intake and distribution have been functioned. The serious situation is not observed since the gates are still capable to operate.**

Picture	Description
	Kasakh intake general view Three irrigation gates are installed.
	Kasakh intake at right side One spillway gate is installed.

	Kasakh intake at left side (1) One intake gate is installed.
	Kasakh intake at left side (2) At upstream of left gate, operation of intake is conducted by small dike. In off-irrigation season, dike is embanked to close the earth canal.
	Kasakh intake at left side (3) Shah-Aru canal is constructed by concrete canal.
	Kasakh intake at right side (1) Headrace canal go down along the Kasakh river and to reach Lower Hrazdan canal
	Kasakh intake at right side (2) Four irrigation gates are installed for regulation of main canal and two spillway gates at left side are installed which release excess water to Kasakh river.

Figure 4-4-2.11 Situation of Existing Kasakh Intake

4-4-3 Current Operation and Maintenance on the Irrigation Network System

(1) Implementation arrangement (organization of WSA / WUA)

There are two (2) organizations for operating and maintaining of existing irrigation network system. One is WSA belonging to SCWE ant another is WUA. Under WSA, there are two (2) organizations related to collecting irrigation fee, Sevan-Hrazdanyan Jrar CJSC and Akhuryan-Araks Jrar CJSC. Operation and maintenance in the Project area has been carried out by the Sevan-Hrazdanyan Jrar CJSC.

This WSA has been carrying out the operation and maintenance (O/M) for Arzni-shamiram canal, Lower Hrazdan canal, Ranchpar and Aknalich pump stations. One of the major activities of the WSA is proper water distribution for irrigation system. WSA is a responsible organization for distributing irrigation water from main canal to secondary canal.

WUA has a responsible for appropriate water distribution for farmers, and O/M along the secondary and tertiary canals. WUA also collect the water fee from farmers. There are Yeghvard, Ashtarak, Vagarshapat and Khoy WUAs in the Project area.

Administrative responsibility demarcation point between WSA and WUA is an intake gate facility where the irrigation water is distributed from the main canal to branch canal. At the gates of the secondary canal' intakes, the operation and management are carried out by the WSA. This is the reason that WSA is the only organization to distribute irrigation water equally along the main canal. WUA has operated and maintained the gates and canals after the secondary canal's intake gate. Table 4-4-3.1 shows the major functions of WUA.

Table 4-4-3.1 Major Functions of WUA

Operation and maintenance	Provide training for members
Supply water to water users	Manage water supply
Rehabilitate the irrigation system	Implement necessary measures
Acquire irrigation water	Ensure environmental safety
Collection of water fee	

(2) Annual operation and maintenance (O/M) plan

a) Water supply method

WSA has been operating and maintaining from water source such as reservoir to the secondary canal's gates along the main canal since they have a responsible for appropriate water distribution. WSA sells the irrigation water to WUA. WUA has a responsible of water distribution technical support for farmers, maintenance of irrigation facilities, safety operation, discharge measurement by measuring-record equipment and others. WUA collects the water fee based on the cropped contracted area. Figure 4-4-3.1 shows the organizational chart of WUA.

Arzni-Shamiram canal and Lower Hrazdan canal has been operated and maintained by WSA. WSA decides water volume released from reservoir based on the water demand requested from farmers. Water demand is estimated by "Armenian irrigation norm".

Regarding the water fee for irrigation, WSA sells the gravity-based irrigation water by 1.01 AMD/m^3 and the pump-based irrigation water by 11.52 AMD/m^3 to WUA as shown in Table 4-4-3.2. On the other hand, WUA sells water to users by 11.00 AMD/m^3 for both gravity-based and pump-based irrigation water. The cost of pump-based irrigation water is differed according to the location. However, WSA sells the constant price of pump-based water fee to every WUA in Armenia.

Based on the interview to PIU, the water fee by pump-based irrigation costs around 50 AMD/m^3 in actual maximum cases. Therefore, the difference cost between the actual cost and the selling price from WSA to WUA has been covered by Armenian government as subsidy.

Table 4-4-3.2 Water Fee for Selling Price and Buying Price

Irrigation type	Water Fee (AMD/m^3)	
	Selling Price (from WSA to WUA)	Buying Price (by Farmer)
Gravity based Area	1.01	11.00
Pump based Area	11.52	11.00

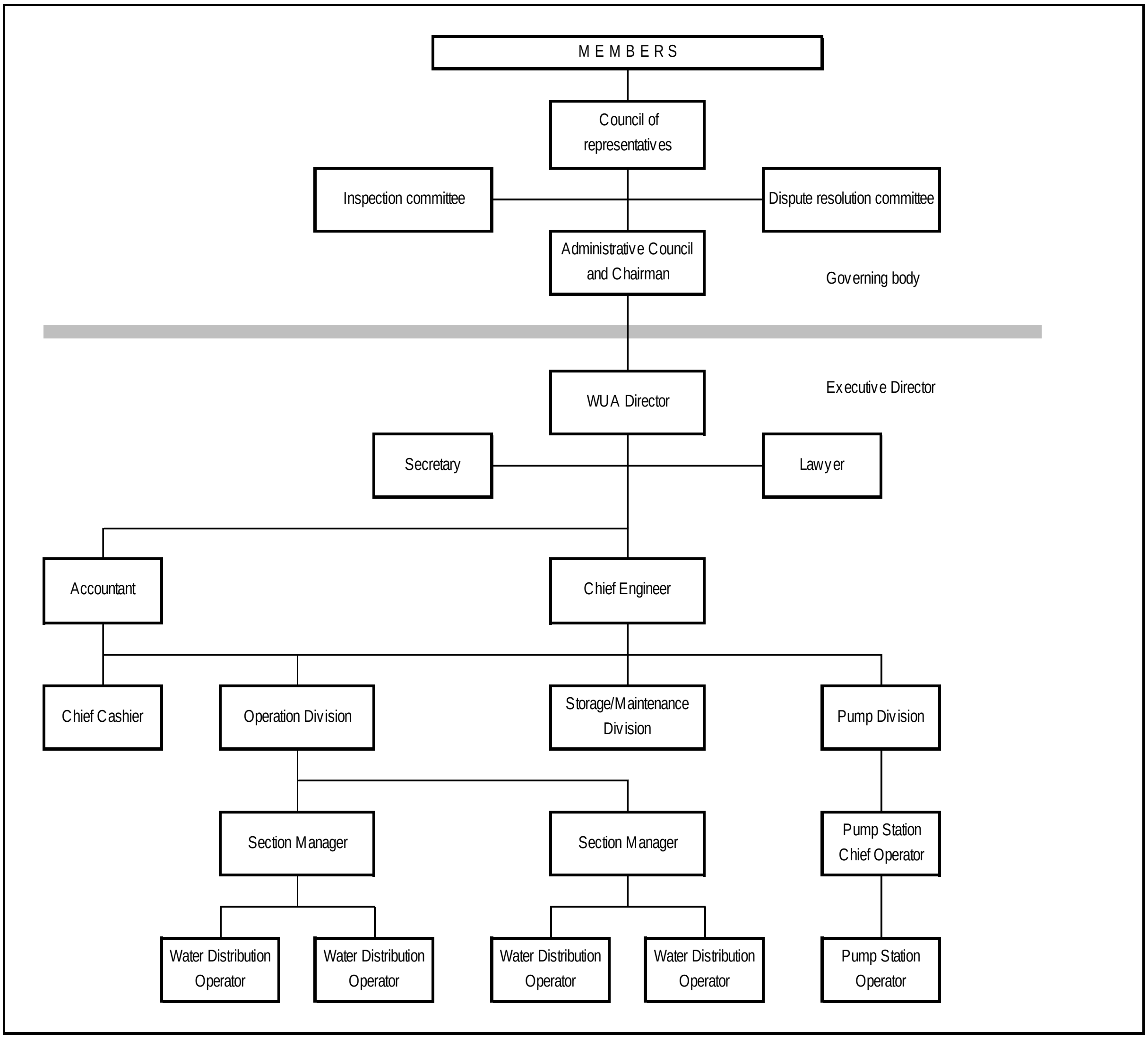


Figure 4-4-3.1 Organization Chart of WUA

b) Maintenance with monitoring (inspection) method

As shown in Figure 4-4-3.2, water level is monitored at the major points along the main canal. This monitoring is carried out twice a day by WSA's remote staff and are reported to the WSA's head office. The remote staff of WSA observe the water level at boundary point between each WUA, and inspects so that irrigation water is diverted to each WUA appropriately. There are six (6) monitoring points along Arzni-Shamiram canal and four (4) monitoring points along Lower Hrazdan canal, respectively.

The observed data are converted to the discharge and the 10 day's average data have been recorded and stored as shown in Table 4-4-3.3.

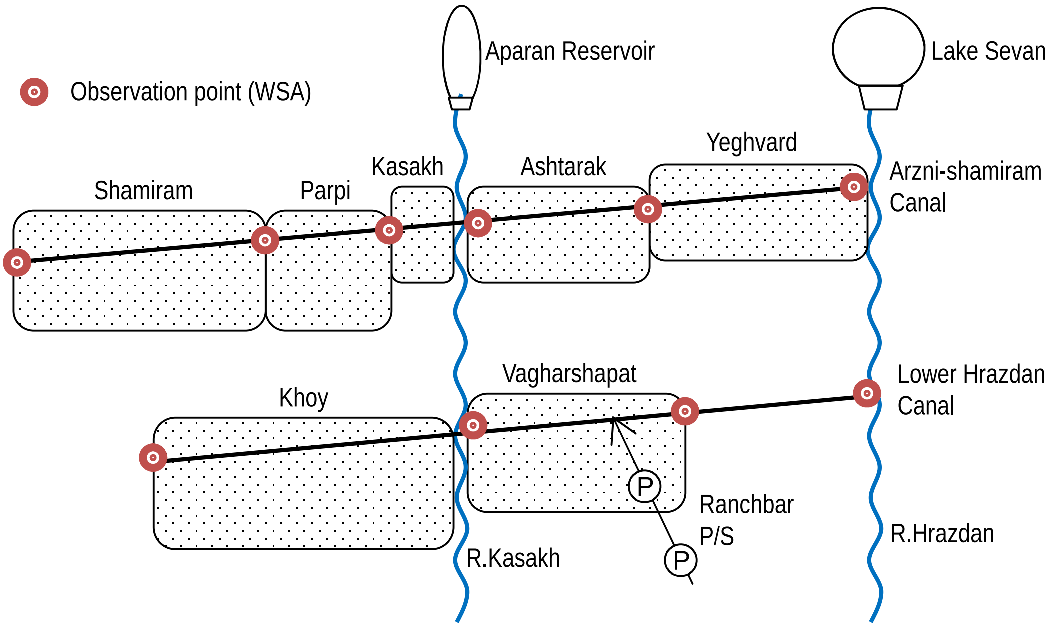


Figure 4-4-3.2 Location of Observation Point along the Main Canal

Table 4-4-3.3 Water Level's Observed Point and Interval of Observation along Main Canal

Canal	Number of Observation point	Observation interval
Arzni-Shamiram	6	2 times/day (10 days average)
Lower Hrazdan	4	2 times/day (10 days average)

In general, irrigation starts from middle of April and ends in November. While WSA and WUA maintain the irrigation facilities such as canals and gates during the non-irrigation period in winter season, maintenance such as cleaning, annual repairing, etc. of irrigation facilities is carried out after February when the accumulated snow begins to melt.

(3) Annual budget for O/M

Figure 4-4-3.3 describes the average maintenance cost for each WUA from 2013 to 2015. The figure indicates that Vagharshapat, Khoy, Ashtarak and Yeghvard WUAs spend 104 million AMD, 116 million AMD, 23 million AMD and 15 million AMD respectively. The total maintenance cost is 258 million AMD.

While maintenance cost is different from the size of irrigation area and irrigation facilities, 40% to 50% of total maintenance cost spends for canal cleaning, and remaining percentage used for the rehabilitation works for canals, pumps and deep wells. Table 4-4-3.4 shows the unit cost for maintenance. Vagharshapat WUA spends a lot for maintenance in comparison with other WUAs.

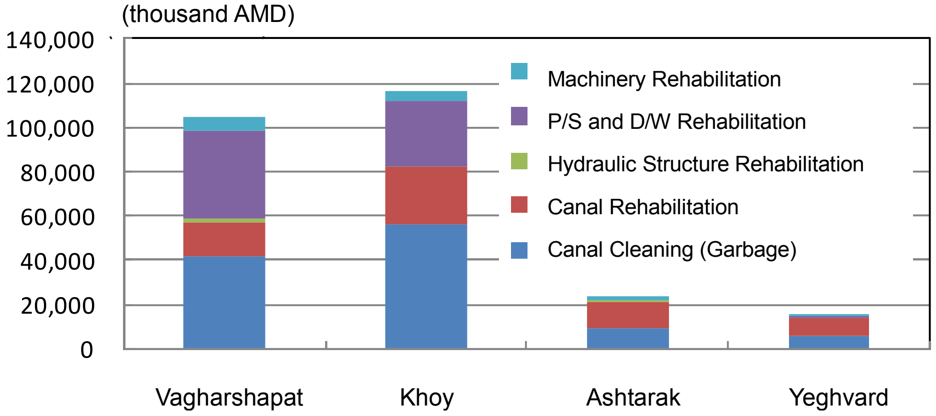


Figure 4-4-3.3 Maintenance Cost for each WUA

Table 4-4-3.4 Unit Cost of Maintenance for each WUA

WUA	Maintenance Cost (million AMD)	Current Area (ha)	Unit Price (AMD/ha)
Vagharshapat	104	2,488	42,000
Khyo	116	4,460	27,000
Ashtarak	23	801	29,000
Yeghvard	15	642	23,000
Total	258	8,391	31,000

4-4-4 Current Issues on Irrigation Network System

Current situation and issues on target canals are shown in Table 4-4-4.1. And detailed current situations of each canal are shown in Appendix A.

In the basis of results of irrigation facility survey, findings on current situations and issues are summarized below;

1) Deterioration/damage such as cracks and exfoliated concrete panels on canals at a number of sections,
2) Lack of cross-section area to convey the design discharge at a number of sections,
3) Sections of open canal replaced by pipeline system due to changing WUA administrative boundary,
4) Areas where substitution new canals are required in the case that existing pumping stations (such as Aknalich PS and Metsamor PS) will be abolished due to the policy of the Project, and
5) Some areas irrigated by unclear water source.

Figure 4-4-4.1 Crack at Side Wall of Canal (Arzni-Branch Canal at No.26)

Figure o 4-4-4.2 Connection Canal to Takahan Canal (Arzni-Branch Canal at No.42)

Figure 4-4-4.3 Leakage at Separation of Joint at Sidewall (No.33)

Figure 4-4-4.4 Outlet of Pipe from Arzni-Shamiram Canal (φ800mm) (Arzni-Branch Canal at No.25)

Table 4-4-4.1 Current Situation and Issues on Target Canals (1/3)

Canal	Current situation	Problems
Azni-Branch	1) Upstream portion of this canal is being managed by Yeghvart WUA and downstream portion by Ashtarak WUA. Water intake from the Arzni-Shamiram canal is performed every WUA. Ashutarak WUA takes water from Arzni-Shamiram canal directly by the pipeline and distributes by a pipeline network to the beneficiary areas of Arzni-Branch Canal. 2) Downstream of the canal from No.33 point on Figure 4-4-2.2 is not currently in use. Other water is used for irrigation of agricultural land around Sasuke town. 3) Although the connection canal for water injection into Takahan Canal near the end of this canal can be confirmed, it is not currently used. 4) The upstream portion of this canal under the control of Yeghvart WUA was renovated in 2012, except for the most upstream section, 5) The inflows from other water sources are confirmed at five locations in the middle of this canal. All of these inflows come from Arzni-Shamiram canal by pipelines.	1) There is a damaged concrete portion at side wall at about 500m section of the non-renovation of downstream of crossing point of railway portion near the intake structure of this canal. 2) There is water leakage from the joint of the side wall of the No.18 on Figure 4-4-2.2 spot aqueduct bridge. 3) There are significant damaged concrete portions and cracks at side wall and bottom of channel within section that is currently being used up to No.33 point on Figure 4-4-2.2. 4) No.33 point on Figure 4-4-2.2 later canal is not currently being used, it is devastated.
Takahan canal	1) The condition of canal is observed generally to good condition except for an aqueduct bridge. 2) The inflow by connection canal from Takahan Canal has been secured and it is considered that the water from Arzni-Shamiram canal by pipeline is in-flow into the middle of the link canal. 3) The section between No.3 point and No.22 point on Figure 4-4-2.3 will be rehabilitated in recent years by the support of the World Bank. The condition of canal will be good.	1) The top portion of the aqueduct bridge of No.35 point on Figure 4-4-2.3 is the exposed rebar by frost damage, etc. and deterioration of concrete is observed.
Shakhi-Aru canal	1) High discharge season of Kasakh River is observed in spring only. Therefore, since the irrigation water from the Kasakh Intake has become chronically shortage of water for irrigation period, the water intake from the Lower Hrazdan is the main water source currently. 2) There are inflows from a distribution gate of Lower Hrazdan canal at No.4 point, from two outlets of pipe(φ150mm) from deep wells and No.29 point on Figure 4-4-2.4. 3) The sections between No.10 point and No.19, No.21 point and No.22, and No.25 point and No.31 point on Figure 4-4-2.4 had been rehabilitated from 2008 to 2010 by the support of the World Bank and the millennium project. The condition of canal is good.	1) Water leakage due to the separation of the joint and the exposed rebar can be observed on the side walls at canal section(No.33 point) of shortly downstream of Kasakh Intake. 2) The deterioration of side wall of canal is serious at No.9 point on Figure 4-4-2.4. 3) The side walls of the canal at No.19 point on Figure 4-4-2.4 is worried about water leakage.

Table 4-4-4.1 Current Situation and Issues on Target Canals (2/3)

Canal	Current situation	Problems
Upper Aknalich canal	1) Aknalich pumping station was built in 1926 and seven pumps in total were installed, three pumps in outside (Capacity Q = 0.065m^3/s, 0.265m^3/s and 0.75m^3/s), four pumps in the pump house (One only operation, Capacity Q = 0.4m^3/s) . The current maximum water discharge amount is 0.75m^3/s. Among them, it is possible to send irrigation water of the amount of 0.38m^3/s to this canal (Upper Aknalich Canal) and irrigation water of the amount of 0.27m^3/s to Inner Aknalich Canal. However, sufficient irrigation water is not supplied from Aknalich PS to this canal due to the drawdown of Aknalich lake presently. 2) The pipeline (φ730mm) for irrigation was built in the direction from No.14 point to No.32 point on Figure 4-4-2.5 by IFAD in 2004. 3) There was an inlet of headrace (pipeline) to the Inner Aknalich Canal at No.2 point on Figure 4-4-2.5, but it is closed with concrete presently. 4) There are inflows by pipe (φ600mm) from Lower Hrazdan canal, by earth canal from Lower Hrazdanl and by three pipe(φ150mm) from deep wells at No.36 point, No.40 point and N.40 point on Figure 4-4-2.5.	1) Downstream canal from the road crossing of the No.32 point on Figure 4-4-2.5 is not currently being used, it has been expired. 2) The flume canal was installed in parallel to this canal from No.35 point on Figure 4-4-2.5 to end of canal. Water from deep wells is supplied to the canal, it is irrigating surrounding farmland. In addition, this canal and other canal irrigated by deep well is not connected. 3) The deterioration such as exposed rebar is serious at canal sidewall No.8 to No.9 on Figure 4-4-2.5 4) Large cracks and partial broken etc. has observed at canal sidewall from the aqueduct bridge at No.21 point on Figure 4-4-2.5 to the road crossing point at No.32 point and deterioration is serious. 5) WUA staff told that even if canal is repaired in the section from No.8 point to No.9 point and in the section from No.21 point to No.32 point on Figure 4-4-2.5, enough water is not capable to come from the pumping station, so, it is unnecessary to repair it. 6) The deterioration of concrete and exposed rebar by frost damage are serious at sidewall of the aqueduct bridges at No.21 point and No.23 point on Figure 4-4-2.5.
Inner Aknalich canal	1) Currently, irrigation water is not passed through only from the beginning point to Highway near No.17 point on Figure 4-4-2.6. Previously water had been reached up to the end of canal. 2) Water from deep wells is supplied to this canal section from No.24 point on Figure 4-4-2.6 to end of canal, it is irrigating surrounding farmland. 3) Near the No.2 point and No.19 point on Figure 4-4-2.6, a new deep well is scheduled to be added in next year. 4) There are inflows by pipe(φ150mm) from Aknalich canal at No.5 point, by earth canal from Hrazdan Canal at No. 8 point and by four pipe(φ150mm) from deep wells at No.24 point, No.28 point, No.30 point and No.34 point on Figure 4-4-2.6. 5) This canal had been rehabilitated from 1997 to the next year by the support of the World Bank.	1) The exposed rebar can be seen at the top of sidewalls (L=600m) from No.2 point to No.4 point and near No.12 point and No.14 point on Figure 4-4-2.6. 2) Grass is flourishing in the canal in section from upstream 520m point of No.22 point to No.24 point and the canal has been expired. It is necessary to rehabilitate it in order to pass water until the end of canal again.

Table 4-4-4.1 Current Situation and Issues on Target Canals (3/3)

Canal	Current situation	Problems
Metsamor canal	1) This canal is divided into main line for the north side and branch line for the south side. The main line is trapezoidal concrete canal and branch line is a flume canal by pre-casted U-shaped. The water is supplied by pipe (1,200mm) at No.1 point on Figure 4-4-2.7 from mainly Metsamor PS. To the branch line, the water is supplied mainly by pipeline from the same PS. In addition, as the pump station stopped, main line and branch line are supplied by open canal and pipeline from Lower Hrazdan canal. 2) This canal will be rehabilitated in recent years by the support of the World Bank. The condition of canal will be good. 3) There are inflows by pipe(φ400mm) from Lower Hrazdan canal at No.25 point, by connection canal from Hrazdan canal at No.6 point, and by pipe(φ150mm) from deep well at No.25 point on Figure 4-4-2.7.	1) The Metsamor pump station has total four pumps and all pumps are working. Capacity of the pumps is P1=0.32m^3/s, P2=0.55m^3/s, P3=0.95m^3/s and P4= 0.35m^3/s. However only P2 is usually running once in two days because inlet water is not enough to operate all pumps. It is observed that suitable irrigation water is not supplied to canal from this pump station. 2) Gate leafs at 6 places are missing.
Lower Hrazdan canal	1) The situation of canal network from this canal to the secondary canals is as follows. a) Regarding connection canal from this canal to Metsamor canal, it is possible to convey water through the pipeline (φ400mm L=about 3.0km) from the inlet of pipe at No.66 point on Figure 4-4-2.8 in this canal to the confluence box at No.25 point in Metsamor canal and it is possible to convey water from end of this canal to the confluence at No.6 point in Metsamor canal. b) Regarding connection canal from this canal to Upper Aknalich canal, It is possible to convey water by pipeline (φ600mm L=about 6.0km) from the inlet of pipe at No.64 point in this canal to outlet of pipe at No.6 point on Figure 4-4-2.8 in Upper Aknalich Canal. It is possible to convey water (Q=0.15m^3/s) by earth canal (L=5.0km) from around No.39 point in this canal to No.25 point in Upper Aknalich canal. c) Regarding connetion canal from this canal to Inner Aknalich canal, it is possible to send water (Q=0.15m^3/s) through the earth canal (L=8.0km) from around No.39 point in this canal to No.8 point in Inner Aknalich canal. d) There are inflows by pipe from Ranchapr No.2 PS at No.19 point, from a connection canal from Kasakh Intake at No. 38 point and by pipe(φ150mm) from deep wells at No.69 on Figure 4-4-2.8.	1) This canal was built in 1954, all sections of canal is aging. 2) Since the freeboard of this canal is not enough, over flow is suspected to be occur during irrigation season. In particular at shortly downstream of the outlet of pipe from Ranchapar PS No.2, it should be cared of operation.

4-5 Agricultural Production and Farm Management

4-5-1 Agricultural Surveys Carried Out

The Survey team carried out the following surveys in order to collect necessary information for the agricultural planning. Details about the planning structure and the surveys are described in Appendix B-3 to B-6.

1) Farm household survey
2) WUA workshops
3) Data/information collection (the Ministry of Agriculture, Marz Agricultural Support Centers, Community Offices, marketing & processing agents, inputs sellers & dealers, etc.)

4-5-2 Number of Farm Households and Family Size

It is reported that the population of Armenia has been decreasing since the 1990s (the population in 1991 was reported as 3,450,000) due to several factors such as excess number of transmigration, decrease in birth rate, and the tendency of slight decrease is still continuing. Regarding the agricultural labor force population, it showed dramatically rising after Armenia's independence from around 180,000 in 1988 to 500,000 in 1994 and it peaked at 570,000 in 2000. However, the population began to decrease since then because of the growth of other economic sectors.

Meanwhile, the population of the project area where locates surrounding area of the biggest city Yerevan indicates only fractional increase in recent five years. According to collected data from concerned communities, total population in the project area is 76,070 in 2014. The population is stable from 2010 to 2014 (see Table 4-5-2.1).

Table 4-5-2.1 Population in the Project Area (2010-14)

WUA	Sex	2010	2011	2012	2013	2014
Yeghvard (3 communities)	Male	8,736	8,702	8,828	8,979	8,883
	Female	8,925	8,776	9,192	9,014	9,133
	Total	17,661	17,478	18,020	17,993	18,016
Ashtarak (4 communities)	Male	6,649	6,645	6,779	6,791	6,715
	Female	6,585	6,924	6,854	6,818	6,855
	Total	13,234	13,569	13,633	13,609	13,570
Vagharshapat (7 communities)	Male	7,613	7,794	7,590	7,638	7,563
	Female	7,758	7,816	7,873	7,923	7,932
	Total	15,371	15,610	15,463	15,561	15,495
Khoy (13 communities)	Male	14,739	14,493	14,484	14,598	14,571
	Female	14,351	14,296	14,672	14,569	14,418
	Total	29,090	28,789	29,156	29,167	28,989
Total	**Male**	**37,737**	**37,634**	**37,681**	**38,006**	**37,732**
	Female	**37,619**	**37,812**	**38,591**	**38,324**	**38,338**
	Total	**75,356**	**75,446**	**76,272**	**76,330**	**76,070**

Source) 27 Community Offices Concerned

As regard to population density in 2014, the average is 305 person/ km^2 in the Project area. The Project area has high population density because of its location. Among WUA areas, Yeghvard is the most congested area, followed by Vagharshapat, Koy and Ashtarak as shown in Table 4-5-2.2. Yeghvard and Vagharshapat WUA areas, having relatively higher figures, are much influenced by urbanization from Yerevan city and Ejimiatsin city, respectively.

Table 4-5-2.2 Population Density in the Project Area in 2014

WUA	Yeghvard (3 communities)	Ashtarak (4 communities)	Vagharshapat (7 communities)	Khoy (13 communities)	Total
Population Density (person/km^2)	359.7	256.3	349.4	284.3	305.0

Source) 27 Community Offices Concerned

Number of households in the Project area is increasing in recent years, even slightly. The number in agrarian sector, however, stays constant. Total number of households and the number of farm households in the project area is 16,849 and 13,574, respectively in 2014 (see Table 4-5-2.3).

The percentage of farm households is about 80% in thePproject area. In Khoy and Vagharshapat WUA areas, agricultural households are highly dominating (96–98% of the total households). In contrast, the percentages in Ashtarak and Yeghvard WUA areas are only 60-65%, and the percentages are declining in recent years. It implies that farm abandonment in Ashtarak and Yeghvard WUA areas is advancing as farmers are facing more difficult condition for continuing their farming than the other two WUA areas. A comparative blessed farmland condition, e.g. land fertility, flatness and accessibility to irrigation gives Khoy and Vagharshapat WUA areas an advantage over Ashtarak and Yeghvard WUA areas in establishing stable farm management. According to farmers interviewed during the surveys, many farmers (especially young male farmers) despaired of continuing farming, and started subsidiary business or even abandoning farming. While there is a wide range of variations in the farmers' difficulties, shortage of irrigated farmland must be one of them.

Table 4-5-2.3 Number of Households in the Project Area (2010-14)

WUA	Sector	2010		2011		2012		2013		2014	
		H.H.	%	H.H.	%	H.H.	%	H.H.	%	H.H	%
Yeghvard (3 communities)	Agri.	2,730	63.3%	2,757	63.7%	2,748	63.8%	2,655	61.2%	2,672	60.2%
	Non-Agri.	1,585	36.7%	1,571	36.3%	1,558	36.2%	1,680	38.8%	1,766	39.8%
	Total	4,315		4,328		4,306		4,335		4,438	
Ashtarak (4 communities)	Agri.	2,381	67.1%	2,369	66.5%	2,386	67.5%	2,358	66.4%	2,279	65.4%
	Non-Agri.	1,167	32.9%	1,195	33.5%	1,151	32.5%	1,193	33.6%	1,205	34.6%
	Total	3,548		3,564		3,537		3,551		3,484	
Vagashapat (7 communities)	Agri.	2,589	98.2%	2,582	98.0%	2,681	97.8%	2,709	97.7%	2,709	97.7%
	Non-Agri.	48	1.8%	52	2.0%	61	2.2%	65	2.3%	65	2.3%
	Total	2,637		2,634		2,742		2,774		2,774	
Khoy (13 communities)	Agri.	5,927	96.2%	5,936	96.3%	5,936	96.2%	5,919	96.3%	5,914	96.1%
	Non-Agri.	231	3.8%	226	3.7%	236	3.8%	230	3.7%	239	3.9%
	Total	6,158		6,162		6,172		6,149		6,153	
Total	**Agri.**	**13,627**	**81.8%**	**13,644**	**81.8%**	**13,751**	**82.1%**	**13,641**	**81.2%**	**13,574**	**80.6%**
	Non-Agri.	**3,031**	**18.2%**	**3,044**	**18.2%**	**3,006**	**17.9%**	**3,168**	**18.8%**	**3,275**	**19.4%**
	Total	**16,658**		**16,688**		**16,757**		**16,809**		**16,849**	

Source) 27 Community Offices Concerned

Table 4-5-2.4 shows the average number of family members (family size) per household in the Project area. The average family size is stable in recent years at about 4.5 person/family. While the highest is in Vagharshapat WUA are at 5.6 person/family, the lowest is in Ashtarak WUA area at 3.9 person/family in 2014. The family size in Yeghvard WUA area is almost same with the size in Ashtarak WUA area.

Table 4-5-2.4 Family Size in the Project Area (2010-14)

Unit: person/family

WUA	2010	2011	2012	2013	2014
Yeghvard	4.1	4.0	4.2	4.2	4.1
Ashtarak	3.7	3.8	3.9	3.8	3.9
Vagharshapat	5.8	5.9	5.6	5.6	5.6
Khoy	4.7	4.7	4.7	4.7	4.7
Total	**4.5**	**4.5**	**4.6**	**4.5**	**4.5**

Source) 27 Community Offices Concerned

4-5-3 Land Use and Farmland Use

1) Land use

The Project area extends across 27 communities in 3 Marzes, and it is divided into four (4) WUA areas under management of Yeghvard, Ashtarak, Vagharshapat and Khoy WUAs. Since WUA area boundaries and boundaries of 27 concerned communities are not overlapped, only 22,754 ha or 91% out of 24,937 ha of the 27 communities' total land area is included in the Project area (see Table 4-5-3.1).

Table 4-5-3.1 Community Area and Project Area

Area Category		Yeghvard	Ashtarak	V. Shapat	Khoy	**Total**
Community Area	(ha)	5,008.5	5,295.5	4,435.0	10,198.0	**24,937.0**
Project Area	(ha)	4,512.5	3,608.5	4,435.0	10,198.0	**22,754.0**
	(%)	90.1	68.1	100.0	100.0	**91.2**
Number of Communities		3	4	7	17	**27**

Source) PIU and 27 Community Offices Concerned

Table 4-5-3.2 shows acreage of farmland and their irrigated land in the Project area by 4 WUAs. Approximately a half or more of each WUA's land in the Project area are categorized in farmland. Khoy WUA has the largest farmland area, while Ashtarak WUA has the lowest area. There is a big difference in irrigation condition between Yeghvard & Ashtarak WUAs and Vagharshapat & Khoy WUAs. Yeghvard & Ashtarak WUAs areas have lower percentages of irrigated farmland than the other two WUA areas. Especially in Khoy WUA area, most of all farmlands are irrigated. The difference represents different water distribution condition for agriculture and geographical condition among 4 WUAs. Yeghvard and Ashtarak WUA areas which locate North-Western part of the Project area, where are dominated by gentle slope plateaus, have less water distribution sources such as canals and wells than the other two WUA areas where locate in Ararat plain.

Table 4-5-3.2 Farmland in the Project Area

Land Category		Yeghvard		Ashtarak		Vagharshapat		Khoy		**Total**	
		Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	**Area (ha)**	**(%)**
1. Farmland in Cadaster (Crop field & backyard)		2,427.9	53.8	1,738.9	48.2	2,797.1	63.1	5,236.9	51.4	**12,200.8**	**53.6**
(1)	Irrigated land (WUA contract 2013)	1,050.6	23.3	915.0	25.4	2,161.0	48.7	5,093.0	49.9	**9,219.6**	**40.5**
(2)	Non-irrigated land	1,377.3	30.5	823.9	22.8	636.1	14.3	143.9	1.4	**2,981.2**	**13.1**
2. Non-farmland		2,084.6	46.2	1,869.6	51.8	1,637.9	36.9	4,961.1	48.6	**10,553.2**	**46.4**
Total Project Area		4,512.5	100.0	3,608.5	100.0	4,435.0	100.0	10,198.0	100.0	**22,754.0**	**100.0**

Source) PIU

2) Farmland use

The Survey team made an estimation average farmland size per farm household in the project area with available information. It is estimated that the average farmland size is about 0.97 ha as shown in Table 4-5-3.3.

Table 4-5-3.3 Average Farmland Size per Farm Household in the Project Area

	WUAs	Yeghvard	Vaghar shapat	Khoy	**Total**
1	Farmland (in Cadaster) (ha)	2,427.9	2,797.1	5,236.9	**10,461.9**
2	Number of farm households in 2014	2,672	2,709	5,414	**10,795**
3	Average farmland (ha/farm household)	0.91	1.03	0.97	**0.97**

Note) Ashtarak is excluded from the calculation as only 68.1% of the community area is included in the project area (see Table 4-5-3.1)

Source) PIU (farmland) and 27 Community Offices Concerned (number of farm households)

The farm household survey carried out by the Survey team reveals farmland use, classified as farmland for annual crop, orchard including vineyard, pasture and other types of land as for home garden and etc. It is also classified by irrigation condition (see Table 4-5-3.4). The average size of own land in Table 4-5-3.4 is 2.12 ha in total which is more than 2 times of the estimation in Table 4-5-3.3 even excluding home garden and etc. It is noted that farm households having bigger farmland than the average level are mainly sampled for the farm household survey.

Table 4-5-3.4 Farmland Use in the Project Area

Farm Land Use	Irrigated + Non-irrigated Land (ha)				
	Own manage, own land	Rent out to tenant	Own land total	Rent in	Total managed land
	(1)	(2)	(3)	(4)	= (1) - (2) + (4)
Annual crops	1.25	0.03	1.29	1.37	**2.59**
Orchard/vineyard	0.57	0.00	0.57	0.27	**0.84**
Pasture	0.08	0.00	0.08	0.01	**0.08**
Others (Home garden, etc.)	0.19	0.00	0.19	0.02	**0.21**
Total	**2.09**	**0.03**	**2.12**	**1.67**	**3.72**

Farm Land Use	Irrigated Land only (ha)				
	Own manage, own land	Rent out to tenant	Own land total	Rent in	Total managed land
	(1)	(2)	(3)	(4)	= (1) - (2) + (4)
Annual crops	1.17	0.03	1.20	1.34	**2.48**
Orchard/vineyard	0.56	0.00	0.56	0.27	**0.83**
Pasture	0.08	0.00	0.08	0.01	**0.08**
Others (Home garden, etc.)	0.18	0.00	0.18	0.02	**0.20**
Total	**1.98**	**0.03**	**2.02**	**1.64**	**3.59**

Source: The Survey Team (Farm household survey)

Table 4-5-3.4 implies that crop farming mostly concentrates on irrigated farmland, and majority of farmland are used for growing annual crops in the Project area. Only a few annual crops, maybe cereals in plateau areas, are grown in non-irrigated farmland. Comparing the farmland use among 4 WUAs, percentage of orchard/vineyard area to the total farmland area is bigger in WUAs located in plateau areas, i.e. Yeghvard and Ashtarak than WUAs located in plain areas, i.e. Vagharshapat and Khoy (see Table 4-5-3.5). While home garden is generally used for growing vegetables, herbs and some fruits mainly for home consumption, substantial number of farm households generates a certain amount of cash income from surplus production from their home gardens according to collected information. In Vagharshapat and Khoy WUAs, many farmers even construct a simple greenhouse in home gardens for growing vegetables for marketing.

Table 4-5-3.5 Farmland Use in the Project Area by WUA

Farm Land Use	Total Managed Land, Irrigated + Non-irrigated Land (ha)											
	Yeghvard			Ashtarak			Vagharshapat			Khoy		
	Own	Rent in	**Total**	Own	Rent in	**Total**	Own	Rent in	**Total**	Own	Rent in	Total
Annual crops	0.56	0.36	**0.92**	0.47	0.36	**0.83**	1.78	2.34	**4.12**	1.28	1.36	**2.64**
Orchard/vineyard	0.76	0.09	**0.85**	0.41	0.13	**0.53**	0.32	0.00	**0.32**	0.71	0.50	**1.22**
Pasture	0.00	0.00	**0.00**	0.00	0.00	**0.00**	0.20	0.00	**0.20**	0.04	0.01	**0.06**
Others (Home garden, etc.)	0.10	0.00	**0.10**	0.08	0.00	**0.08**	0.38	0.01	**0.38**	0.15	0.03	**0.18**
Total	1.42	0.45	**1.86**	0.96	0.48	**1.45**	2.67	2.36	**5.02**	2.19	1.91	**4.10**

Source) The Survey Team (Farm household survey)

It is interesting that the sample farmers rent not a small farmland from other land holders. On the other hand, a few sample farmers rent out their farmland to other farmers (see Table 4-5-3.4). The majority of farmland rented-in is used for growing annual crops. The result implies that farmers, who have farmland above a certain level and actively engaged in farming in the Project area, make an effort to expand the size of farmland under their management by renting farmland from other land holders who may be aged, transmigrated or busy for off-farm jobs/business. Farmers in Vagharshapat and Khoy WUAs are more active in renting in farmland than farmers in Yeghvard and Ashtarak WUAs.

4-5-4 Profile of Farmers and Farm Household Economy

The following consideration is derived mainly from outputs of the farm household survey in August-September, 2015, covering 81 farm households in 27 concerned communities (3 farm households from each community).

1) Profile of farmers

Age and farming experience

The average age of head of the sample farm households is 55.8 years old, while the age ranges from 30 to 82. As regard to farming experience, the average is 25.9 years, while the experience ranges from 8 to 66 years. It shows that many farmers have a certain long experience in farming. However, number of the head having farming experience above 24 years remains only 19 out of 81 or 23.5 % of the total. Many farmers have newly started farming after the land privatization policy of the country, as the related law was passed in 1990 (see Table 4-5-4.1 and Table 4-5-4.2 for details).

Table 4-5-4.1 Age and Farming Experience of Head of the Sample Farm Households

WUA area	Number of H.H.	Age		Farming experience (Year)		Farming experience +24 years
		Range	Average	Range	Average	
Yeghvard & Ashtarak	21	38-82	58.8	15-66	26.6	5
Vagharshapat	21	30-78	51.7	8-51	24.8	4
Khoy	39	33-79	56.9	10-62	26.3	10
Total	**81**	**30-82**	**55.8**	**8-66**	**25.9**	**19**

Source) The Survey Team (Farm household survey)

Table 4-5-4.2 Years when the Sample Farm Households Obtained Property Rights of Farmland

WUA area	1990-94		1995-99		After 2000		Total	
	Number	%	Number	%	Number	%	Number	%
Yeghvard & Ashtarak	10	48	6	29	5	24	21	100
Vagharshapat	13	62	6	29	2	10	21	100
Khoy	20	51	16	41	3	8	39	100
Total	**43**	**53**	**28**	**35**	**10**	**12**	**81**	**100**

Source) The Survey Team (Farm household survey)

Education background

Majority of head of the sample farm households are well educated as shown in Table 4-5-4.3. Most of them completed their secondary school education, and the percentage of university graduates or more accounts 21%. This situation would be a big advantage for the Government to disseminate new technologies and knowledge to the farmers.

Table 4-5-4.3 Educational Background of the Sample Farm Households

Education	Ashtarak & Yeghvard		Vagharshapat		Khoy		Total	
	Number	%	Number	%	Number	%	Number	%
No Education	0	0	0	0	0	0	**0**	**0**
Elementary	0	0	0	0	0	0	**0**	**0**
Middle	2	10	0	0	2	5	**4**	**5**
High / Upper middle	7	33	6	29	15	38	**28**	**35**
Vocational	7	33	7	33	18	46	**32**	**40**
University or Upper	5	24	8	38	4	10	**17**	**21**
Total	**21**	**100**	**21**	**100**	**39**	**100**	**81**	**100**

Source) The Survey Team (Farm household survey)

Membership of WUAs

Table 4-5-4.4 shows that overwhelming majority of the sample farm households are members of WUAs. It is confirmed that two (2) non-member farmers actually enjoy an irrigation service, as the farmers share water with other family member, such as farther who has WUA membership. It shows that irrigation is an indispensable condition to encourage efficient and stable farm management in the project area.

Table 4-5-4.4 Membership of WUAs of the Sample Farm Households

WUA Membership	Ashtarak & Yeghvard		Vagharshapat		Khoy		Total	
	Number	%	Number	%	Number	%	Number	%
Members	20	95	21	100	38	97	**79**	**98**
Non-members	1	5	0	0	1	3	**2**	**2**
Total	**21**	**100**	**0**	**100**	**39**	**100**	**81**	**100**

Source) The Survey Team (Farm household survey)

Family members (who live together and share livelihood)

Table 4-5-4.5 shows number of family members of the sample farm households. The average number is 5.81 person/family, which is bigger than the statistical data collected from 27 communities concerned as shown in Table 4-5-2.4. Out of 5.81 persons, about 4 persons are categorized into the working active age (15-64 years old).

Table 4-5-4.5 Family Members of the Sample Farm Households

Age	Male			Female			Total		
	Total Number	%	Average per H.H.	Total Number	%	Average per H.H.	Total Number	%	Average per H.H.
Under 14	56	23	0.69	38	17	0.47	**94**	**20**	**1.16**
15-64	163	67	2.01	162	71	2.00	**325**	**69**	**4.01**
Over 65	25	10	0.31	27	12	0.33	**52**	**11**	**0.64**
Total	**244**	**100**	**3.01**	**227**	**100**	**2.80**	**471**	**100**	**5.81**

Source) The Survey Team (Farm household survey)

It is interesting that an ordinary farm household may have at least 1 person of permanent employee, including self-employment, as shown in Table 4-5-4.6. It implies that many farm households depend on not a small income from non-farming activities.

Table 4-5-4.6 Number of Permanent Employees, including Self-Employed of the Sample Farm Households

WUA area	Male		Female		Total	
	Total Number	Average per H.H.	Total Number	Average per H.H.	Total Number	Average per H.H.
Ashtarak & Yeghvard	16	0.76	12	0.57	**28**	**1.33**
Vagharshapat	20	0.95	8	0.38	**28**	**1.33**
Khoy	21	0.54	11	0.28	**32**	**0.82**
Total	**57**	**0.70**	**31**	**0.38**	**88**	**1.09**

Source) The Survey Team (Farm household survey)

2) Income and expenditure

Mid-level or more experienced farmers who have more than the average living standards might be mainly selected for the farm household survey according to their profiles as describe above. Average annual income in 2014 declared by sample households is AMD 5,979.1, while the average expenditure is AMD 4,103.3. The highest average income WUA is Vagharshapat and the lowest average WUA is Yeghvard & Ashtarak (see Table 4-5-4.7).

Table 4-5-4.7 Income and Expenditure of Farm Household in 2014

WUA	Number of H.H.	Income (thousand AMD/year)		Expenditure (thousand AMD/year)	
		Range	Average	Range	Average
Yeghvard & Ashtarak	21	270 – 8,880	2,958.9	450 – 5,500	2,461.3
Vagharshapat	21	2,220 – 27,000	8,305.7	1,500 – 18,000	5,466.7
Khoy	39	750 – 32,270	6,126.7	500 – 30,000	4,382.1
Total	**81**	**270 – 32,270**	**5,979.1**	**450 – 30,000**	**4,103.3**

Source) The Survey Team (Farm household survey)

3) Income source

Importance of income sources evaluated by sample households is shown in Table 4-5-4.8 Naturally, income from farming, especially from crop sales, is the most important income source. It is interesting that salary or wages from non-agriculture sector is the second important income source, while salary or wages from agriculture sector is a very minor source for the farm households. It implies that many farm households in the Project area have family members who have off-farm side-jobs or have main jobs in non-agricultural sector. It seems that pension is a small but considerable supplementary income source for many farm households.

Table 4-5-4.8 Important Income Sources of Farm Household in 2014

Unit: %

Income Sources	WUA: Yghvard & Ashtarak (21 H.H.)					WUA: Vagharshapat (21 H.H.)					WUA: Khoy (39 H.H.)					Total (81 H.H.)				
	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**
Sales of crops	14	19	33	33	**100**	0	0	10	90	**100**	0	3	18	79	**100**	4	6	20	70	**100**
Sales of livestock / milk / eggs	38	14	5	43	**100**	57	10	10	24	**100**	59	8	18	15	**100**	53	10	12	25	**100**
Salary or wages (agriculture)	95	0	5	0	**100**	95	0	0	5	**100**	95	0	5	0	**100**	95	0	4	1	**100**
Salary or wages non-agriculture	24	5	19	52	**100**	14	10	38	38	**100**	51	8	13	28	**100**	35	7	21	37	**100**
Own-business (self-employed)	81	0	10	10	**100**	90	5	0	5	**100**	90	0	5	5	**100**	88	1	5	6	**100**
Sales of handicraft	95	0	5	0	**100**	100	0	0	0	**100**	97	0	3	0	**100**	98	0	2	0	**100**
Pension of family members	48	14	29	10	**100**	43	24	19	14	**100**	49	28	18	5	**100**	47	23	21	9	**100**
Remittance	90	5	0	5	**100**	71	14	5	10	**100**	79	8	5	8	**100**	80	9	4	7	**100**
Public supports	95	5	0	0	**100**	100	0	0	0	**100**	92	5	3	0	**100**	95	4	1	0	**100**
Others	100	0	0	0	**100**	95	0	5	0	**100**	100	0	0	0	**100**	99	0	1	0	**100**

Source) The Survey Team (Farm household survey)

While Table 4-5-4.8 shows difference result among WUAs, the difference gives the following implications.

Yeghvard & Ashtarak WUA

- Income from crop farming is low due to low % of irrigated farmland.
- There are many farm households whose income from livestock is higher than the income from crop farming.
- There are many farm households whose income from non-agriculture sector is higher than the income from farming.

Vagharshapat & Khoy WUA

- There are many farm households who enjoy a substantial income from crop farming, mainly from vegetables.

- However, only income from farming is not enough for managing family budget.
- There are many farm households whose family member(s) has (have) a stable job in non-agricultural sector.

4) Expenditure items

Table 4-5-4.9 shows priority expenditure items of sample farm households. It is also natural that the first priority expenditure item is "agricultural inputs and management". After it, "food and beverage" and "housing, home-consumables and public services" are second priority items. In Yeghvard & Ashtarak WUA, the priority for "food and beverage" is very high, maybe, due to high % of low income families. The table implies that the expenditures to "medical care and health" and "clothes" are almost equally important to many farm households. Difference among WUAs in Table 4-5-4.9 is not much comparing the income source evaluation as shown in Table 4.5-4-8.

Table 4-5-4.9 Priority Expenditure Items of Farm Household in 2014

Unit: %

Expenditure Items	WUA															Total (81 H.H.)				
	Yghvard & Ashtarak (21 H.H.)					Vagharshapat (21 H.H.)					Khoy (39 H.H.)									
	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**	Negligible / None	Minor Subsidiary	Important Subsidiary	Principal	**Total**
Agricultural inputs and management	0	5	14	81	**100**	0	0	10	90	**100**	0	3	10	87	**100**	0	2	11	86	**100**
Foods and beverage	0	0	24	76	**100**	0	0	38	62	**100**	0	15	44	41	**100**	0	7	37	56	**100**
Clothes	5	10	62	24	**100**	0	19	57	24	**100**	0	38	38	23	**100**	1	26	49	23	**100**
Housing, home-consumables and public services	0	5	33	62	**100**	0	14	52	33	**100**	0	18	46	36	**100**	0	14	44	42	**100**
Electric appliances, furniture, Cars, and durable goods	57	24	10	10	**100**	43	29	14	14	**100**	54	15	13	18	**100**	52	21	12	15	**100**
Medical care and health	33	29	14	24	**100**	38	19	10	33	**100**	28	26	18	28	**100**	32	25	15	28	**100**
Education and recreation	43	24	10	24	**100**	48	19	19	14	**100**	56	21	15	8	**100**	51	21	15	14	**100**
Recreation and Entertainment	62	33	5	0	**100**	33	43	14	10	**100**	41	38	18	3	**100**	44	38	14	4	**100**
Social relation	5	62	33	0	**100**	0	38	43	19	**100**	5	38	36	21	**100**	4	44	37	15	**100**
Other	90	10	0	0	**100**	62	10	5	24	**100**	74	0	0	26	**100**	75	5	1	19	**100**

Source) The Survey Team (Farm household survey)

5) Strategy to increase living standards of family

Table 4-5-4.10 shows that there are many farm households who maintain good motivation to continue crop farming, while majority of them has a negative vision for livestock farming. Simultaneously, a substantial number of households look for a good job opportunity in local area. Many farm households also consider that education for children is important for increasing living standards of family, because education brings a good job opportunity. Such conditions imply that a movement to abandon farming is slowly progressing among farm households in the Project area.

Table 4-5-4.10 Strategy to Increase Living Standards

Unit: %

Strategy	WUA												Total (81 H.H.)			
	Yghvard & Ashtarak (21 H.H.)				Vagharshapat (21 H.H.)				Khoy (39 H.H.)							
	Less important	Important	very important	**Total**	Less important	Important	very important	**Total**	Less important	Important	very important	**Total**	Less important	Important	very important	**Total**
To devote to crop farming	29	14	57	**100**	23	10	67	**100**	19	14	67	**100**	23	12	64	**100**
To devote to livestock farming	43	19	38	**100**	59	3	38	**100**	62	10	29	**100**	56	9	36	**100**
To find out a new good job/business in local area	57	14	29	**100**	41	28	31	**100**	33	5	62	**100**	43	19	38	**100**
To go to other area/country for getting jobs	86	14	0	**100**	72	13	15	**100**	71	10	19	**100**	75	12	12	**100**
To educate children for getting good jobs	29	10	62	**100**	36	15	49	**100**	38	0	62	**100**	35	10	56	**100**
To sell processed (value added) foods/products	57	14	29	**100**	44	15	41	**100**	67	14	19	**100**	53	15	32	**100**

Source) The Survey Team (Farm household survey)

4-5-5 Agricultural Production

1) Project area

Table 4-5-5.1 shows production of major crops in 27 communities extended across the Project area in compiling statistical data collected from the community offices.

Table 4-5-5.1 Production of Crops in 27 Communities Extended across the Project Area* (2010-2014)

Planted Area (ha)

Crops	2010	2011	2012	2013	2014
Wheat	1,704.9	1,544.6	1,558.9	1,613.1	1,822.4
Barley	77.2	121.9	119.0	78.0	91.9
Maize	13.4	17.6	42.0	46.1	37.0
Alfalfa	768.8	758.6	825.1	838.2	968.4
Potato	726.5	776.8	856.9	705.3	728.1
Other miscellaneous food & forage crops	280.2	343.2	290.7	372.6	334.3
Tomato	402.2	466.0	421.1	469.6	507.9
Cucumber	249.9	254.8	256.3	202.6	225.1
Eggplant	82.2	74.0	100.7	95.3	119.2
Sweet pepper	126.4	115.9	137.3	131.4	109.2
Cabbage	217.4	243.1	256.9	214.8	219.1
Water melon	199.0	299.3	270.2	273.1	409.3
Other miscellaneous vegetables	1,364.9	1,288.2	1,407.2	1,472.6	1,343.9
Grape	1,313.5	1,291.6	1,321.4	1,303.0	1,300.2
Apricot	375.1	371.8	371.4	382.9	381.3
Peach	155.7	155.4	157.7	144.1	141.8
Apple	213.3	209.8	209.2	206.4	200.5
Pear	53.2	50.9	45.4	47.4	48.2
Other miscellaneous fruits & berries & nuts	106.6	120.1	115.9	132.4	150.8
Total	**8,430.4**	**8,503.6**	**8,763.3**	**8,728.9**	**9,138.6**

Production (ton)

Crops	2010	2011	2012	2013	2014
Wheat	5,344.8	5,622.9	5,443.9	6,058.5	6,850.1
Barley	230.4	349.2	253.2	171.4	315.1
Maize	32.8	45.8	102.6	62.0	83.5
Alfalfa	8,654.3	8,334.9	9,351.8	9,500.1	11,092.8
Potato	22,927.0	25,205.2	31,327.4	29,455.8	29,102.0
Other miscellaneous food & forage crops	569.0	670.6	616.6	736.9	646.6
Tomato	19,434.5	20,668.9	19,754.5	23,678.8	24,283.3
Cucumber	8,938.4	10,048.9	8,779.5	8,509.2	9,009.8
Eggplant	4,410.4	3,771.4	5,343.5	4,321.0	4,562.0
Sweet pepper	4,892.2	4,642.5	5,221.5	5,443.2	3,947.9
Cabbage	6,565.7	7,434.7	6,966.7	6,998.0	6,230.2

Water melon	9,014.0	12,312.2	11,470.5	12,134.5	16,552.0
Other miscellaneous vegetables	21,090.2	25,232.6	24,819.7	29,647.0	26,989.0
Grape	12,848.7	13,636.7	14,295.4	15,922.2	17,501.9
Apricot	2,002.8	2,436.3	2,658.9	2,880.4	290.1
Peach	1,374.7	1,372.5	1,543.1	1,553.8	1,396.4
Apple	944.8	1,271.6	1,682.3	1,831.2	3,399.8
Pear	333.4	350.0	367.7	432.1	440.4
Other miscellaneous fruits & berries & nuts	750.8	768.3	869.7	877.2	818.7

Yield (ton/ha)

Crops	2010	2011	2012	2013	2014
Wheat	3.1	3.6	3.5	3.8	3.8
Barley	3.0	2.9	2.1	2.2	3.4
Maize	2.4	2.6	2.4	1.3	2.3
Alfalfa	11.3	11.0	11.3	11.3	11.5
Potato	31.6	32.4	36.6	41.8	40.0
Other miscellaneous food & forage crops	2.0	2.0	2.1	2.0	1.9
Tomato	48.3	44.4	46.9	50.4	47.8
Cucumber	35.8	39.4	34.3	42.0	40.0
Eggplant	53.7	51.0	53.1	45.3	38.3
Sweet pepper	38.7	40.1	38.0	41.4	36.2
Cabbage	30.2	30.6	27.1	32.6	28.4
Water melon	45.3	41.1	42.5	44.4	40.4
Other miscellaneous vegetables	15.5	19.6	17.6	20.1	20.1
Grape	9.8	10.6	10.8	12.2	13.5
Apricot	5.3	6.6	7.2	7.5	0.8
Peach	8.8	8.8	9.8	10.8	9.8
Apple	4.4	6.1	8.0	8.9	17.0
Pear	6.3	6.9	8.1	9.1	9.1
Other miscellaneous fruits & berries & nuts	7.0	6.4	7.5	6.6	5.4

Note*) Acreage of the project area is only 91.2% of total acreage of the 27 communities

Source) 27 Community Offices concerned

Various kinds of crops are grown in about 8,500-9,000 ha in total every year in the 27 communities, while the annual average is 8,713 ha during 2010-2014. In terms of planted area, wheat is the largest crop, while vegetables and fruits including grapes are also widely grown. Considering a price advantage of vegetables and fruits over cereals, many farmers in the 27 communities generate agricultural profit mainly from vegetables and fruits. The Project area is characterized as a leading area of vegetables and fruits production in the country. As regard to vegetables, planted area of other miscellaneous vegetables is more than 2 times bigger than the area of tomato, while tomato is the largest single crop in terms of planted area among vegetables. It seems that diversification of vegetable crops including herbs is progressed in the 27 communities. On the contrary, fruits and grapes are dominated by some limited crops, i.e. grapes, apricot and apple. Planted area of grapes is remarkably bigger than other fruits in the 27 communities. Higher productivity of many crops in the 27 communities comparing the national average proves that the Project area is a leading crop farming area in the country.

Table 4-5-5.2 shows number of livestock in the 27 communities. Out of 13,574 farm households in the communities, only 4,749 farm households or 35% of total farm households are growing some sort of livestock in 2014. In general, livestock farming is not popular among farmers in the 27 communities. In terms of the number, chicken is the largest, followed by cows/cattle, sheep, pigs and few goats and horses. It seems that cows/cattle are the most important animal to livestock farmers in the 27 communities. As regard to number of cows/cattle, the number of milk cows is much bigger than the number of meat cattle. As same as in case of chicken, the number of layer hen is much bigger than the number of chicken for meat.

Table 4-5-5.2 Number of Livestock in 27 Communities Extended across the Project Area (2010-2014)

Livestock		2010	2011	2012	2013	2014
Household growing livestock		5,460	5,158	4,953	4,725	4,749
1	Milk cows/Cattle total	11,543	12,865	12,754	13,584	13,044
1-1	Milk cows (milking)	5,167	5,459	5,725	6,036	5,872
1-2	Meat cattle (adult)	1,039	804	1,058	604	457
1-3	Infant/Infertile	5,337	6,602	5,971	6,944	6,715
2	Pigs	3,481	3,097	2,822	3,942	4,329
3	Sheep	12,474	11,299	10,815	15,110	12,136
4	Goats	126	212	171	309	199
5	Horses	30	10	31	44	42
6	Chicken total	50,868	44,033	40,991	43,578	46,644
6-1	Layer hen (egg)	43,236	36,898	35,395	37,717	39,811
6-2	Other chicken	7,632	7,135	5,596	5,861	6,833

Source) 27 Community Offices concerned

2) WUA areas

While 4 WUAs extend their command areas in the Project area, crop and livestock farming in each WUA area is discussed here. Detailed statistical data on crops and livestock by 4 WUA areas is attached in Appendix B-7 respectively, and abstractive information related to agriculture collected from each community office is summarized in Appendix B-8 for easy understanding.

Yeghvard WUA area: (represented by information from 3 communities concerned)

There are 3 communities related to the Project in Yeghvard WUA area. Cropped area in the Yeghvard 3-communities is mainly irrigated by Arzni Branch Canal. Crop planted area in the Yeghvard 3-communities was about 625-680 ha in total during 2010-2014, while the average was 643 ha. The area is only 7.4 % of the total cropped area in the 27 communities.

Cropped area of alfalfa is the largest, followed by apple and apricot. Fruits production is the most popular farming in the Yeghvard 3-communities, by utilizing well-drained soil, hilly land condition and long duration of sunshine. The Yeghvard 3-communities have a long history of fruits cultivation, since they were developed as Sovkhozes to produce fruits and grapes during Soviet era. On the contrary, vegetables are not popular among farmers, except for growing them in backyard mainly for own consumption. Productivity of each crop is still lower than other 3 WUA areas, due to mainly inferior irrigation condition and relatively low soil fertility. Production of vegetables and fruits, however, tend to increase because of increased productivity of those crops in recent years.

Although a general understanding that livestock farming is more popular in Yeghvard WUA area than the other 3 WUA areas, only 627 farm households or 23% of total 2,672 farm households were growing some sort of livestock in the Yeghvard 3-communities in 2014. Neverthless, the Yeghvard 3-communities grow a big number of livestock comparing to the other WUA areas. In case of cows/cattle which are the most important livestock for farmers, 4,930 heads or 37.8% of the total (13,044 heads) in the 27 communities were grown in 2014 in the area. There must be specialized livestock farmers, even not a large number, who manage a large number of animals. The order of importance among livestock is almost same as the other areas except for sheep. Number of growing sheep is more than the number of cows/cattle in the area.

Ashtarak WUA area (represented by information from 4 communities concerned)

There are 4 communities related to the Project in Ashtarak WUA area. Cropped area in the Ashtarak 4-communities is mainly irrigated by Lower Hrazdan Canal and Takahan Canal. Most of the present cropped area in 3 communities along to Lower Hrazdan Canal, i.e. Noraket, Baghramyan and Merdzavan, is located outside of the Project area. Only the area located on the northern side of Lower

Hrazdan Canal in the 3 communities, where is located at higher altitude than the canal and is extended on gentle slopes, is included in the Project area.

Crop planted area in the Ashtarak 4-communities was about 1,110-1,140 ha in total during 2010-2014, while the average was 1,122 ha. The area is only 12.9 % of the total cropped area in the 27 communities. As same as the Yeghvard 3-communities, 3 communities out of the 4 communities were developed as Sovkhozes to produce mainly grapes during Soviet era. Remained one community, Merdzavan, was also developed as a managing community of research farms including a grape research farm. Influenced by the history, more than a half of farmland is occupied by fruits and grapes. In terms of cropped area, grapes are the extremely biggest, followed by alfalfa, apricot, wheat, barley and various fruits.

Collected data shows considerable rise of grape production from 2010 to 2014. While there is no significant difference in planted area of grapes, the productivity has been improved. Meanwhile, several commercial investors have already started to convert idle lands into vineyard or orchard. Though there is no single vegetable crop which has widely produced, total vegetable cropped area is not so small, probably due to diversified vegetable crops. Except for fruits and cereals, productivity is lower than the average of the 27 communities.

Only 522 farm households or 23% of total 2,279 farm households were growing some sort of livestock in the Ashtarak 4-communities in 2014. The percentage is same as the percentage of the Yeghvard 3-communities. Though the order of importance among livestock is almost same as the other areas, number of pigs is relatively bigger in this area.

Vagharshapat WUA area (represented by information from 7 communities concerned)

There are 7 communities related to the Project in Vagharshapat WUA area. Cropped area in the Vagharshapat 7-communities is mainly irrigated by Shah-Aru Canal and Upper- and Lower- Akhnalich Canals. Because of unreliable water supply from the canals due to reduced water resources suppling to Upper- and Lower- Akhnalich Canals, and deteriorated canal networks to individual farmers, many farmers depend on tube-wells powered by electricity to irrigate their crops.

Crop planted area in the Vagharshapat 7-communities was about 2,340-2,620 ha in total during 2010-2014, while the average was 2,489 ha. The area is continuously expanding year by year in 2010-2014. In terms of cropped area wheat is the largest, followed by water melon, alfalfa, tomato, potato, grapes, cucumber and various vegetables. Comparing to annual crops, fruits production except for grapes is not popular in the area. The area is located in Ararat plain and is blessed with fertile soil. It is generally understood that Ararat plain is the most agricultural advanced area in the country. Productivity of many crops in the area is higher than the average of the 27 communities, except for fruits crops.

While farmers in the Vagharshapat 7-communities are very active in growing all annual crops in general, Vagharshapat WUA area is famous in vegetable cultivation. Vegetables production in the area shows a significant increase in 2010-2014 because of increased planted area. A blessed location of the area which has a good road access to big cities, such as Yerevan, Ejimiatsin, Armavir and Ashtarak, has made a big push to the increased production.

Farmers grow various kinds of vegetables and herbs in their backyard, beside crops, such as wheat, alfalfa, potato, cabbage and water melon which are mainly grown in relatively large scaled open field. More than a half of planted area is occupied by vegetables in 2014, if potatoes are counted in vegetables. Most of the farmers construct a simple greenhouse or tunnel in their backyard or a field near to their houses for growing vegetables for marketing purpose. Some of them even install a private tube well for securing stable irrigation water for their vegetables. Tomato and cucumber are the most common crops cultivated in greenhouses. Multiple cropping in a year under greenhouse or tunnel is also popular in the area.

History of the Vagharshapat 7-communities is a reason why vegetable farming is very popular among farmers. Out of the 7 communities, 5 communities were Kolkhozes mainly growing vegetables, and 1 community was a Sovkhoz for vegetable seeds production in Soviet era. Considering the history, there have to be many farmers who have good experience in vegetable cultivation in the Vagharshapat 7-communities.

In contrast to crop farming, farmers in the Vagharshapat 7-communities are not so active in livestock farming. Though 1,189 farm households or 44% of total 2,709 farm households were growing some sort of livestock in 2014, total number of livestock grown in the area is relatively small except for chicken. Many farmers probably keep small number of livestock mainly for their own consumption in the area. According to collected information from community offices in the area, livestock farming is not a profitable business any more, as the communities lost a right to access to grazing pastures which they had in mountainous regions mainly in Aragatsotn Marz and Kotayk Marz before the independence. As same as the other areas, cows/cattle, especially milk cows are the most important livestock for farmers.

Khoy WUA area (represented by information from 13 communities concerned)

There are 13 communities related to the Project in Khoy WUA area. The communities are located on the north-western side of Vagharshapat WUA area, and extended on Ararat plain bordered on foothills. Cropped area in the Khoy 13-communities occupies almost a half of the total cropped area in the 27 communities. The area is mainly irrigated by Lower Hrazdan Canal, while a small part is irrigated by Upper Akhnalich Canal and Kasakh River (pump irrigation). Even though the area is endowed with the best irrigation condition in the Project area, not a small number of farmers depend on tube-wells for irrigating their crops although the dependence is lower than Vagharshapat WUA area.

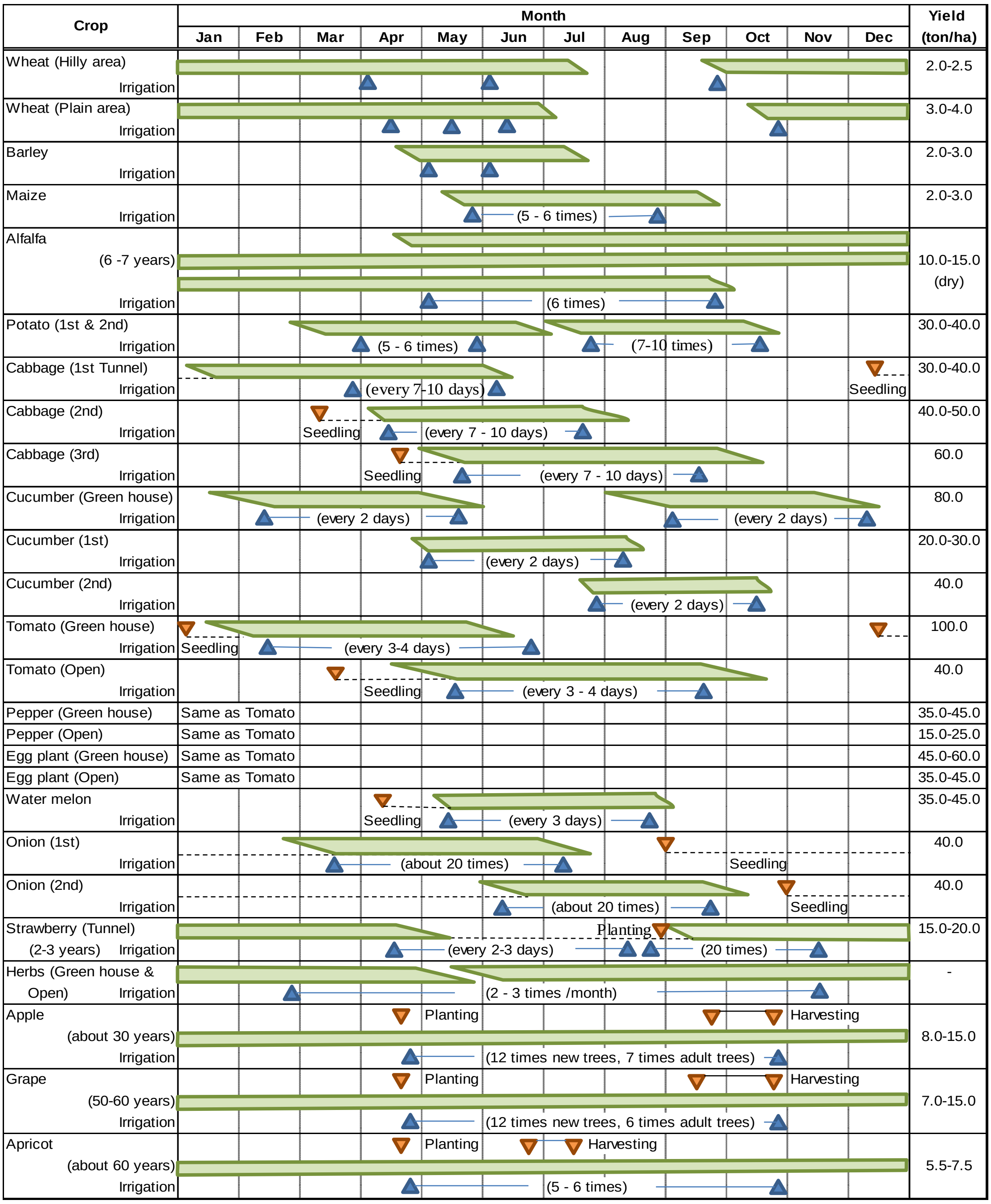
Crop planted area in the Khoy 13-communities was about 4,350-4,750 ha in total during 2010-2014, while the average was 4,459 ha. The area is continuously expanding year by year in 2010-2014. In terms of cropped area wheat is the largest, followed by grapes, potato, alfalfa, tomato, cabbage, apricot, cucumber, and various vegetables and herbs. With blessed conditions to run farming business, i.e. good prepared irrigation, fertile and plain land and good access to the market, the area leads not only the Project area but also whole country in terms of crop farming together with Vagharshapat WUA area.

While farming system and cultivated crops is similar to Vagharshapat WUA area, a fruits farming mainly growing grapes is much popular in the Khoy 13-communities and cultivated crops are more diversified. Since 6 communities out of the 13 communities were Kolkhozes to grow grapes and fruits in Soviet era, while other communities were vegetable Kolkhozes except for one grape Sovkhoz, the history may influence to the difference. Another difference is a size of cropped field. An average size of cropped field in the area is generally smaller than the area in Vagharshapat WUA area, according to the observation, probably due to geographical condition mainly. As same as Vagharshapat WUA area, greenhouse or tunnel cultivation is popular among farmers in the area. Diversified vegetables and herbs are grown under greenhouses or tunnels. Several communities are getting famous in special crops, such as strawberries, tarragon, etc.

Farmers in the Khoy 13-communities are also not so active in livestock farming, except for Ferik community. Though 2,411 farm households or 41 % of total 5,914 farm households were growing some sort of livestock in 2014, total number of livestock grown in the area is not so large except for chicken. Many community offices in the area mentioned the issue of grazing land area similar to the case of Vagharshapat WUA area. As same as the other areas, cows/cattle, especially milk cows are the most important livestock for farmers.

4-5-6 Cropping Calendar

Temperature, rainfall and availability of irrigation mainly determine cropping seasons of major crops in the Project area. Figure 4-5-6.1 indicates the cropping seasons of major crops based on collected information from various sources including a farm household survey by the Survey team. Mainly, the season of most crops begins in April and May, as rainfall increases when spring season starts in the Project area. The cropping ends in September and October before cold winter season comes. Wheat is an exception since it is widely sowed in autumn, when a certain rainfall is expected. In any case, the farming system in the Project area is designed based on timing with appropriate climate.



Source) The Survey Team

Figure 4-5-6.1 Crop Calendar of Major Crops in the Project Area

While rain-fed farming of wheat or forage crops, which require relatively small amount of water, is practiced in mountainous areas in Armenia with comparatively blessed rainfall, irrigation is required for growing all crops in Ararat plain where the Project area is located due to small amount of rainfall and high temperature.

4-5-7 Use of Farm Inputs

1) Inputs use

Agricultural inputs such as crop seeds, fertilizers, agrochemicals, farm machinery and farm facilities are significant inputs to achieve a stable and high production of agriculture. Table 4-5-7.1 indicates situation of agricultural inputs use by crops about interviewed 81 farmers by the Survey team's farm household survey. 82% and 61% of sampled farmers use fertilizers and herbicides respectively for their crop production, and those percentages are relatively higher compare to other inputs. While fertilizers are commonly used for almost all crops, herbicides are not much used for cereals and sweet pepper. Other farm inputs such as compost, pesticides and commercial seeds are used only by 20-35% of sampled farmers. Little number of farmers uses compost although fertilizers are popular among farmers. There are notable gap between the two inputs and others in respect to the popularity among farmers.

Many farmers has recognized that pests and diseases are serious problem for their crop production when the Survey team interviewed about their problems, but Table 4-5-7.1 shows that pesticides and fungicides are still not popular among them. They are still used selectively by limited farmers to limited crops. As regard to pesticides, wheat and maize are only crops for those pesticides are used by more than 50 % of growers. In case of fungicides, only grapes, greenhouse tomato and cucumber are such crops. Many farmers don't know well about basic information, even right names of herbicides, pesticides and fungicides which they use, according to the farm household survey. They usually make consultation with agrochemicals shops about appropriate chemicals to their crops when necessary.

As for commercial seeds and seedlings, those of cereals, potato, tomato, cucumber, cabbage and watermelon are often procured from market. It is noted that many growers of tomato and cucumber under greenhouse depend much on commercial seedlings.

Table 4-5-7.1 Use of Agricultural Inputs by Crops

Crops	No. of farmers to grow	Number of Users						
		Fertilizer	Compost	Herbicide	Pesticide	Fungicide	Marketed Seeds	Marketed Seedlings
Wheat	35	35	3	4	33	8	23	0
Barley	10	10	0	0	4	2	6	0
Maize	2	1	0	1	2	0	2	0
Alfalfa	26	13	2	20	0	0	4	0
Potato	29	28	3	26	13	9	27	0
Tomato	26	22	8	15	6	7	10	10
Tomato (green house)	18	18	11	11	2	10	2	16
Cucumber	30	28	3	23	3	11	23	1
Cucumber (green house)	12	11	8	8	0	7	0	12
Eggplant	17	11	6	10	2	2	0	7
Eggplant (green house)	0	0	0	0	0	0	0	0
Sweet Pepper	10	7	2	2	1	2	1	2
Sweet Pepper (green house)	6	6	4	1	0	0	0	0
Cabbage	9	7	0	8	2	3	5	4
Water melon	8	8	0	6	4	4	5	3
Grape	33	23	9	28	15	22	0	3
Apricot	20	10	11	16	0	8	0	3
Apple	16	11	7	8	1	6	0	3

Source) The Survey Team (Farm household survey)

According to the farm household survey by the Survey team, many farmers complained about high cost of farm inputs. It is implied that high price of inputs is a major reason of relatively low percentage of inputs users as shown in Table 4-5-7.1. In the same view point, a major reason of high percentage of fertilizer-users must be the government subsidy policy to fertilizers, and the reason of herbicide-users is the affordability of herbicides considering labor hiring cost for weeding.

As regard to fertilizers, there might be growing concern about an excessive use of nitrogen fertilizers in Armenia. A result of the farm household survey implies that many respondents use only nitrogen fertilizers and overuse them to their crops (see Table 4-5-7.2). According to the Agrochemical Service Company under the Ministry of Agriculture, an excessive use of nitrogen fertilizers is recognized throughout the country, while an underuse of phosphate fertilizers and potassium fertilizers is another concern. The company suggests that a balanced fertilizer application could bring about high-productivity and high-quality of harvest on sustainable basis.

Table 4-5-7.2 Chemical Fertilizer Use for Crop Cultivation

Crops*	**Amount (kg/ha in chemical component)**					
	Ave. of Respondent Farmers			Government Recommendation		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Wheat	130.5	0.0	0.0	90 - 120	90	60 - 70
Barley	74.5	0.0	0.0	70 - 90	60 - 70	70
Alfalfa	63.3	0.0	14.3	0	90 - 120	45 - 60
Potato	332.2	0.0	0.0	120	90	90

Note*) Crops widely grown by sample farmers in terms of cropped area
Source) The Survey Team (Farm household survey)

2) Number of Farm Machinery

Many farmers in the Project area expressed serious shortages of farm machinery during an interview survey with them. Though there are agricultural machinery services by service providers in the Project area, shortages of farm machinery and improper timings of the services are serious issue for appropriate crop management works as planned. Table 4-5-7.3 shows number of farm machinery in the Project area.

Table 4-5-7.3 Number of Farm Machinery in the Project Area

Farm Machinery	2010	2011	2012	2013	2014
Tractors (main-body)	385	376	361	366	365
Tractor plows	123	125	131	127	129
Cultivators (for ridging)	92	86	92	88	88
Tractor seeder	52	53	53	54	54
Tractor mower	29	29	30	31	31
Baler (tractor operated)	27	27	28	29	31
Tractor trailers	154	150	155	158	155
Combine harvester	5	5	5	5	5

Source) 27 Community Offices concerned

While total number of tractors, which is the most important farm machinery, is 365 units in 2014, the number is not so small considering 9,139 ha of total planted area in the Project area in 2014 (see Table 4-5-7.4). It seems that 25 ha of planted area per tractor unit is theoretically within a reasonable level for managing farmland, if all tractors are in good working condition, and are properly operated in large scaled fields in accordance with well-organized schedule. About 10 ha is, however, the optimal land unit size per one tractor (80 HP) considering the present operation condition, according to a private tractor dealer.

Table 4-5-7.4 Numbers of Tractors and Planted Area in the Project Area

	Yeghvard	Ashtarak	V. shapat	Khoy	Total
Number of Tracrors (unit)	28	40	132	165	365
Planted Area (ha)	630.2	1,142.6	2,622.5	4,743.3	9,138.6
Area/Tracor (unit/ha)	22.5	28.6	19.9	28.7	25.0

Source) 27 Community Offices Concerned

In Armenia, many over aged farm machinery such as tractors are still used at field, even from the Soviet time continuously. Age of those machineries is sometimes more than 30 years old. One of serious issues in agriculture sector in this country is renewal of those old machineries. Decline of tractor numbers as shown in Table 4-5-7.3 implies that number of break down tractors is overtaking the number of renewal. Meanwhile, fragmented farmland after the privatization policy is one of reasons why many farmers have faced to the shortages of farm machinery. Present farm machinery services cannot properly cope with requirements for managing a large number of fragmented farmlands owned by individual farmers.

3) Procurement Sources

Table 4-5-7.5 shows procurement sources of farm inputs. The table suggests that private market is the major source of farm inputs for farmers. Some farmers are managing self-produced inputs such as seeds and compost by themselves. Besides, government program is another major source of chemical fertilizers, as there is a government subsidy system of fertilizers to encourage farmers in their intensive farming. Farmers are able to procure three types of fertilizers, i.e. Ammonium nitrate, Double superphosphate and Potassium chloride, at 35 to 50 % cheaper price than the market prices through the subsidy system.

Table 4-5-7.5 Source of Procurement of Farm Inputs in 2014/2015

Farm Inputs	No use farmers	Self-production/ management	From Govt. program	From research institutes	From private/ market	From neighbor	From others	Total* (81 farmers)
Commercial seeds / seedlings	17	9	4	0	58	1	0	89
Compost	46	11	1	0	18	4	2	82
Chemical fertilizers	8	2	48	0	50	0	0	108
Pesticide / Fungicide / Herbicide	2	0	7	0	75	0	1	85
Mechanization services (machinery-hiring)	17	4	0	0	61	4	0	86
Fuel (diesel)	64	1	0	0	17	0	0	82

Note*) As one sample farm household has plural sources, total number is not equal to the sample number
Source) The Survey Team (Farm household survey)

4) Greenhouse

Greenhouse cultivation is becoming more popular in recent years in Armenia due to an increased demand for quality vegetables and flowers from urban area, as well as for export. Growing vegetables and flowers in greenhouses is more costly than open field cultivation, but it has its advantages: better quality products, more protection from rain, hail and pests, and possibility of harvest season control.

Table 4-5-7.6 shows total area and number of greenhouses by Marzes. Almost 95 % of total greenhouse areas in Armenia are concentrated in Ararat Marz and Armavir Marz which are located in Ararat plain. Vagarshapat WUA and Khoy WUA areas, located in Armavir Marz, are the center of greenhouse crop production in the Project area. Table 4-5-7.6 also implies that most of greenhouses installed in Armavir Marz are small size greenhouses for vegetable cultivation. Many farmers in the both WUA areas construct a simple greenhouse in or near by their backyard. Some advanced farmers install a personal tube well, and even a drip irrigation system with their greenhouses. According to interviewed farmers and the Greenhouse Association, RA, tomato and cucumber are the most popular crops for greenhouse cultivation. In addition to those major crops, other crops such as pepper, eggplant, strawberry, herbs and ornament flowers are also grown under greenhouses.

In Armavir Marz, an average planted area of vegetables and melon from 2009 to 2013 counts 12,165 ha according to the data from the Ministry of Agriculture. Considering this figure, greenhouse area for vegetables in Armavir Marz is estimated to about 3 % of the total vegetables and melon planted area.

Table 4-5-7.6 Total Area of Greenhouses and Use by Region in 2014

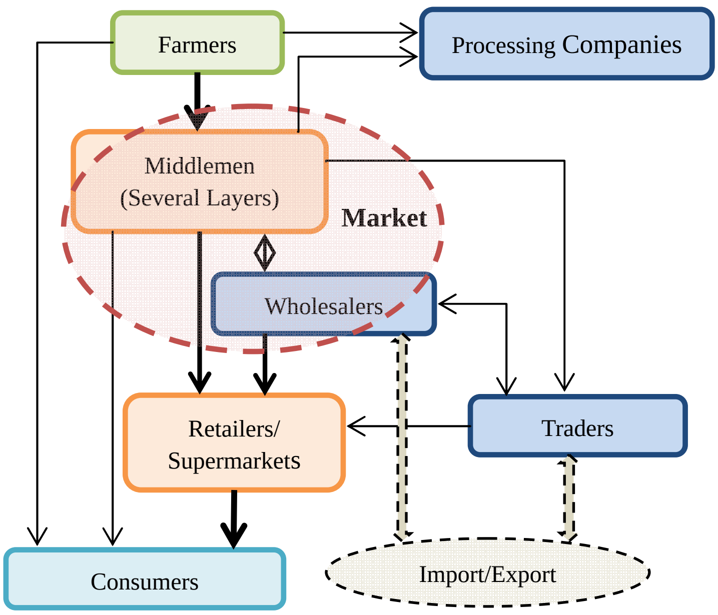
No	Marz	Area						Farmer/Owner		Average
		Vegetables		Flowers		Total	(%)			
		(ha)	(%)	(ha)	(%)	(ha)		(h.h.)	(%)	(ha/h.h.)
1	Ararat	120.0	70.9	49.3	29.1	169.3	27.6	2,212	28.0	0.08
2	**Aragatsotn**	**1.9**	**70.4**	**0.8**	**29.6**	**2.7**	**0.4**	**11**	**0.1**	**0.25**
3	**Armavir**	**349.3**	**85.4**	**59.7**	**14.6**	**409.0**	**66.6**	**5,485**	**69.5**	**0.07**
4	Gegharkunik	0.1	50.0	0.1	50.0	0.2	0.0	1	0.0	0.20
5	**Kotayk**	**15.9**	**60.7**	**10.3**	**39.3**	**26.2**	**4.3**	**48**	**0.6**	**0.55**
6	Lori	0.0	NA	0.0	NA	0.0	0.0	3	0.0	0.00
7	Syunik	1.3	37.1	2.2	62.9	3.5	0.6	6	0.1	0.58
8	Shirak	0.4	66.7	0.2	33.3	0.6	0.1	8	0.1	0.08
9	Vayots Dzor	0.6	100.0	0.0	0.0	0.6	0.1	5	0.1	0.12
10	Tavush	1.6	94.1	0.1	5.9	1.7	0.3	118	1.5	0.01
	Total	491.1	80.0	122.7	20.0	613.8	100.0	7,897	100.0	0.08

Note: Figures in bold are Merzes placed in the project area

Source: The Greenhouse Association, RA

4-5-8 Marketing of Agricultural Products

The Project area has an advantage location for marketing agricultural products to Yerevan city which is the biggest consuming place of agricultural products in the country. As mentioned in the Chapter 3-5, middleman is the most major buyers for farmers in the Project area. From retailer’s aspect, a stable supply of certain volume and quality of agricultural products are needed for their business. Middleman is playing the role of filter to collect up enough volume of products from farmers for retailer’s demand. Limited number of farmers who are producing enough volume of products by commercialized large-scare farming can sell their products without middleman. Selling channel of agricultural products is significant issue for farmers because it is directly related to their income. Figure 4-5-8.1 describes the distribution channels of vegetables and fruits which are the most important farm income sources in the project area.



Source: The Study Team

Figure 4-5-8.1 Distribution Channel of Vegetables and Fruits

Contract farming is going to be developed in the Project area, even at an initial stage. Many processing companies and traders consider that they should depend in a large part of their handling products on contract farming if they will expand their business. However, they still hesitate to get into expanded contract farming due to the following problems on the management.

- Quality control of the products produced by contract farmers
- Breach of contract (by contract farmers) when market price of the products increases

Table 4-5-8-1 indicates sale destinations of main 8 products from farmers based on result from the farm household survey.

Table 4-5-8.1 Marketing Channels of Major Agricultural Products in the Project Area

Products	Number of Farmers	Sale Destinations* from Farmers						
		Middle-man	Processor	Wholesaler	Retailer/ Supermarket	Coopera-tives	Exporter	Customer/ Neighbor
Wheat	11	8	0	1	0	0	0	2
Potato	23	9	0	9	1	0	1	4
Tomato (open field)	15	7	8	2	1	0	0	0
Tomato (greenhouse)	18	12	0	4	0	0	0	2
Cucumber (open field)	18	9	1	5	0	0	0	4
Cucumber (greenhouse)	10	7	0	2	0	0	0	1
Grape	21	0	18	0	0	0	0	3
Apricot	14	3	0	4	2	0	2	3
Cow Milk	15	0	6	0	5	1	0	4
Cattle Meat	16	8	0	1	3	0	0	5

Note*) As some farmers have several sale destinations, the total number is not necessarily equal to the number of farmers
Source) The Survey Team (Farm household survey)

Potato, apricot and cow milk are sold through relatively wide varieties of selling channels. Milk and cattle meats are often sold directly to consumers who live in the same or surrounding communities, even Yerevan city. A direct selling doesn't always secure farmers a satisfactory profit, as it needs increased transportation cost and other indirect cost sometimes. However, a direct selling to customer can be one of options to maximize farmer's profit by disintermediation in such a suburban area. Majority of grape and some part of tomato, cucumber and milk are sold to processing companies. In case of grape, many farmers are doing contract cultivation with brandy distilleries and wineries. Since grape cultivation has been historically developed with development of the industries, and the industries are important foreign currency sources, the government supports the contract farming of grape. In case of tomato, the open field farmers tend to sell a large volume of their products to processers at a small profit. On the contrary, the greenhouse farmers are selling their products to middleman and others for fresh consuming. Agricultural cooperatives are not active in marketing in the Project area, except in a case of milk selling, while cooperatives can be an effective solution for farmers to increase their bargaining power in marketing.

Table 4-5-8.2 indicates the result of the farm household survey on the number of sample farmers who produced and marketed agricultural products by crops and livestock in 2014. According to the figures in the table, cereals and chicken products are mainly produced for self-consuming purpose. In contrast, many vegetables, grape and cattle products are mainly produced for marketing.

Table 4-5-8.2 Number of Growers to Marketed Products by Crops/Livestock

Crop / Livestock	Number of Farmers		
	Produced (h.h.)	Marketed (h.h.)	% of marketed
Wheat	35	11	31.4
Barley	10	2	20.0
Maize	2	2	100.0
Alfalfa	26	12	46.2
Potato	30	23	76.7
Tomato	28	15	53.6
Tomato (green house)	20	18	90.0
Cucumber	34	18	52.9
Cucumber (green house)	13	10	76.9
Eggplant	21	7	33.3
Eggplant (green house)	1	0	0.0
Sweet Pepper	14	4	28.6
Sweet Pepper (green house)	7	6	85.7
Cabbage	11	9	81.8
Water melon	8	7	87.5
Grape	39	21	53.8
Apricot	32	14	43.8
Apple	22	6	27.3
Cow milk	27	15	55.6
Beef Cattle/Meat	18	16	88.9
Broiler Chicken/Meat	22	0	0.0
Egg	40	4	10.0

Source) The Study Team (Farm household survey)

Table 4-5-8.3 indicates three categories of crop prices: farm-gate price, wholesale price and retail price of crops which are grown by many farmers and are commonly marketed by the growers. Potato represents longer storable crops, tomato represents vegetables and grape represents fruits.

Table 4-5-8.3 Price Variation of Major Crops in 2014/15

(RMD)

Crop	Price Category	Average (moderate)	Maximum	Minimum
Potato	Farm Gate	160	250	60
	Wholesale	200	280	80
	Retail	260	300	230
Tomato (High season) Jun-Oct	Farm Gate	131	500	40
	Wholesale	220	660	80
	Retail	238	400	130
Tomato (Off season) Nov-May	Farm Gate	562	800	50
	Wholesale	814	1,250	200
	Retail	563	800	300
Grape	Farm Gate	160	300	100
	Wholesale	440	1,200	180
	Retail	710	1,400	300

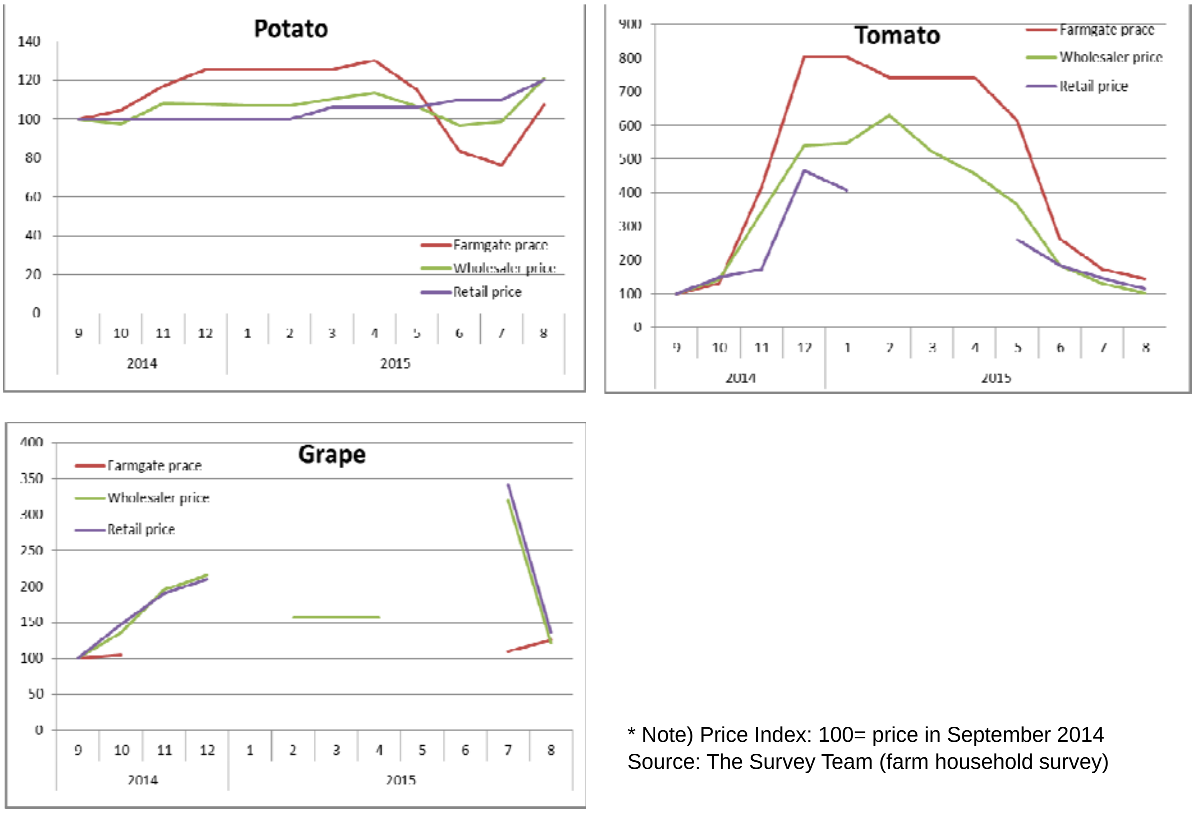
Source) The Survey Team

The result implies that middleman are generally selling the purchased products from farmers to other buyers with 20~30 % higher price. As regard to tomato's retail price (both in high season and in low season), logically it must indicates higher price than the wholesale price. But the wholesale prices in the table show higher prices than the retail prices. This is probably caused by complicated market condition of tomato, as tomato has various market segments, production sources and quality grades, such as for processing, for fresh consumption and for export, as well as from open field, from greenhouse and from import. A further survey is necessary to ravel out the confused information about tomato price.

More detailed information about farm-gate price collected through the farm household survey is listed in Appendix B-9. The prices show that there are huge gaps between minimum price and maximum price in every crop. Especially, the price gaps of tomato (both open field and greenhouse) are more than ten times. The prices of tomato are staying at the bottom due to the saturated situation in the market during in August to September when is the peak harvesting season of open-field tomato. Greenhouse farming is one of the effective ways for farmers to increase their profit by shifting the harvest season.

Figure 4-5-8.2 shows the price indexes of the 3 major crops: potato, tomato and grape to see their price fluctuation by season. Potato and tomato price indexes explain that farm-gate price tend to show wider fluctuation than wholesale price and retail price. Those crops' farm-gate prices are sharply down during their harvesting season. Farmers must be tackling with lower selling price during the high harvesting season. It is noted that price fluctuation of tomato is much wider than that of potato. It means that potato has less seasonality than tomato due to its high storage performance. Difference in storable period of both crops may cause the wider gaps. As greenhouse cultivation of tomato is becoming popular, the crops are available in Armenian market even in autumn to winter seasons together with imported one. Some farmers grow tomato and other vegetables targeting to market during off season by foster culture or by suppression culture with greenhouses. The tomato price index, showing the peak during December to April, implies that greenhouse farmers generate a substantial income from their greenhouse crops.

On the contrary, the index of grape farm-gate price shows rather stable and seasonal than potato and tomato. The stable price is mainly due to the contract farming system guided by the government. The government provides a direction of minimum buying price to processers, so that farmers don't lose motivation to grow grape. While the indexes of wholesale price and retail prices show wider fluctuation, it is probably caused by mixed information of two different market segments of grapes. One is cheaper grapes for processing and the other is expensive grapes for fresh consumption.



* Note) Price Index: 100= price in September 2014
Source: The Survey Team (farm household survey)

Figure 4-5-8.2 Price Index of Major Crops

4-5-9 Agricultural Cooperatives

In the Project area, agricultural cooperatives are not active. According to the result of the farm household survey, cooperatives are not a popular buyer of farm products for most of the interviewed farmers. It is quite rare to sell agricultural products to cooperatives except for dairy product (see Table 4-5-8.1). And also, a series of interviews to distributor, trader and processors of agricultural products reveals that it is uncommon for them to procure agricultural products from agricultural cooperatives. There is only a case that a wholesaler bought potatoes from cooperatives or farmers' group in the past year.

According to the head of division of agricultural cooperative support in the Ministry of Agriculture, not a small number of farmers are still suspicious about the benefit of agricultural cooperatives due to the negative mindset caused by their experiences during the Soviet era. There were many cooperatives established in short time by several projects even after the independence. However, many of them were not sustained. While a participatory process before the establishment and a careful monitoring for a certain long-period after the establishment are essential conditions to the development of self-sustained cooperatives, many projects fail to pay serious attention to them. Agricultural cooperatives are not yet became ingrained in farmers not only in the Project area but also in Armenia.

4-5-10 Agricultural Credit

Since April 2011, the government has been implementing an agricultural finance supporting program which compensates the interest rate of agricultural credit. The subsidized agricultural credit is provided through three private banks, i.e. ACBA Credit Agricole Bank, Ardshininvest Bank and Converse Bank. The compensation rate for the interest rate by the government is 4% (ordinary interest rate is 14 %), and more favorable rates (6%) of government compensation are implemented in the poverty-stricken areas. While 915 communities were involved in the program in 2015, 6% interest was applied for all the communities. The payback period of the credit is more than 1 year (depending on the loan condition), and the payments are to begin after 6 months of the borrowing.

Following Table 4-5-10.1 describes the total amount of the agricultural credit provided by the three private banks since 2000. According to the table, the loan amounts are hugely increasing since 2011 when the governmental supporting program started. The amount of agricultural credit without the government assistance also indicates a healthy growth. The total amount of agricultural credit from private financial agencies excluding the above three banks was about forty billion ADM in 2013.

Table 4-5-10.1 Agricultural Loans Provided by the 3 Private Banks (2000-2014)

Year	Loan Amount (Billion AMD)
2000	10.4
2001	9.4
2002	7.8
2003	8.2
2004	8.6
2005	11.3
2006	14.2
2007	22.4
2008	36.5
2009	44.2
2010	52.6
2011	73.4
2012	91.9
2013	103.2
2014 (up to June)	115.9

Source) The Ministry of Agriculture, RA

Table 4-5-10.2 shows the result of interviews to farmers in the target area about constrains and problems related to accessibility of credit. Interviewees replied that accessibility to credit is not a little problem for their agricultural activities. Nearly 40% of interviewed farmers regard access to credit is a considerable issue of farm management. Other survey result suggests that there must be high potential demand for agricultural credit, as many farmers are burdened with high production cost issues such as payment for fertilizers, agrochemicals, farm-machinery, irrigation, etc.

As mentioned in previous paragraph, there are subsidized agricultural credit systems in Armenia but many surveyed farmers presumed that those credit systems are not applicable due to its repayment conditions. For instance, some farmers claimed that harvest of orchard will start after several years of seedling, but repayment of the loan will start only after 6 months of the borrowing. They insisted that the agricultural loan system should have more varieties with different payment conditions for different purposes such as loan for orchard reclamation, agricultural machinery and greenhouse construction.

Table 4-5-10.2 Result of Interviews about Accessibility to Agricultural Credit

Accessibility	Crop farming		Livestock farming	
	Farmers	%	Farmers	%
No problem	36	44.4	25	30.9
Slightly problem	7	8.6	3	3.7
Very problem	30	37.0	11	13.6
Not applicable/no idea	8	9.9	42	51.9
Total	81	100.0	81	100.0

Source) The Survey Team (Farm household survey)

4-5-11 Difficulties Confronting Farmers

A series of workshops with 4 WUA members in the Project area suggests that farmers in the area share the following common issues (see Table 4-5-11.1). A problem tree arranging the common issues in order based on the cause and effect is attached in Appendix B-10.

Table 4-5-11.1 Common Issues Recognized by Farmers

Field	Problems & Constrains
Production	Soil fertility is low
	Production of marketable products is not enough
	Farm input cost is too high (seeds, fertilizers etc.)
	Quality of farm inputs is low (seeds, fertilizers etc.)
	Extension and support from government is not enough
	Lack of accessible agricultural credit (high interest rate and short repayment term)
	Natural disasters (hail and low temperature)
	Damages from insects and disease
Irrigation	Shortage of water
	Breakages of water canals
	Many water losses
	Water fee is high
	Water is contaminated / Not clean
	Unequal distribution of irrigation water among the member
	Ground water level in down
Machinery	Shortage of farm machinery
	Tractor hiring service cost is expensive
	Machineries are old
	Timing of machinery service us not appropriate
	Tractor and spare parts are expensive
Marketing	Sales price is low and/or highly fluctuated
	Accessibility to the market (hard to find good buyers)
	Difficult to transport the products to the market
	Lack of information/knowledge about marketing
	No government support for marketing

Source) The Survey Team

The farm household survey carried out by the Survey team reveals seriousness of the farmers' issues recognized by farmers' themselves (see Table 4-5-11.2).

Table 4-5-11.2 Seriousness of Issues Recognized by Farmers

Problems and constraints	No problem	Slightly problem	Very problem	Not applicable / no idea	Total
Technical information /services	63	9	9	0	**81**
Own skill & knowledge	66	12	3	0	**81**
Land size (need more land)	64	4	13	0	**81**
Land fertility	32	15	34	0	**81**
Salinity of land	63	8	8	2	**81**
Water shortage	31	16	34	0	**81**
Conditions of irrigation facilities	26	15	40	0	**81**
Water conflict	39	19	23	0	**81**
No good varieties of crops	27	19	35	0	**81**
Pests & disease	11	13	57	0	**81**
Availability of inputs	55	12	14	0	**81**
Inputs cost	19	10	52	0	**81**
Man-power	39	14	22	6	**81**
Availability of machinery	44	7	25	5	**81**
Machinery/mechanization service cost	22	12	41	6	**81**
Conditions of storage facility	50	4	20	7	**81**
Means of transportation	52	12	13	4	**81**
Access to good markets /buyers	24	11	44	2	**81**
Selling price is low	6	5	68	2	**81**
Market price stability (Price fluctuation)	7	7	65	2	**81**
Access to credit	36	7	30	8	**81**
Other	11	2	9	59	**81**

Note) Color marked: More than a half respondents answered as "Very Problem"
Source) The Survey Team (Farm household survey)

The most serious problems are closely related to marketing. Many farmers have difficulty in adapting them to low or fluctuated market price. Farmers also look for good markets and buyers who may be able to buy their products at favorable and stable price. If it's hard to find out those kinds of buyers, farmers want to be purchased their products by the government as practiced during the Soviet era. Although more than 20 years have passed after the independence, not a small numbers of farmers still have nostalgic eyes for the government intervention in the marketing. While many farmers complain about (high) inputs cost, this problem is inextricably linked with the marketing issues. If farmers could sell their products at their good price, they should consider that inputs are quite affordable. Considering a high cost structure of Armenian crops represented by wheat, a comprehensive policy should be established for reducing inputs cost, for introducing a rational farming system and for streamlining the existing marketing system. Then, proper measures in line with the policy should be taken by all stakeholders including farmers.

Pests and disease are also serious concern of many farmers. Many farmers claim that they cannot control pests and disease properly because of low quality of insecticides/fungicides. They, however, don't seriously consider that their farming skill and knowledge is not enough or agricultural extension services supporting them are not enough for controlling pests and disease properly, according to Table 4-5-11.2. On the other hand, many farmers said during the workshops that they need assistance from extension agency or agrochemical shops in order to know proper way of spraying to prevent or to control disease and pests of their products. Actually, farmers fail to control pests and disease due to improper use of insecticides/fungicides in many cases. They should be used on proper time and with right way for producing the due effect.

During the workshops, some participated farmers also complained about the quality of subsidized fertilizers. According to the farmers, the fertilizers are not inspected properly by the importing companies who are selected by the government. As a result of this circumstance, quality of imported fertilizers became lower than the Soviet era. Meanwhile, the head of state non-profit company “Agrochemical Service” under the Ministry of Agriculture said that farmers are not using fertilizers properly. The institution makes a soil analysis (content of basic nutrient elements: nitrogen, phosphate and potassium) every 5 years in each community nationwide. The result of the analysis indicates that farmers are not applying three main fertilizers in the right balance. Generally, farmers are fertilizing exceeded volume of nitrogen and less phosphate and potassium. The institution also inspects the quality of subsidized fertilizers whether it contains sufficient level of active elements, when the government imports them. According to the institution, lower production is not caused by low-quality fertilizers but unbalanced fertilization. There is a gap of recognition about the quality of subsidized fertilizers between farmers and the government institution.

It must be true that Armenian farmers have a certain good level of farming technology considering relatively high level of crop productivity at present. However, they should need more advanced farming skills and knowledge not only to control pests and disease, but also to adapt them to internationally competitive agriculture which the government aims at. Improvement of farmers’ technology through enhancement of agricultural R&D (research and development) and extension systems is a fundamental issue of Armenian agriculture, though many farmers don’t recognize it well.

Irrigation and mechanization are in the next group in seriousness. The both problems are mainly caused by low investment after the independence. Many over-aged facility and machinery are still used at field. Though they are maintained to some extent, they have already reached the end of their life span.

Figure 4-5-11.1 shows an image of current circumstance of farmers in the Project area by compiling the major issues described above. The issues are influenced each other and those issues finally amount to low farming income. A comprehensive measure to address every issue and constraint around farmers should be taken in order to develop agriculture in the Project area.

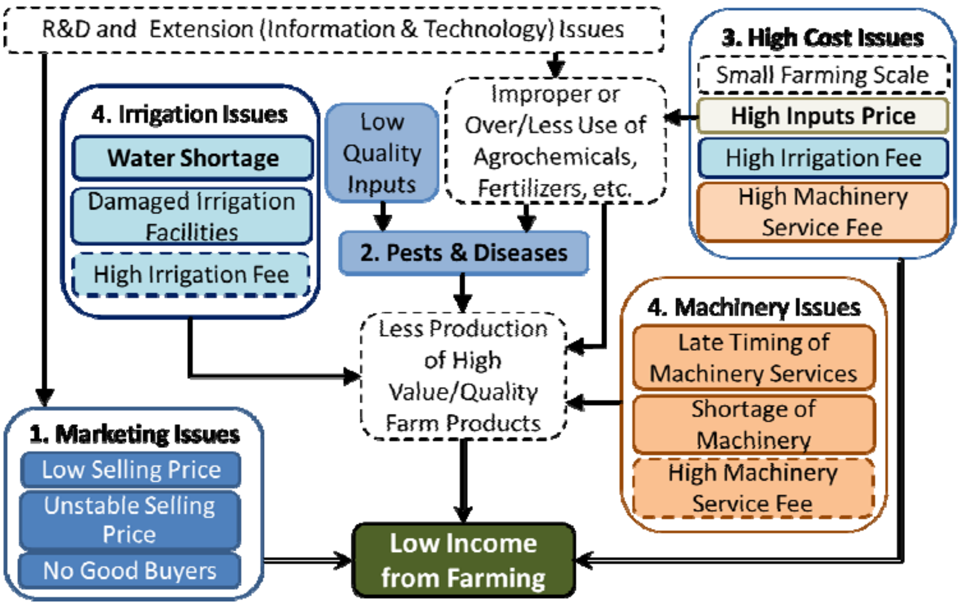


Figure 4-5-11.1 Constrains of Farmers in the Project Area

4-6 Information on Cost Estimate and Procurement

4-6-1 Condition of Cost Estimate

(1) Direct cost

Direct cost consists of 3 parts, i.e. 1) labor cost, 2) machinery and equipment operation cost and 3) material cost including transportation and storage expenses. Direct cost of construction work is derived by cost accumulation method of each work type.

(2) Indirect cost

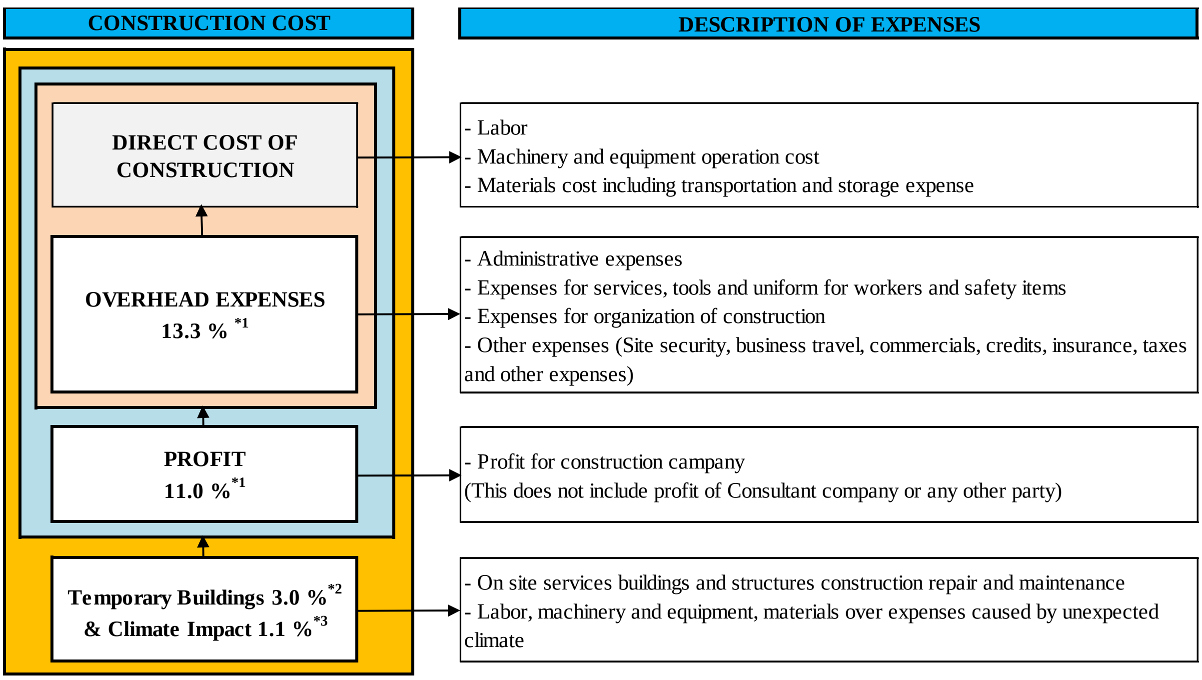
Indirect cost consist of Overhead expenses, Profit, Temporary buildings and Climate impact. Overhead expenses is including management cost of a contractor in site and head office such as administrative expenses, safety cost, insurance taxes and so on. Rate of overhead expenses is decided by Armenian construction law and its amount is13.3% of the direct cost.

Profit is only for a contractor profit, for a consultant company's or other parties' profit are not included in this expense. 11.0 % of accumulated amount of direct cost and overhead expenses correspond to the profit.

Temporary building cost is used for a construction, repair and maintenance of buildings in the construction site. Its cost is decided as 3.0 % of accumulated amount of direct cost, overhead expenses and profit.

Climate impact cost compensates prospected expenses generated by unexpected climate and weather condition like a water shortage for the construction in dry season. This cost is also regulated 1.1 % of accumulated amount of direct cost, overhead expenses and profit.

Contents of construction cost (direct and indirect cost) are illustrated in Figure 4-6-1.1.



*1 23.06.2011 No.879-N about "Construction works current cost estimation" rules of MUD of RA (Paragragh 8)
*2 21.08.2001 of MUD of RA about "Establishment of norms of temporary buildings and structures of construction" Chapter V, point 32, "
*3 21.08.2001 of MUD of RA about "Establishment of norms of climate impact on construction" Area I, Chapter V, point 32,

Figure 4-6-1.1 Contents of Construction Cost

(3) Consultant fee

Detail design and supervision of the construction are included in the consultant fee. This cost is estimated as 6 % of construction cost.

(4) Price escalation (Price contingency)

Price Escalation (Price Contingency) is calculated based on an average price escalation rate in 5 years. Reflecting the inflation in each country, price escalation of foreign currency and local currency are calculated separately. The rate of price escalation 2016, base year of the Project, is 1.8 % for foreign currency and 2.7% for local currency.

Price escalation of total Project Cost is calculated from that of base year and base cost in each year shown in Table 4-6-1.1. Calculated rate is 10.24%.

Table 4-6-1.1 Price Escalation in Armenia

Year	2016			2017			2018			2019			2020			2021			2022			Total	Price Escalation
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total		
Base cost for JICA financing	0	0	0	3.802	8.665	5.76	2.534	5.777	3.84	17.34	207.5	64.24	13.01	155.6	48.18	8.672	103.8	32.12	4.336	51.88	16.06	160.6	10.24%
Price escalation	0	0	0	0.068	0.234	0.121	0.092	0.316	0.164	0.954	17.27	4.856	0.962	17.5	4.917	0.809	14.78	4.15	0.49	8.992	2.522	16.45	
Foregin currency(FC) 1.8%	1	1	-	1.018	1.027	-	1.036	1.055	-	1.055	1.083	-	1.074	1.112	-	1.093	1.142	-	1.113	1.173	-		
Local Currency(LC) 2.7%	0	0	-	0.018	0.027	-	0.036	0.055	-	0.055	0.083	-	0.074	0.112	-	0.093	0.142	-	0.113	0.173	-		

(5) Physical contingency

Physical contingency is provided as 5% according to Yen loan rule.

(6) Exchange rate

Average exchange rate of 3 months from February to April 2016 is adopted in the cost estimation.

Exchange rate of US Dollar (USD) to Armenia Dram (AMD) is derived from the official rate of the Armenian Central Bank. The rate of US Dollar to Japanese Yen is calculated using the rate of declared by The Bank of Tokyo-Mitsubishi UFJ, Ltd. Calculated exchange rates are as follows,

1 US Dollar = 486.99 Armenia Dram
1 US Dollar = 113.65 Japanese Yen

4-6-2 Procurement of the Construction Machinery

(1) General construction machinery

Several construction machinery manufacturers in Japan and Europe have agents in Armenia and general construction machinery such as backhoe, damp truck, bulldozer etc. are distributed in the market. These machineries are used under lease mainly. These agents have workshops for maintenance of machineries and provide the service of repairing.

(2) Soil mixing machine

Construction work using soil mixing machine which is utilized for making soil-cement mixture is not common in Armenia therefore the machine is not well distributed in construction market. However, construction machinery agents can import and distribute this machine. Additionally, some agents can repair and maintenance this machine in their maintenance workshop. Therefore, it is judged that operation of soil mixing machine is feasible in the Project.

4-6-3 Procurement of the Construction Materials

(1) Bentonite Products

1) Armenia

Armenia is an export country of bentonite and its mine is located in Ijevan, north east part of Armenia (see Figure 4-6-3.1). Mined bentonite includes montmorillonite over 80% and has enough quality for using anti-infiltration works. Capacity of produce is 2,000 ton/month but this volume is to be increased up to 20,000 ton/month by future investment in equipment and facilities.

Also part of produced bentonite is transported to Belarus and manufactured to bentonite sheet.This bentonite sheet is imported and available in construction market in Armenia.

Source) Google map

Figure 4-6-3.1 Location of Bentonite Factory in Armenia

2) Georgia

Even enhanced product from Ijevan is not enough considering the necessary volume of the reservoir construction. Therefore, a bentonite mine in the neighboring country, Georgia was surveyed.

Georgia also exports good quality bentonite which contains montmorillonite over 85%. Bentonite is mined in Mitispri, western part of Georgia (see Figure 4-6-3.2). Estimated amount of deposit is 50,000,000 ton and annual product is 400,000 ton. This amount is enough for the consumption in the construction in Yeghvard reservoir.

Source) Google map

Figure 4-6-3.2 Location of Bentonite Factory in Goergia

(2) Cement and aggregate

1) Cement

There are two cement companies in Armenia. Production of one company has low strength and used for interior work of buildings. For construction work, cement manufactured in Ararat city is used. Cement of this company is supplied for the North-South corridor road project financed by World Bank and construction of nuclear power plants which required high stability. Annual product is 150,000,000 ton and this amount is over the estimated consumption in the construction.

2) Fine aggregate

Good quality aggregate is only produced from Araks river and many sand pit are scattered along the river. Araks river is a border with Turkey and the amount of product is decided as fifty-fifty with Turkey according to an agreement. Annual product is reached over 100,000m^3/year, however there is no danger of depletion for that sand is procured from upstream every year.

3) Corse aggregate

Mine of course aggregate is located in suburb of Yerevan. Excavated solid basalt from open-pit quarry is send to crusher plant installed beside quarry. Crashed basalt sieved 6 categories by diameter are distributed in construction market. Alkali-aggregate reaction test is conducted but no negative result has been reported.

(3) Pipe

Pipes can be procured in Armenia. Some factories have laboratories for quality control and tensile test, water pressure test and compression test are conducted.

(4) Gate and valve

Gate and valve are exported from Europe, Russia and China. So that products made in Russia and China are inferior in quality, European product are installed for significant facilities in Armenia. Some European valve companies had their factories in Slovenia and valves distributed in Armenia widely.

(5) Observation instrument

There is little demand of observation instrument for reservoir in Armenia, these instrument is imported in the construction stage.

4-6-4 General Information for Construction

Main port where imported materials are unloaded is Poti port in Georgia. At the Poti port, there are almost no troubles about unloading including custom clearance by Georgia. Custom clearance by Armenia takes about 1 week and smooth pickup is secured. No remarkable troubles are reported when imported.

CHAPTER 5 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5-1 Environmental and Social Considerations

5-1-1 Project Components

Table 5-1-1.1 shows the structure and scale of proposed reservoir and canals. In addition, Figure 5-1-1.1 shows the location of the proposed structures. Concerning the open-canal, 5m width at both right and left sides will be secured for the canal management[1]. Since steel pipe will be installed for all of the pipelines, while regulation valve for inner pressure of the pipe is not necessary. However, it is planned to set a regulation valve to regulate discharge to the Kasakh River and an energy absorber.

Table 5-1-1.1 Outline of the Structures

Structure	Scale	Location
Reservoir	Capacity: 94,000,000 m^3 (94MCM) Width of dam crest：8m Full water surface area: 808ha Reservoir area:796ha	Yeghvard Reservoir
Feeder Canal 1 (Pipeline)	Length: 4.4km Steel pipe, ϕ1,600mm	This canal diverts water from Arzni-Shamiram canal to Yeghvard Reservoir.
Feeder Canal 2 (Open canal)	Length: about 0.23km Concrete, Width：4m	This canal diverts water from Arzni-Shamiram canal to Yeghvard Reservoir.
Outlet Canal 1 (Pipeline)	Length: 0.73km Steel pipe ϕ1,200mm	This canal diverts reserved water to Arzni-Branch canal.
Outlet Canal 2 (Pipeline)	Length: 4.7km Steel pipe ϕ1,700mm	This canal diverts reserved water from Dike 1 to existing Ashtarak pipeline and to Kasakh River

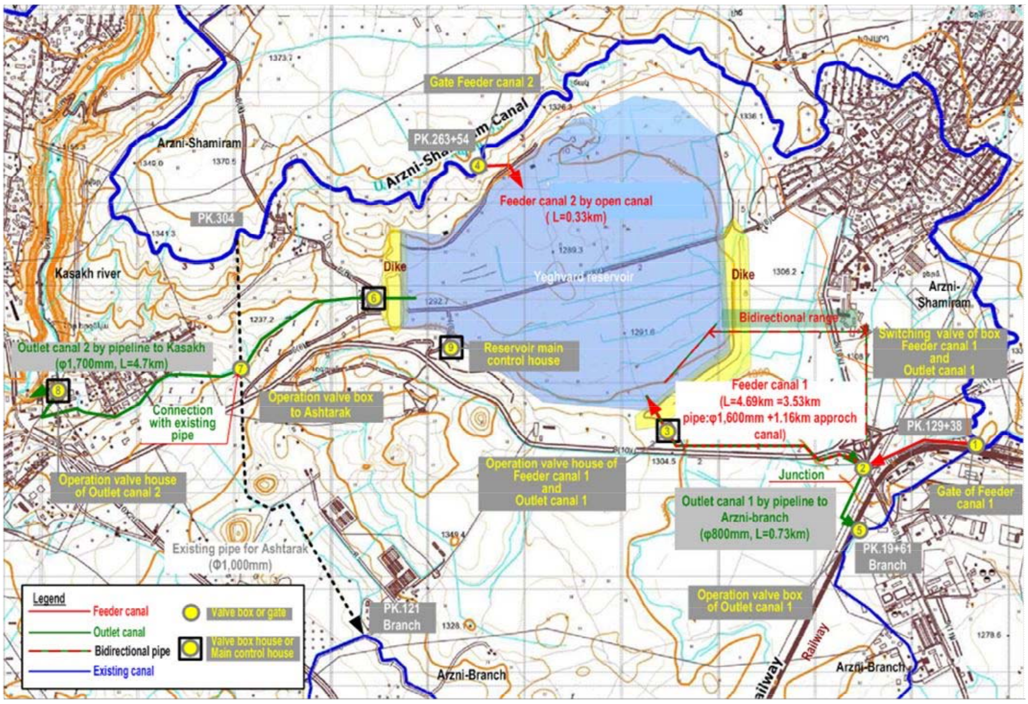


Figure 5-1-1.1 Proposed Project Components

In addition to the main structures above, rehabilitation and upgrading of the existing canal system, namely, Arzni-Shamiram Canal, Lower Hrazdan Canal, Arzni-Branch Canal, Shakhi-Au Canal, Inner Aknalich Canal, Upper Aknalich Canal will be implemented. Moreover, due to the Project, existing pump station and deep wells would be abolished, since pump-up irrigation system will be shifted to gravity irrigation system. Contents and scales of rehabilitation by the irrigation facility are described

[1] Space for canal management is called as “Protection Zone” and it should be secured in case of canal construction.

in the Table 5-1-1.2. It is noted that any cases of overflow in open canals have not been reported in Armenia.

Table 5-1-1.2 Rehabilitation Plan of Irrigation Canal System

Facility and structure	Rehabilitation outline
Arzni Shamiram	・ L=5.5km (PK20 to PK45, PK70 to PK90 and PK95 to PK105) ・ Remove concrete panel and lining concrete
Lower Hrazdan part2, BP. to PK219	・ L=17.8km (PK10 to PK188) ・ Add the concrete for raising to the sidewall ・ L=approx. 5km, Φ400mm pipeline (PK16) is installed toward Upper Aknalich ・ L=approx. 6km, Φ1000mm pipeline (PK188)is installed toward inner Aknalich
Aknalich PS.	・ Abolished (4 pumps at house, 3 pumps at outside)
Metsamor PS.	・ Abolished (4 pumps at house)
Ranchaper PS. 1	・ Abolished (4 pumps at house)
Ranchaper PS. 2	・ Abolished (4 pumps at house)
Arzni-Branch	・ L=2.3km (BP to PK23) ・ Remove the current canal and construct the lining concrete and/or install the pre-casting concrete canal ・ Replacement of gates
Arzni-Branch, PK120 to EP (PK165+19).	・ L=3.7km (PK120 to PK152 and PK161 to PK165+19 ・ Remove the current canal and construct the lining concrete and/or install the pre-casting concrete canal ・ Replacement of gates and aqueduct bridge
Tkhan canal, BP. to PK130	・ L=5.9km (PK71 and PK130) ・ Remove the current canal and construct the lining concrete and/or install the pre-casting concrete canal ・ Replacement of gates and aqueduct bridge
Shakhi-Aru canal, BP. to PK118	・ L=8.0km (BP. to PK31, PK69 to PK118) ・ Remove the current canal and construct the lining concrete and/or install the pre-casting concrete canal ・ Replacement of gates
Inner Aknalich canal	・ Construction of intake at Kasakh River ・ Replacement of gates
Upper Aknalich cana BP to PK104	・ L=10.4km (BP to PK104) ・ Replace the current canal to the concrete halfpipe canal ・ Replacement of gates and aqueduct bridge
Metsamor canal	・ No rehabilitation works

5-1-2 General Conditions of the Project Area

5-1-2-1 Current Situation around the Yeghvard Reservoir and the Proposed Canals

As Figure 5-1-1.1 shows, four (4) canals are proposed for the Project. The situation around the Yeghvard reservoir and proposed canals are described below.

(1) Reservoir basin

The lands within the Reservoir basin are state land, communal lands and private land, and most of the land belong to Yeghvard Community (City) and Nor-Yerznka Community. Northern parts of the lands are farmlands, since they are close to the Arzni-Shamiram canal, on the other hand, western and southern parts of the Reservoir are used as farmlands and rangelands. In some parts, the land is not suitable, since top soil had been already taken, and no crop is cultivated. As of April 2016, 53 plots as farmlands have been identified within the Reservoir basin. Photos showing the situations in the Reservoir basin are as illustrated in Figure 5-1-2.1 and 5-1-2.2.

Figure 5-1-2.1 Overview of the Yeghvard Reservoir

Figure 5-1-2.2 Wheat Field in the Yeghvard Reservoir

(2)Feeder Canal-1 and Outlet Canal-1

Both Feeder Canal-1 and Outlet Canal-1 will be a pipeline and they will be located on south-east of the Reservoir. The Feeder Canal-1 is planned to divert water of the Arzni-Shamiram canal to the Reservoir. The proposed route of the canal is along the road, which is surrounded by farmlands as illustrated in Figure 5-1-2.3. Outlet Canal-1 will be constructed along the railway as shown in Figure 5-1-2.4, and the canal is planned to divert water of the Reservoir to the Arzni-Branch Canal. At the junction point of Outlet Canal-1 and Feeder Canal-1, water flow direction will be switched by bulb operation depending on the season. During water storage period at the Reservoir, namely, from March to May, water flow direction is from the Feeder Canal-1 to the Reservoir, while during irrigation season, water flow is from the Reservoir to the Feeder Canal-1.

Figure 5-1-2.3 Proposed Route of Feeder Canal-1

Figure 5-1-2.4 Proposed Route of Outlet Canal-1

(3)Feeder Canal-2

Feeder Canal-2 will be an open canal to divert water from the Arzni-Shamiram Canal to the Reservoir. The proposed construction site is grassland (see Figure 5-1-2.5), which is located on the northern part of the Reservoir.

Figure 5-1-2.5 Proposed Route of Feeder Canal-2

(4)Outlet Canal-2

Outlet Canal-2 will be pipeline along the past waterway (see Figure 5-1-2.6). Proposed Outlet Canal-2 will divert water from the Reservoir to the existing pipeline for Ashtarak and to the Kasakh River. The proposed route is along the natural stream, where water is observed during only early spring and irrigation season.

Figure 5-1-2.6 Proposed Route of Outlet Canal-2

5-1-2-2 Natural Conditions

(1)Protected areas

In Armenia, 35 sites including national parks and sanctuaries have been specified as the Protected Areas. The distribution map of the 35 protected areas was prepared by the World Wildlife Fund (WWF) in collaboration with MNP in 2014 (see Figure 5-1-2.7). According to the map, there is no Protected Area around the Yeghvard Reservoir and command area. Therefore, it can be said that direct impacts on those Protected Areas by the Project is not expected. It is noted that the Lake Sevan, which is the largest lake in Armenia, is also identified as one of the Protected Areas and it is registered as the Ramsar site in 1993.

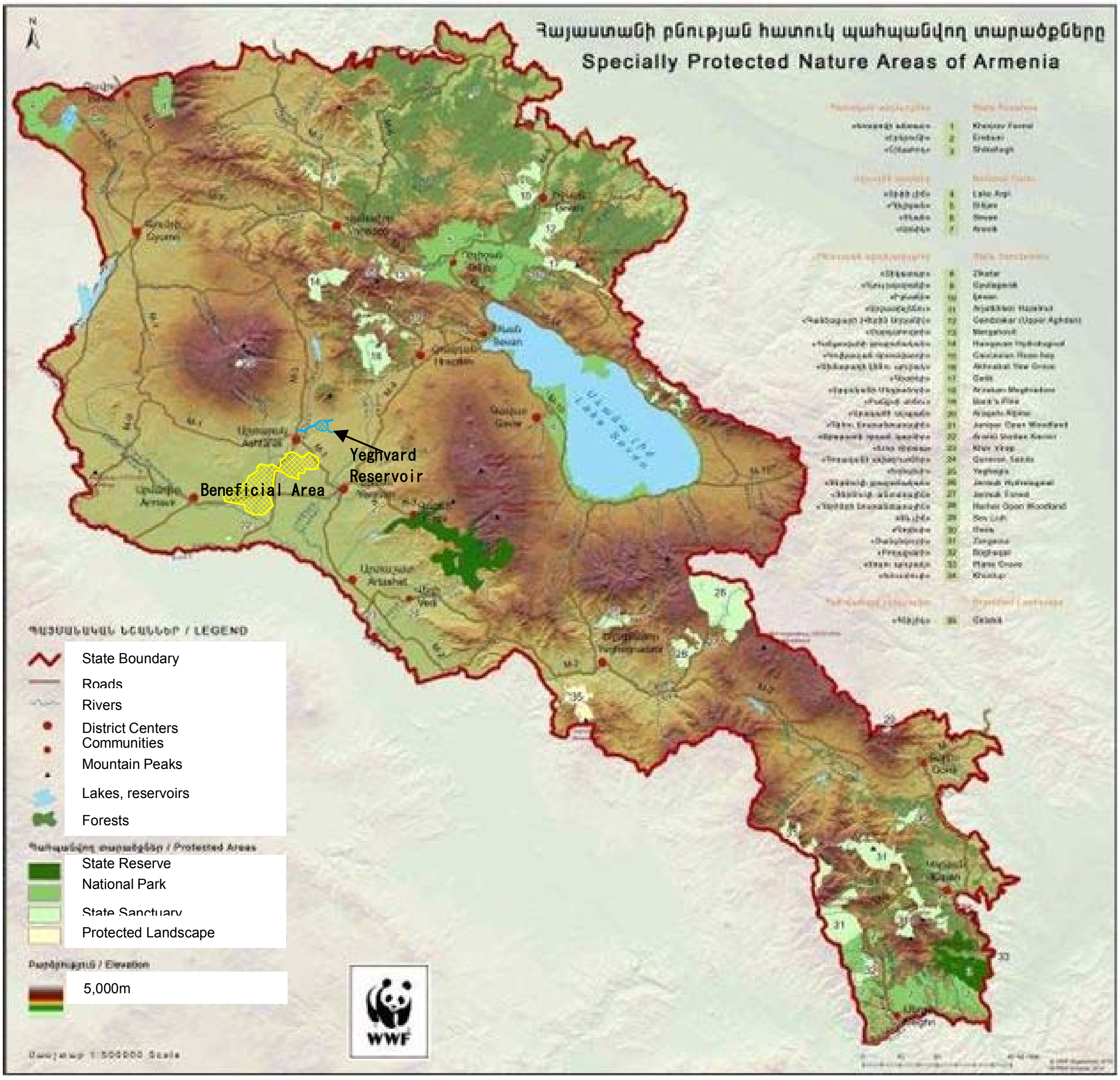
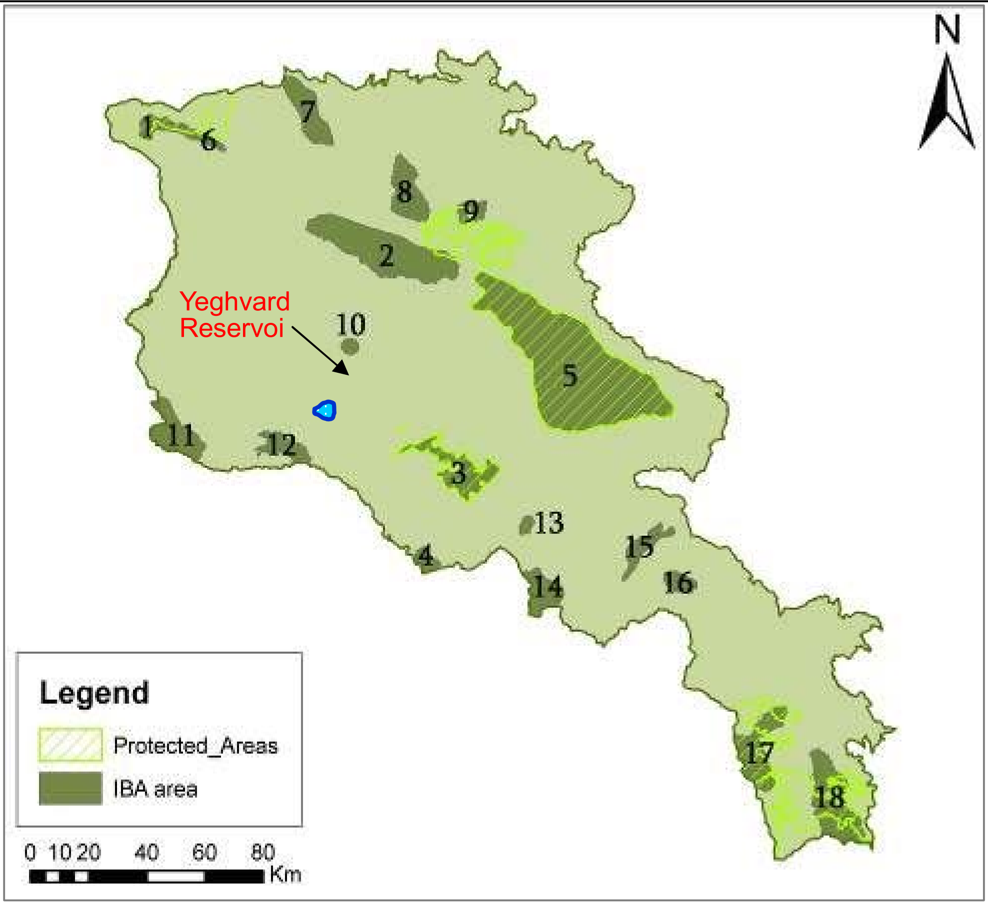


Figure 5-1-2.7 Distribution of Protected Areas in Armenia

Important Bird Areas (IBAs) are identified by the Armenian Society for the Protection Bird in collaboration with the Bird Life International and International Union for Conservation of Nature (IUCN). Figure 5-1-2.8 illustrates the location of IBAs in Armenia and the Project site. It can be said that the proposed project site is not located in and around the IBAs, therefore, any negative impacts on IBAs by the Project are not anticipated.



No.	Name of IBA
1	Lake Arpi IBA
2	Pombak Mt. Chain IBA
3	Khosrov Reserve IBA
4	Armash fish-farm IBA
5	Lake Sevan IBA
6	Amasia IBA
7	Tashir IBA
8	Dsegh IBA
9	Haghartsin IBA
10	Mount Ara IBA
11	Sardarapat IBA
12	Metsamor IBA
13	Gndasar IBA
14	Noravank IBA
15	Jermook IBA
16	Gorayk IBA
17	Zangezoor IBA
18	Meghri IBA

Figure 5-1-2.8 Distribution of IBA in Armenia

(2)Lake Sevan

The Lake Sevan is managed by "Sevan National Park" under the MNP. For promotion of conservation of the Lake Sevan, "The Law on Lake Sevan (2001)" and "The Law on Approval of Annual and Complex Measures on Conservation, Restoration, Reproduction, and Use of the Ecosystem of the Lake Sevan (2001)" have been established. The laws aim at conservation of the Lake Sevan and surrounding ecosystem by increase of the lake water level through integrated countermeasures, which contributes to sustainable development. Especially, the Arpa-Sevan tunnel has diverted a large amount of water to the Lake Sevan, consequently, the water level of the lake has been increased by 3.4m until now. On the other hand, due to the water level increase in recent years, part of forests, which had been planted during the period the water level was low, have been submerged. It causes water pollution due to rotten submerged trees. Not only trees but also some structures, which had been constructed, have been abandoned, since they cannot be used any more (see the photo right).


A structure and trees which are submerged due to increase of water level of the Lake Sevan

Due to the suspension of water diversion from the lake by the Yeghvard Project, it is estimated that water level of the lake will be increased by 4cm per year, which is very small compared with that by the Arpa-Sevan tunnel and so on, namely, 4m increase in 10 years (40cm/year). Therefore, it can be said that the Project will not result in submerge of existing structures and trees around the Lake Sevan.

The Government of Armenia has changed current watershed by construction of the Arpa-Sevan and Vorotan-Arpa tunnels for the Lake Sevan conservation. Furthermore, in 2001, the Government launched an environmental improvement strategy for Lake Sevan with the target of elevating its water level by 6m (up to 1,903.5m) by 2030. Additionally, amount of annual releasing (intake) water from Lake Sevan for irrigation is restricted to 170MCM, and operation period of hydropower stations along the Hrazdan River is limited to only irrigation period. Consequently, the lake water level has been recovered gradually.

5-1-2-3 Social Conditions

(1)Population

1) Beneficiary area

Under the Armenian administration system, there are ten (10) Marzes and Yerevan City, in total, eleven (11) regions. As mentioned before, the command area of the Project ranges Kotayk Marz, Aragatsotn Marz and Armavir Marz. The Yeghvard Reservoir is located in Kotayk Marz. In Kotayk Marz, energy industry such as electricity and food manufacture by using meat, fruit, vegetable, milk, wheat flour and beverage are actively operated. Total area of the Marz is 2,986km^2, half of the land, 1,546km^2, is used as farmlands. Concerning Aragatsotn Marz, main industry is agriculture, and cereals, grass, potato and so on are cultivated mainly. Other industries are food manufacture and mining. Total area of Aragatsotn Marz is 2,756km^2, farmland accounts (2,182km^2) for about 80% of the whole area. Regarding Armavir, horticulture including grape cultivation and livestock such as sheep and goat are widely operated. Total area of the Marz is 1,242km^2 and around 80% of the area (971km^2) is farmland.

The beneficial area consists of 27 communities in Koraykk Marz, Aragatsotn Marz, Armavir Marz. The area is covered by four (4) WUA, Yeghvard WUA, Ashtarak WUA, Vagharshapat WUA and Khoy WUA. There is a tendency that the actual male residents' number is smaller than that of registered one, it depends on the community, though. It is probably because young men go to the urban area or foreign countries to work as seasonal workers. In case of women, the same trend is observed, however, the extent is small compared with that of men.

2) Project affected area

The Project affected area, construction site of reservoir and feeder/outlet canals, are located in Yeghvard Community and Nor-Yerznka in Kotayk Marz, and Ashtarak Community in Aragatsotn Marz. However, the affected area in Ashtarak Community is very limited. Yeghvard city is located from Yerevan City is around 20 km and its key sector is manufacturing industry, including production of food and beverages such distilled alcoholic beverages, dairy products, flour production as well as production of leather goods and shoes. The people of Yeghvard Community are also involved in agricultural sector, mainly grain farming. Nor-Yerznka Community is located on 20 km away from Yerevan City. The main industry of the community is agriculture, mainly fruit production and cattle rearing. Population each community in the affected area is shown in Table 5-1-2.1.

Table 5-1-2.1 Population of Affected Area by Community

Region (Marz)	Community	Living			Registered		
		Male	Female	Total	Male	Female	Total
Kotayk	Yeghvard	5,338	5,996	11,334	5,632	6,040	11,672
	Nor-Yerznka	716	796	1,512	822	806	1,628
Aragatsotn	Ashtarak	9,018	9,464	18,482	9,749	9,866	19,615
Total		**15,072**	**16,256**	**31,328**	**16,203**	**16,712**	**32,915**

Source) National Statistical Service of the Republic of Armenia, 2011

(2)Ethnic minority people

In Armenia, major ethnic is Armenian, while ethnic minority people, Russians, Yezidi, Assirian, Greeks, Kurds people also stay as citizens. For example, in Kotayk Marz, 98% of the population is Armenian, 1.2% of that is Yezidi. The minority people are generally well integrated with Armenian people and they are not classified into indigenous people. Basically, the minority people do not have difficulty of communication by Armenian language. The minority people are regarded as citizens of Armenia, they can get passport as Armenians and can purchase lands officially. One of the beneficiary communities, Ferik Community, there are many Yezidi people, and they will be beneficiaries of the Project. On the other hand, it was confirmed that there is no ethnic minority people in the affected areas.

(3)Gender issue

Generally, women do not take leaderships in Armenia, and traditionally it is thought that women have to be protected by men. There is a tendency that migrant labors to other countries/cities are men. In rural area, roles and responsibilities for farming are shared between men and women. For instance, heavy works such as harvest and irrigation works are shouldered by men, while relatively light works such as selection of harvested fruits to be packed are done by women. In other words, cereal production which needs operation of agricultural machines is implemented by men, while vegetable production which requires manual works is done by women. If heads of farm households are female, they can hire labors for those heavy works easily, since it is common for Armenian farmers to purchase seeds/fertilizers and employ labors by using loan. Sometimes, widows are supported by the neighbors, friends and relatives for the works.

The situations regarding gender issues is changing in Armenia, and the Head of Ashtarak Community, which is located on near the Project site, is female. Moreover, in June 2015, European Neighborhood Programme for Agriculture and Rural Development (ENPARD) was established under the support by the European Union and Austrian Development Cooperation. The ENPARD does not focus on gender mainstreaming, however, one of the program component is to enhance women’s leadership in farming activities. The program will support 56 agricultural groups, and it is planned that more than 40% of leaders of target groups have to be female. Considering those situations mentioned above, gender issue in Armenia is not a big problem.

5-1-2-4 Farming Conditions in the Beneficial Area

The beneficial area is covered by four (4) WUAs. The area utilizes the Lake Sevan and the Hrazdan River as main irrigation sources, additionally, it utilizes pumped-up water through pump stations from the Metsamor River.

The crop diversification is well advanced in the area. The planted area of each WUA is summarized as follows.

- Yeghvard WUA: High percentage of orchard and perennial grass (Alfalfa), and low percentage of vegetables and wheat
- Ashtarak WUA: High percentage of grape, and low percentage of vegetables and wheat
- Vagarshapat WUA: High percentage of wheat and vegetables, and low percentage of fruits and others
- Khoy WUA: All kinds of crops are equally planted. Representing the cropping in the target irrigation area

According to the Department of Horticulture Crop Production and Plant Protection, MOA, applied agrichemicals in Armenia are imported from various countries. Consequently, prices of agrochemicals are relatively high, and the amount of agrichemical consumed by farmers is not very big. During Soviet Union period, agrichemical had been applied for farming in the Ararat Plain intensively, however, it has not been done very much after the independence. Moreover, no case of agrichemical pollution of irrigation canals and rivers has been reported so far in Armenia according to the official personnel of MOA and Ministry of Nature Protection (hereinafter "MNP"). On the other hand, there is no surface water quality or soil quality standard regarding agrichemical in Armenia. Hydrogeological Monitoring Center under the MNP conducts water quality monitoring of some river waters regularly, however, the monitoring does not cover agro chemical.

5-1-3 Institutional and Legislative Framework for Environmental and Social Considerations

5-1-3-1 Responsible Organization for Environmental and Social Considerations in Armenia

The MNP is responsible for natural conservation, sustainable use and restoration of natural resources, environmental improvement and so on in Armenia. Also, the MNP formulates national policies for environmental conservation, environmental standards, environmental guideline, etc. In the Ministry, there are various departments and agencies, and also thirteen (13) State Non-Commercial Organizations (SNCOs). The number of staff of MNP is around two thousands in total and the organization structure of the MNP is illustrated in Figure 5-1-3.1.

The Center of Expertise for Environmental Impact Assessment SNCO, MNP is the responsible for examination and approval of environmental and social impact assessment (ESIA) report. The number of staff of the Center is 17 (seventeen) in total, the organization examines the ESIA report under the support from other agencies under the MNP, other ministries and private companies according to necessity.

As illustrated in Figure 5-1-3.1, the divisions are under the departments according to the Homepage of the MNP. There is no clear mention about relationship among the departments within the MNP, however, cooperation between some departments are practiced. For instance, when an official letter is submitted to the Environmental Impact Expertize Center in the MNP, the response in the documents is issued after the approval by the Legal Department.

Under the MNP, the Environmental Impact Monitoring Center is an institution responsible for environmental analysis. The Center has been supported by the USAID through provision of some analytical instruments, and has been requested for water quality analysis by some international organizations such as FAO. Therefore, it can be said that the Center has sufficient experience and ability, which leads to fair and appropriate analysis.

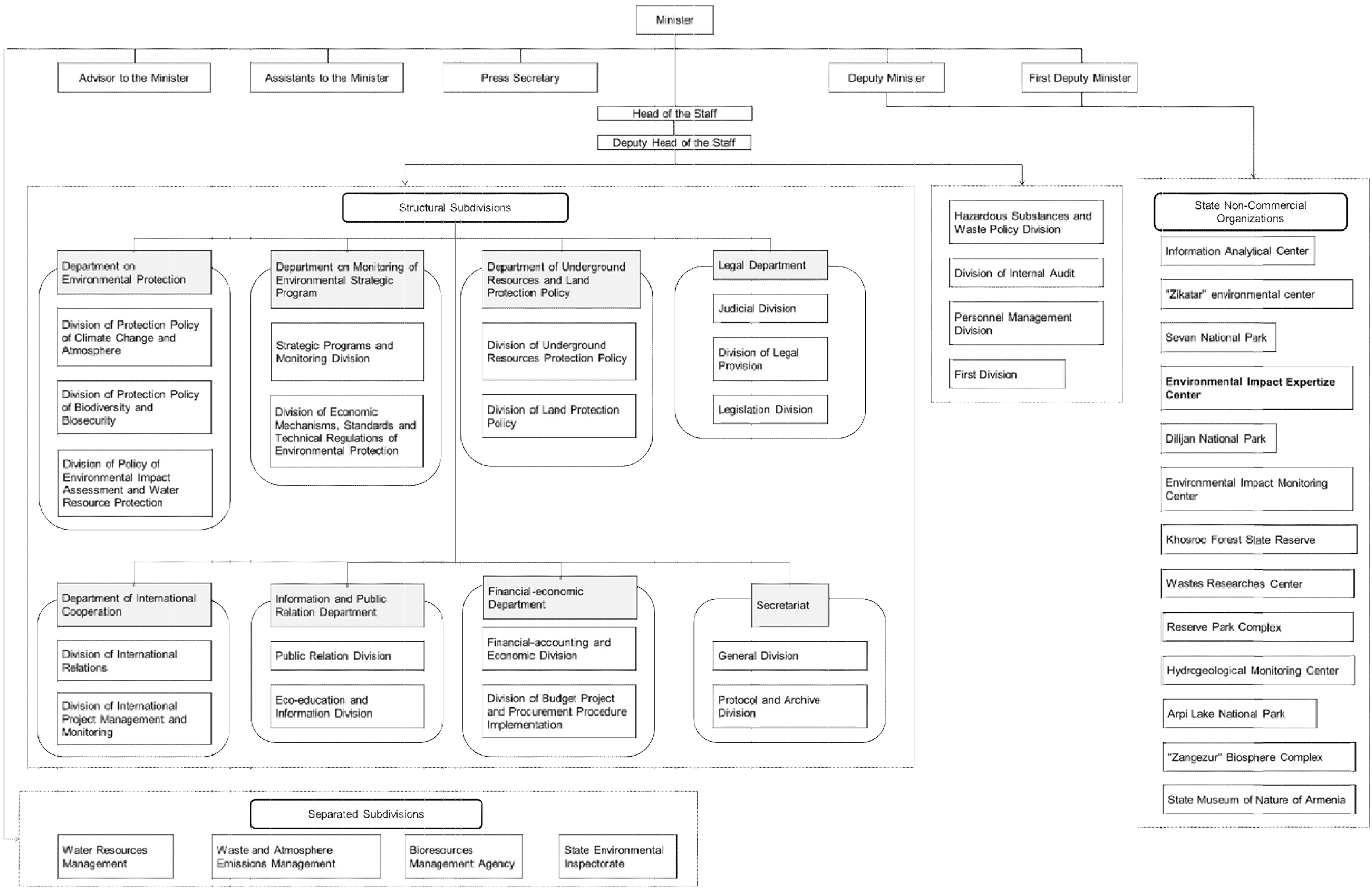


Figure 5-1-3.1 Organization Structure of the MNP

Source) Homepage of the MNP, 2015
(The organization chart is modified based on description in the Homepage)

5-1-3-2 Relevant Laws on Environmental and Social Considerations

Armenia has laws on the environmental conservation as shown in Table 5-1-3.1. The "Law on Environmental Impact Assessment and Expertise" is the one concerned to the environmental and social considerations.

Table 5-1-3.1 Laws on Environmental Conservation

Adaption/ Amended	The name of Laws (in English)
1991/ 2006	Law on Specially Protected Natural Areas
1992	Law on Ensuring Sanitary- epidemiological Security of the RA Population
1994	Law on Atmosphere Air Protection
1995	Law on Environmental Impact
1996	Law on Automobile Roads
1998	Law on the Protection and Use of Fixed Cultural and Historic Monuments and Historic Environment
1998	Law on Environment and Nature Use Charge
1999	Law on Flora
2000	Law on Fauna
1991/ 2001	Land Code
2001	Law on Hydro-meteorological Activity
2001	Law on Environmental Education
2002	Code on Underground Resources
1992/ 2002	Water Code
2002	Law on Seismic Defense
2002	Law on Water Users' Associations and Federations of the Water Users Associations
2004	Law on Waste
2005	Forest Code
2005	Law on Environmental Supervision*
2006	Law on Rates of Environmental Charges Decree of the Government on Approval of Technical Regulation of the Requirements for Decision of Norms for Removal of Fertile Soil Layer, and Storage and Usage of the Removed Fertile Layer**
2006	Law on National Water Program
2008	Law on Oversight of Land Use and Protection
2010	Decree of the Government of RA N 71-N on Approval of the Red List of Animals of the RA Decree of the Government of RA N 72-N on Approval of the Red Book of Plants of the RA
2011	Decree of the Government of RA on Approval of the Order of Usage of Fertile Soil Layer, Annulment of the Decree No. 1622-N of the Government of RA dated on 19.09.2002, and Amendment of the Decree No. 286-N of the Government of RA dated on 12.04.2001**
2014	Law on Environmental Impact Assessment and Expertise
2014	Public notifications and discussions procedure, Decree No.1325-N

*The State Environmental Inspectorate under the MNP supervises soil transportation to minimize the environmental impact.

**In case of project which would disturb fertile top-soil, it is needed to transport the top-soil to outside of the area.

(1)Law on Environmental Impact Assessment

In 1991, after the independence of Armenia, it was unclosed that the environmental situation in this country had been deteriorated, and environmental conservation was identified as a high priority issue. Responding to the situation, various laws on environmental conservation have been formulated. The first relevant law to the Environmental Impact Assessment in Armenia was the "Law on Environmental Impact (hereinafter "the previous law") in 1995. However, there were some gaps between the previous environmental law and international standards set by international organization such as WB, ADB, and so on. For the improvement of this issue, the "Law on Environmental Impact Assessment and Expertise (hereinafter "the new law") was formulated in 2014.

The biggest difference between the previous law and the new law is that the new law regulates the procedure of environmental assessment. In addition, under the new law, assessment is implemented by two stages (i) Initial Stage, which includes screening and categorization to category A, B and C according to the activity type; and (ii) Main Stage, during which an assessment for Category A and B is implemented in more detail. The Project corresponds to the construction sector which including over 1 million m^3 of reservoirs, artificial lakes, or ponds (on No. 4 of Article 14 of the new law), and it is categorized as Category A. So far, MNP has approved only two projects under the new law, because it has been short time after the adoption.

Any projects are categorized into Category A, B and C depending on the scale and characteristics. Generally, Category A Projects are large scale, or can cause complicated environmental impacts. For instance, projects of construction of hydropower stations with the power of 30 MW and more are categorized into A. In case of water management project, construction of reservoirs, artificial lakes, water basins with 1 million m^3 and more are classified into Category A. In case of Category B, medium-scale projects are categorized, e.g. hydropower stations with 10-30 MWt power and so on. Category C projects include Production of biogas or energy with biogas with the power of 1 MWt and more Hydropower stations with the power of 1-10 MWt and so on. There is no mention of reservoir scale in definition of Category B and Category C. Any projects which are classified into Category C do not need ESIA preparation.

(2)Necessity of environmental and social considerations at each stage

Regarding Environmental and Social Considerations for Master Plan and Development Strategy, a Strategic Environmental Assessment is necessary according to the Law. However, the Strategic Environmental Assessment is not categorized into Category A or B or C. On the other hand, if the project is categorized as Category A or B, the undertaker must prepare an ESIA Report on the Feasibility Study (F/S) Stage and the Detail Design (D/D) Stage. The contents of ESIA Report and the procedure, on F/S Stage and D/D Stage, are the same.

(3)Project which requires ESIA report preparation

As mentioned before, the procedure of preparing ESIA Report on the new law consists of Initial Stage and Main Stage (see Figure 5-1-3.2). When the project is categorized as a Category C at the Initial Stage, the undertaker doesn’t need to prepare an ESIA Report. However, if it is categorized as Category A and B, ESIA Report preparation is needed. Furthermore, there’s no difference between ESIA Report contents of Category A and that of Category B. The difference between the Category A and B is only period of ESIA Report examination, namely, 60 working days and 40 working days for Category A and Category B, respectively. In addition, the examination for Strategic Environmental Assessment Report is 60 working days.

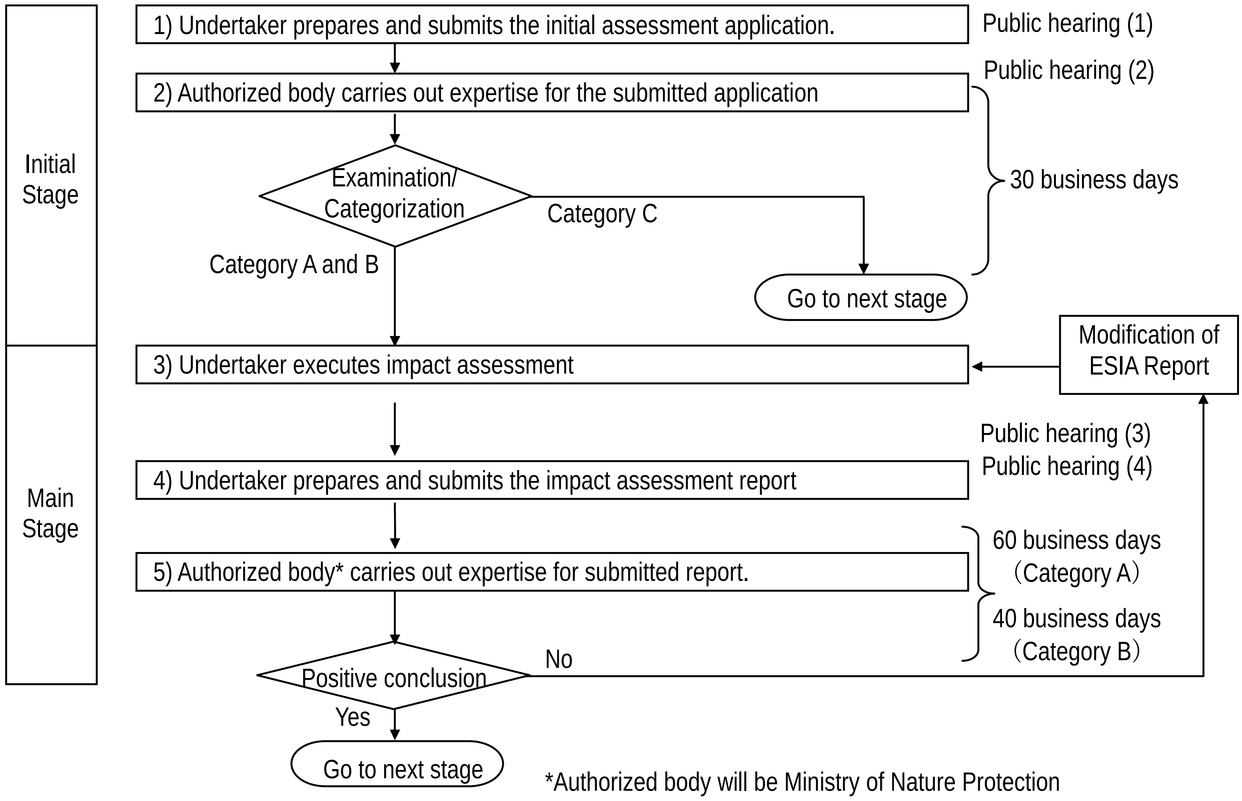


Figure 5-1-3.2 Process of Preparing, Application, and Approval of ESIA Report

1) Initial Stage

The undertaker prepares an initial assessment application and submits it to the MNP. The contents of the initial assessment application include the project components, estimation of the environmental impact by the project, results of Public Hearing and so on. After this, the MNP will notify results of the Category and contents which should be included in the ESIA Report, if the project is categorized as Category A or B. Before submission of the application document, the undertaker must hold the Public Hearing which explains the project outline and expected project impact, and include the results of Public Hearing to the application document. After that, the MNP will hold the other Public Hearing to confirm contents of the submitted application document. Based on the application, the MNP suggests the survey contents of ESIA Report.

2) Main Stage

Based on the notice from the MNP on Initial Stage, the undertaker should implement the environmental impact assessment and prepare an ESIA Report. The contents of Strategic Environmental Assessment Report and ESIA Report are shown below.

[Strategic Environmental Assessment Report]

i. The aim of the master plan and the development strategy, and their relation and accordance with master plan of the given area,

ii. International agreements and other related legal acts ratified by the Republic of Armenia related to the master plan and the development strategy,

iii. The environmental issues related to the area subject to impact and their reflection in the master plan and the development strategy,

iv. The natural environmental conditions and socio-economics situations of the area,

v. The comparison of all possible options,
vi. The mitigations,
vii. The monitoring program,
viii. The information on sources of data included in the report,
ix. Information on assessment methods, and issues, including absence of data, arising during their application,
x. Summary of the report.

[ESIA Report]

i. The aim of the project
ii. The natural environmental conditions and socio-economics situations of the area.
iii. The consistency between the development plan of the area and the project
iv. The comparison of all possible options
v. The estimated impacts by implementation of the project (the impacts to natural resources and materials by the project, air pollution, drainage, waste, emergency situations, and so on)
vi. The impacts to the natural environment and socio-economic environment by the project
vii. The mitigations
viii. The scales, possibilities, and reductions/ mitigations of estimated emergency situations[2]
ix. The monitoring program
x. The information on sources of data included in the report
xi. Information on assessment methods, and issues, including absence of data, arising during their application.

In addition, the undertaker has to attach results of the Public Hearing, including the minutes, the attendance list, videotape, the notification for the Public Hearing, and so on. And if the project is on the F/S Stage, the summary of F/S report is required to be attached.

The ESIA Report is examined by the MNP. At this stage, the undertaker and MNP have the Public Hearing to explain the project impact and its mitigation measures again. For the examination by MNP, 60 working days and 40 working days are needed for Category A and Category B, respectively, however, if MNP needs more days for examination of ESIA Report, they can extend the period up to half of days of original period. When an ESIA Report is submitted to the MNP, summary of the project report such as F/S report shall be attached. If the ESIA report is satisfactory, the MNP gives positive conclusion, and the project can proceed to next step as Figure 5-1-3.2.

Table 5-1-3.2 shows the gap between the Environmental Law in Armenia and the JICA Environmental and Social Guidelines (hereinafter referred to as “JICA Guidelines”).

Table 5-1-3.2 Gap Analysis between the Environmental Law in Armenia and JICA Guidelines

Items	JICA Guidelines	Environmental Law in Armenia	GAP	Measure for settlement
Procedure	JICA confirms that projects comply with the laws or standards related to the environment and local	The procedure of the Environmental Impact Assessment is regulated in Law on Environmental Impact	None	—

2 Emergency situation includes natural disasters, man-made disasters, and accidents

Items	JICA Guidelines	Environmental Law in Armenia	GAP	Measure for settlement
	communities in the central and local governments of host countries; it also confirms that projects conform to those governments' policies and plans on the environment and local communities. JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies,	Assessment and expertise (2014).		
Language of the Environmental Impact Assessment Report	ESIA Reports must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them.	ESIA Report is to be prepared in Armenian. And the explanation of project is also implemented in Armenian. In general, the local people uses Armenian.	None	—
Information Disclosure	In principle, project proponents etc. disclose information about the environmental and social considerations of their projects. JICA assists project proponents etc. by implementing cooperation projects as needed. JICA encourages project proponents etc. to disclose and present information about environmental and social considerations to local stakeholders.	Before submission of the application documents and ESIA Report to MNP, the Public Hearing is required to be held. In the Public Hearing, it is required to be explained to participants (e.g. relevant municipalities, residents, and so on) about the project outline and the estimated environmental impacts. Furthermore, the public notice, contents of Public Hearing, and the consent form from municipalities are required to be attached to the application documents and ESIA Report. (No. 26 of Article 16/ Law on Environmental Impact Assessment and Expertise). After the Public Hearing for the application, MNP would announce the category of the Project and the contents which the undertaker should implement the environmental impact survey. In addition, after the Public Hearing of submission of ESIA Report, MNP would present the result of the report to relevant person ("Public notification and discussion procedure," 2014).	None	—
Access to ESIA Report	ESIA Reports are required to be made available to the local residents of the country in which the project is to be implemented. The ESIA Reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted;	When the Public Hearing, the contents of ESIA Report is required to be explained (Article 26, Law on Environmental Impact Assessment and Expertise). Submitted ESIA Report to MNP would be disclosure on the website of MNP, and be allowed to copy or read. Furthermore, if the report revised, the revised version would be disclosure on website.	None	—
Consultation with Local Stakeholders	In principle, project proponents etc. consult with local stakeholders through means that induce broad public participation to a reasonable extent, in order to take into consideration the environmental and social factors in a way that is most suitable to local situations, and in order to reach an appropriate consensus. JICA assists project proponents etc. by implementing cooperation projects as needed. In the case of Category A projects, JICA encourages project proponents etc. to consult with local stakeholders about their understanding of development needs, the likely adverse	Before the application and submission ESIA Report, the Public Hearings are required to be implemented. The participants can make comments about the project, the estimated environmental impacts, and the mitigations. In addition, the undertaker has to consider the comments from participants. And if the comments are reasonable, the undertaker has to reflect them to ESIA Report. (Article 26, Law on Environmental Impact Assessment and Expertise). The undertaker have to attach the memorandum of the Public Hearing and recorded videotape to the	None	—

Items	JICA Guidelines	Environmental Law in Armenia	GAP	Measure for settlement
	impacts on the environment and society, and the analysis of alternatives at an early stage of the project, and assists project proponents as needed.	application documents and ESIA Report, and submit them to MNP (Article 26, Law on Environmental Impact Assessment and Expertise).		
Confirmation of Monitoring	JICA confirms with project proponents etc. the results of monitoring the items that have significant environmental impacts. This is done in order to confirm that project proponents etc. are undertaking environmental and social considerations for projects. The information necessary for monitoring confirmation by JICA must be supplied by project proponents etc. by appropriate means, including in writing. When necessary, JICA may also conduct its own investigations. In addition, JICA discloses the results of monitoring conducted by project proponents etc. on its website to the extent that they are made public in project proponents etc.	Monitoring Program is required to prepare. However, there is no mention that publication of results of Monitoring Program is required or not.	Necessity of Publication of monitoring results is not mentioned.	JICA would confirm the actual situations of publication of monitoring results.

In addition to the table above, some norms/standards are not established in Armenia as described in (3) below. Therefore, it is recommended to apply international standards as required.

(3)Environmental standards in Armenia

Some norms/standards regarding unified effluent from factories, soil contamination, and specific irrigation water quality, limitation of agrichemical in surface water are not established in Armenia. Moreover, In case of groundwater, purposes of use are various, namely, drinking, domestic use, aquaculture and so on, there is no specific standard/norm. This sub-chapter describes existing regulation, norms/standard, laws concerning environmental conservation.

1) Air quality standard

National of ambient air quality standard in Armenia is speculated in “Norms of maximum allowable concentrations of ambient air pollutants in residential areas”. In the regulation, 389 parameters of quality are provided, however, parameters to be monitored are fixed depending on the location, and it is not necessary to monitor all of the parameters. In case of big cities such as Yeghvard City, dust, NO_2, SO_2 and CO are parameters to be monitored according to the MNP. Thus, only those parameters are regarded as the standard in the Project. The allowable values of those parameters are as shown in Table 5-1-3.3.

Table 5-1-3.3 Air Quality Standard in Armenia

Air pollutant	Maximum one-time concentration (mg/m^{3})	Mean daily concentration (mg/m^{3})
Dust	0.5	0.15
SO_2	0.5	0.05
NO_2	0.0085	0.04
CO	5.0	3.0

Source) Government Decree #160-N dated 02.02.2006

2) Industrial effluent standard

The Government of Armenia has yet to establish any uniformed standards regarding effluent discharge from industrial factories. According to the Water Code of Armenia, every commercial/industrial unit shall propose their own effluents' permissible values to be discharged to surrounding water basins. All factories should set the permissible level in the document based on the specified formula and submit it to Water Resource Management Agency under the MNP to get approval on the proposed permissible values. During the operation of factories, another organization under the MNP, namely, State Environment Inspectorate is in charge of monitoring of the effluent discharge situations based on the proposed permissible level by themselves. The parameters, which are generally regulated in discharged water, are temperature, pH, TDS, SS, BOD, COD, SO_4, PO_4, NO_3-N, NO_2-N and so on.

3) Surface water standard in Armenia

In Armenia, there is a surface water quality standard which classifies 5 categories, and the water uses are determined based on the class of water quality. Concerning irrigation water, water which satisfies Class I to Class IV can be used. In Armenia, Background Concentration (BC) is specified for each river, and water quality threshold depend on the river. Rivers concerned to the Project are Kasakh River and Hrazdan River, and Background Concentrations of those rivers as well as general surface water quality standard is shown in Appendix-K-1 Table-1.

There is no regulation which focuses only irrigation water quality specifically in Armenia, the surface water quality standard has been established, though. According to the official personnel of the MOA, the international standards prepared by the Food and Agriculture Organization (FAO) are applied. There is no big difference between the surface water quality in Armenia and the FAO guidelines for irrigation for common water quality parameters, the Armenian standard is stricter for some parameters. FAO water quality standard is attached in Appendix-K-1, Table-2.

Concerning regulation of organic pollutants such as pesticide and insecticide in Armenia, any standards are not established yet. Therefore, staff of SNCO of Environmental Impact Monitoring Center under the MNP recommends applying the environmental quality standard for the Project mentioned in EU journal. The standard of the pollutants is shown in Appendix-K-1, Table-3.

4) Noise

Noise standard has been established in Armenia, and the threshold values are fixed depending on the surrounding conditions and time (daytime or night time). The norm for noise pollution control is described in Table 5-1-3.4.

Table 5-1-3.4 Noise Standard in Armenia

Facilities and buildings	Day time / night time	Noise equivalent level, dB	Noise maximum level, dB
Territories adjacent to residential buildings, clinics, ambulatories, rest houses, care homes, disabled persons homes, libraries, kindergardens, schools and other educational facilities	6:00 – 22:00 22:00 – 6:00	55 45	70 60
Rooms of apartments, sleeping rooms of rest houses, care homes, disabled persons homes, kindergardens, boarding schools	6:00 – 22:00 22:00 – 6:00	40 30	55 45
Noise in workplaces for construction works		80	

Source) Ministerial of Health Care of RA, Order No.138 on The Sanitary Norms N2-III-11.3 “Noise in the Work Places, Residential, Public Buildings and Residential Construction Sites” (2002)

5) Waste

“Law on Waste” has been established in 2004 in Armenia, waste are classified into six categories, namely, 1) household waste, 2) non-household waste, 3) industrial waste, 4) constructional waste, 5) big-scale waste, and 6) hazardous waste. Costs of waste disposal are maximum 3,000 AMD and 10,000 AMD, for 1 m^3 and 1 ton, respectively. Authorized body for waste management is the MNP, and any construction companies which generate waste must make a "waste passport", and submit to the MNP. The permission of waste disposal is given by MNP. The place for disposal is also decided by the MNP.

5-1-4 Examination of Alternatives

5-1-4-1 Alternatives of Water Resources

In the Project, the construction of canals and a reservoir is proposed. These facilities together will be able to provide sufficient and stable irrigate water for the target area. Therefore, canals and the reservoir would be considered as one package. When alternatives of the project are examined, the package of canals and reservoir would be compared with others.

The aim of the Project is irrigation system improvement of the target area, and two options of water resources to fulfil the purpose can be considered. The first option is use of groundwater for irrigation and second one is use of surface water including meltwater. In addition, the case that the project is not implemented, called as "Zero- option", is also examined.

(1)Zero-option

The Government of Armenia has been controlling the amount of water taken from the Lake Sevan since 1980's and water diversion project for the Lake Sevan conservation, such as the construction of the tunnel for taking water from Arpa River and Vorotan River has been implemented. As a result, the water quantity has been recovered up to 38 billion m3, however, the government restricts the amount of water discharge from the lake to 170 MCM/year except for drought years. If the Project is not implemented, the target area will depend on the Lake Sevan as main irrigation water resource, as ever. It would cause to decrease the water level of Lake Sevan. On the other hand, when the water level of the Lake Sevan is conserved by means of reduction of discharge of irrigation water from the lake, the agricultural production in the Project target area can be reduced, since water demand for irrigation cannot be satisfied.

Yeghvard Reservoir was planned with the scale of 228 MCM, in the Soviet Union period, and the embankment had been constructed in the early 1980’s. Because of financial issues, the construction was stopped in 1985. However, a part of the embankment was constructed. Therefore, if it will not be used, the investment in Soviet Union period would be useless. Furthermore, barley, wheat and alfalfa have been cultivated in the area of the Reservoir, however, the farmers understand that the construction of the Reservoir will be resumed. That’s why they cannot invest enough such as construction of the irrigation systems and so on.

If Zero-option is adopted, it would not be possible to take effective countermeasure for conservation of Lake Sevan and the investment for the construction of Yeghvard Reservoir in the Soviet Union period would not be used. In addition, the farmers, who has cultivated in the Reservoir site, would be forced to keep on cultivating unproductively. Therefore, the Zero-option cannot be recommended.

(2)Use of groundwater

Under Ararat Plain, high-quality ground water is generated. The groundwater has been used for cultivation, and drinking water. In recent year, however, aquaculture by using ground water has been widely operated in the Ararat Plain. Therefore, the groundwater level of Ararat Plain has been decreased significantly. Comparing the depth of confined groundwater level between 1983 and 2013, it has been reduced by 6 to 9m (WB, 2014). The reduction of groundwater has caused the conflicts among water users for irrigation, drinking water, industries, cooling water for nuclear power, and so on.

In the command area, there are some cases that WUA is pumping up the groundwater and use it for irrigation. In such case, the Government has to shoulder operation cost for deep well pumps, which can be big burden for the national budget. The possible irrigation areas by pumping up groundwater are limited, because the groundwater resources are limited. Considering the situations mentioned above, stable water supply for the project command area cannot be ensured by use of only groundwater.

(3)Use of surface water

As mentioned, the amount of flow of Armenian rivers varies depending on seasons. In early spring, after snow is melted, the flow of water is maximized and it is not used for irrigation (called as “free water”). Therefore, it is possible to take water from rivers, which have large watershed areas and large amount of flow, such as the Hrazdan River. It is proposed to divert the “free water” into the Yeghvard Reservoir through the existing canals during the period that river flow is more than demand. Presently, from June to October, available water volume is lower than that of irrigation demand, and the beneficiary areas depend on the Lower Hrazdan canal that intakes water from the Lake Sevan. If the free water can be used, it would be possible to irrigate instead of dependent on other water resources including the Lake Sevan, which can contribute to conservation of the lake. Moreover, if sufficient irrigation water is provided, agricultural production of the area and the livelihood will be improved.

The Government established the National Water Program in 2006 and promotes the conversion from the pumping up irrigation to gravity irrigation based on the policy, finally, aims at independence on groundwater by the effective use of surface. The Government of Armenia has published the concept “the shift from energy high input agriculture,” given that groundwater level has been reduced. If the gravity irrigation, which uses surface water, is operated, it would reduce dependence on ground water and contribute to conservation of groundwater in the Ararat Plain. In addition, by construction of the Reservoir, some pumps will not be used, which can reduce the numbers of pumps and working hours. Finally, it could reduce the maintenance cost.

Taking into consideration the above conditions, alternatives for water resources are examined. Table 5-1-4.1 shows the result.

Table 5-1-4.1 Examination of Alternatives for Water Resources

Item	Zero- option	Use of Groundwater	Use of Surface water
Impacts during the construction (Ex. Air quality, Water contamination, Noise, and so on)	—	—	△ During the construction period, air and water pollution are expected.
Conservation of Lake Sevan	× Lake Sevan would be used as the water sources for irrigation.	○ It would reduce the dependence to Lake Sevan, however, it is limited.	◎ The amount of water use from the Lake Sevan would be reduced, and it would contribute to conservation of the Lake Sevan.
Impacts to the groundwater of Ararat Plain	—	× Pumping-up might reduce the level of groundwater.	◎ The impacts on groundwater are not expected, because the project will not use groundwater.
Land acquisition	—	— No need	× Land acquisition is expected.
Impacts to the socio-economical activities Regional and development	—	× It would contribute to the irrigation development, but it also would give negative impacts on other industries.	○ Stable irrigation agriculture would be possible.
Possible irrigation area	8,391ha	8,391ha<area<12,347ha	12,347ha
Project cost	— However, the investment in the Soviet Period would not be used.	△ Relatively not expensive	× Expensive
Maintenance and management cost	—	△ Middle	○ Low
Comprehensive evaluation	Not adopted	Not Adopted	Adopted

— : No impact, × : Huge negative impact, △ : Negative impact, ○ : Positive impact, ◎ : Huge Positive impact

5-1-4-2 Alternatives of the Reservoir Site

Considering topographical conditions, there are 10 points that can be candidate sites for construction the Reservoir on the right and left banks of Hrazdan River. However, water holding capacities of those sites are very small. Even the Meghradzor site (see, Figure 5-1-4.1), which has the largest storage capacity (located Meghradzor Community of Kotayk Marz), about 30 million m^3, and it is much smaller than 90 million m^3 of Yeghvard reservoir. Thus, to ensure the same level of water storage capacity of the Yeghvard Reservoir, it is necessary to construct plural reservoirs. In such case, construction cost would be more expensive than that for construction of Yeghvard Reservoir and area for land acquisition would be larger, because they are new constructions. In and around the Meghradzor site, there is no protected area to be conserved, and it can be judged that there is no difference between Yeghvard Reservoir and Meghradzor site in terms of natural environment. The alternatives of reservoir site are examined based on scale of land acquisition and cost. Therefore, the site of Yeghvard Reservoir is considered as the most suitable. Table 5-1-4.2 illustrates comparison of the options for reservoir construction.

Figure 5-1-4.1 Locations of the Yeghvard Reservoir and Meghradzor Site

Table 5-1-4.2 Examination of Alternatives for Reservoir Site

Item	Yeghvard Reservoir	Meghradzor Site and Other sites
Land Acquisition	△ The land acquisition around canals is expected. However, the area of land acquisition would be limited, because the reservoir is one. And the lands of Yeghvard Reservoir are communal land. Furthermore, the farmers, who has cultivated in the present, understand the necessity to stop cultivation.	× In addition to the land acquisition and resettlement for canal construction, land acquisition of the reservoir construction is also required. Furthermore, the range and scale of land acquisition would be more serious.
Project cost	△ Expensive	× Very expensive
Comprehensive evaluation	Adopted	Not adopted

— : No impact, × : Huge negative impact, △ : Negative

5-1-4-3 Alternatives of the Anti-infiltration Works in the Yeghvard Reservoir

The soil in the planned reservoir area has high permeability in terms of geological characteristics and it is necessary to apply anti-infiltration work. There are four (4) options for the anti-infiltration works, namely, 1) Bentonite sheet, 2) Bentonite-soil mixture, 3) Soil-cement, and 4) Soil-Cement with a sandwiched bentonite sheet. Those anti-infiltration works were examined in terms of reliability and cost. As a result, it is judged that the last one, namely, "Soil-Cement with a sandwiched bentonite sheet" is recommended as the best option. It is noted that there is no difference in terms of impacts on natural environment among the alternatives. The examination result is as shown in Table 5-1-4.3.

Table 5-1-4.3 Examination of Anti-infiltration Works for the Yeghvard Reservoir

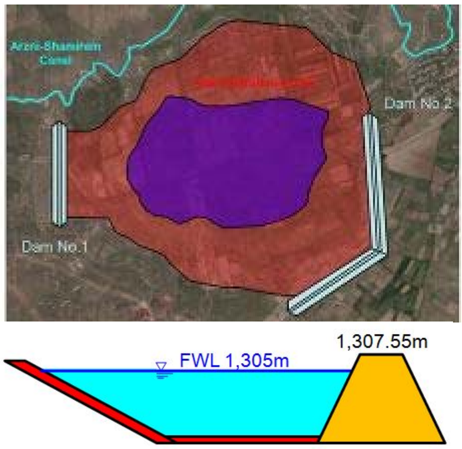
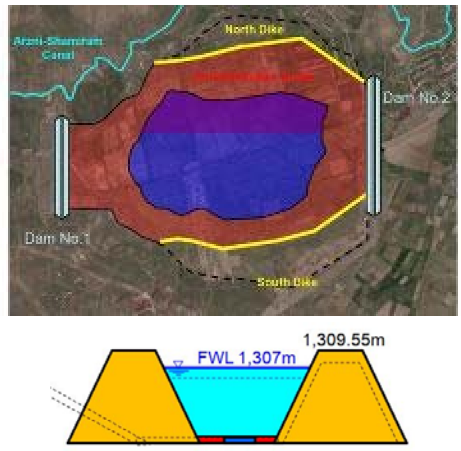
Parameters/Work	1.Bentonite sheet	2. Bentonite-soil mixture	3. Soil-Cement	4. Soil-Cement with a sandwiched bentonite sheet
1) Reliability	Even though due attention is paid during construction works, it is very difficult to prevent human error completely	If the applied material is not completely enclosed, it could be melted and flushed away.	Curing[3]is necessary.	Two kinds of materials are mixed to supplement each other, and execution management can be easy compared with the case of one kind of material.
2) Cost	Reservoir bottom: $12.6/m^2 North slope: $22.4/m^2 South slope: $24.1/m^2	Reservoir bottom: $18.3/m^2 North slope: $28.1/m^2 South slope: $30.4/m^2	Reservoir bottom: $15.3/m^2 North slope: $15.3/m^2 South slope: $15.3/m^2	Reservoir bottom: $14.5/m^2 North slope: $14.5/m^2 South slope: $14.5/m^2
Conclusion	-	-	-	Recommended as the anti-infiltration work

5-1-4-4 Examination of Dike Construction

There are two (2) options for dike construction, namely, Plan A: Utilization of existing dikes and Plan B: Construction new dikes. Those options are examined as illustrated in Table 5-1-4.4. In case of Plan A, cost is relatively low compared with that of Plan B. In addition, it is possible to use the existing dikes in the Reservoir. Concerning social aspect, in case of Plan B, the planned submerged area is small, since southern and northern parts of the Reservoir basin will not be submerged, however, these parts are not used for agricultural purpose at present. It means that there is no big difference between the Plan A and Plan B in terms of social aspect. Therefore, Plan A is proposed for the Yeghvard Reservoir.

[3] "Curing" is to keep moisture of the applied soil cement for increase of strength and impervious capacity

Table 5-1-4.4 Examination of Dike Construction for the Yeghvard Reservoir

Plan	Plan A: Utilizing of existing dikes	Plan B: Construction of New Dikes
Outline		
Capacity	94 MCM	Same as on the left
LWL	1,290 m	Same as on the left
FWL	1,305 m	1,307 m
Dam Height	25.55 m	27.55 m
Reservoir Area	7.96 km	5.42 km
Anti-infiltration Area	5.44 km	3.10 km
Construction Cost	88.8 million USD	90.9 million USD
Social aspect	Existing farmlands (80ha), which are located on the center of the reservoir, will be submerged.	Existing farmlands (80ha), which are located on the center of the reservoir, will be submerged. Even though the area to be submerged is smaller than that of Plan A, productive places for farming are located on the central parts of the Reservoir, therefore, there is no big difference between the plans in terms of social aspect.
Selection	Adopted	Not adopted

5-1-4-5 Examination of Route of Outlet Canal-2

At the examination of route of the Outlet Canal 2, there are two options, which is planned to divert stored water at the Reservoir to the Kasakh River as shown Figure 5-1-4.2. First one, namely, Outlet Canal 2 (1) is planned to pass through the natural stream, while second one, Outlet Canal 2 (2) is proposed to go through the orchard and residential area. Concerning the first option, the area along the natural flow belongs to the Nor-Yerznka village, which enables to minimize the acquisition of private lands and no relocation is needed. In case of second one, relocation of several houses is necessary and orchard area along the canal 2 (2) will be damaged. Therefore, the route of Outlet Canal 2 (1) is selected finally as named Outlet Canal 2 as shown in Figure 5-1-1.1.

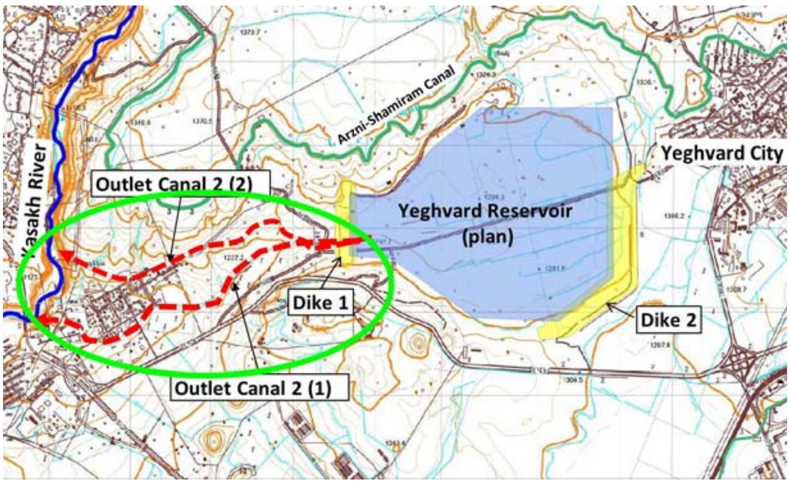


Figure 5-1-4.2 Examination of Options for Outlet Canal 2

5-1-4-6 Examination of Pipeline System and Open-canal System for the Proposed Canals

Regarding canal construction, there are two options, namely, open-canal system and pipeline system. Considering topographic conditions, cost, social impact, suitable system is proposed for each canal. As a result, pipeline system is proposed for all the canals except the Feeder Canal 1. Following table describes examination results:

Table 5-1-4.5 Examination of Open-canal System and Pipeline System for the Proposed Canals

(1) Feeder Canal 1

Parameter	Open-canal	Pipeline
Possibility of water storage at the Reservoir	If open-canal system is applied, it is needed to secure at least 15m head between the starting point of the Feeder Canal-1 and the full water level at the Reservoir. However, sufficient water head cannot be secured considering that the proposed canal should pass over the Dike No.2. If an open canal is installed, pump system should be installed to fill the Reservoir to the full water level.	Pipeline installation is not restricted by topographical conditions. It is possible to store planned water without pump system installation.
Social impact	3m width for the open canal and addition 4m width for maintenance road (7m width in total) should be secured for open canal construction, which results in permanent land acquisition.	Only temporary land acquisition is needed, which leads to less social negative impact compared with that in case of open-canal installation.
Cost	During operation stage, electrical fee for pump operation is needed.	Gravity irrigation system can be applied, and operation cost such as electrical fee is not needed.
Selection	Not adapted	Adapted

(2) Feeder Canal 2

Parameter	Open-canal	Pipeline
Possibility of water storage at the Reservoir	There is enough water head between the intake point from the Arzni-Shamiram Canal and the full water level of the Reservoir.	It is possible to store water at the Reservoir.
Social impact	The land in and around the proposed Feeder Canal 2 is not used for agricultural purpose, therefore, the impact on surrounding area by the open-canal construction is not significant.	Same as left
Cost	Cost of open-canal construction is relatively low.	Cost of pipeline installation is higher than that of open-canal.
Selection	Adapted	Not adapted

(3) Outlet Canal 1

Parameter	Open-canal	Pipeline
Possibility of water diversion from the Reservoir to the Arzni-Branch Canal	If open-canal system is applied, it is needed to detour highland, around E.L. 1,300m, which is higher than elevation at bottom of the Reservoir, EL 1,290m. In such case, the alignment length is 6.5km.	If pipeline system is applied, it is possible to share 1.2km length of the canal alignment with the Feeder Canal 1. The pipeline can cross over the railway, and the draft alignment length for outlet part is 0.73km (total canal length is 1.93km), which is much shorter than that of open-canal.
Social impact	Canal width and protection zone should be secured, which leads to larger affected area and permanent loss	Only temporary land acquisition is needed, which leads to minor social negative impact.
Cost	Due to long distance of canal alignment, it is costly.	Due to short length of the canal, the cost can be lower than that of open-canal.
Selection	Not adapted	Adapted

(4) Outlet Canal 2

Parameter	Open-canal	Pipeline
Possibility of water diversion to the end	If open-canal is applied, at least 14m head is needed between the bottom of Reservoir and the	It is possible to divert water to the Arzni-Branch Canal from the Reservoir.

Parameter	Open-canal	Pipeline
point of the Arzni-Branch Canal and Kasakh River from the Reservoir	end point of the Arzni Branch Canal. However, the estimated head is 13.7m, which is insufficient. Therefore, it is difficult to divert water to the Arzni-Branch Canal from the Reservoir through open-canal system.	
Social impact	The proposed route passes through farmlands and buildings. In case of open-canal, the area to be affected will be large and permanent.	In case of pipeline, affected area will be smaller, and only temporary land acquisition is needed.
Cost	Compensation for the affected area is large, since protection zone along the canal is needed.	Compensation for the affected area is smaller than that of open-canal system.
Selection	Not adapted	Adapted

5-1-5 Scoping and TOR for Environmental Examination

5-1-5-1 Scoping

At the scoping stage, due to construction of the Yeghvard Reservoir and irrigation canals, it is expected that some environmental impacts, namely, impacts on air quality, water quality and soil, noise, waste, land acquisition and so on will be caused. Scoping results is described in Table 5-1-5.1.

Table 5-1-5.1 Scoping Result

Environmental parameter	Evaluation		Reason of evaluation
	Before and during construction	Operation stage	
1. Air quality	B^-	D	**Construction stage:** Dust and gas emission will be caused, especially, canal (3) is expected to pass through some villages, which leads to impacts on the villages. **Operation stage:** Increase of vehicles is not expected, and there is low possibility of air pollution.
2. Water quality	B^-	C	**Construction stage:** Mud water from the construction site will be caused. **Operation stage:** Water quality deterioration of the Hrazdan River, due to the Project is not expected, since minimum discharge of the river is secured. At the Yeghvard Reservoir, water from existing Arzni-Shamiram canal including snow water is stored, water quality of the Reservoir will not have problem in terms of quality. However, there is a possibility that outbreak of plankton will be caused during summer season. Considering that main crops in the command area are wheat, vegetables, grass and fruits, damage on the crops due to cold water irrigation cannot be expected.
3. Waste	B^-	D	**Construction stage:** Waste from construction works and labor camps will be generated. **Operation stage:** Dredging of canals is necessary, however, the amount is very small and negligible.
4. Soil Contamination	B^-	C	**Construction stage:** Oil leakage from construction vehicles and equipment is expected. **Operation stage:** Due to increase of irrigation area in the command area, soil can be affected by the agrichemical application increase.
5. Noise and Vibration	B^-	D	**Construction stage:** Noise and vibration due to construction works are expected. **Operation stage:** Given that traffic increase is not expected, noise and vibration will not be caused.
6. Ground Subsidence	D	D	**Construction stage /Operation stage:** During construction and operation, ground subsidence will not be caused, since there is no plan to use ground water.

Environmental parameter	Evaluation		Reason of evaluation
	Before and during construction	Operation stage	
7. Offensive Odor	D	D	**<u>Construction stage /Operation stage:</u>** Any works to caused offensive odor is not planned.
8. Bottom sediment	D	D	**<u>Construction stage /Operation stage:</u>** Any works to caused bottom sediment is not planned. During the operation stage, bottom sediment will not be influenced since the canal concrete lining will be done.
9. Protected area	D	D	**<u>Construction stage /Operation stage:</u>** There is no protected area in and around the project site.
10. Ground water	D	C/B$^+$	**<u>Construction stage:</u>** Water level of ground water ranges around 100m deep, consequently, no impact on the ground water by the project is expected. **<u>Operation stage:</u>** Use of ground water is not planned. In the beneficial area, the project can contribute to recovery of ground water due to shift from use of ground water to use of surface water. On the other hand, there is a possibility that expansion of irrigated land will cause pollution of ground water by increase of application of fertilizers and agrochemicals.
11. Hydrological Situation	D	C	**<u>Construction stage:</u>** It is not planned to close any natural rivers nor to change /expand existing water courses, which will not result in hydrological change. **<u>Operation stage:</u>** The project will divert the free water of the Hrazdan River during March to May, considering the regulated minimum discharge. Therefore, the Project reserve the hydrological situation of the Hrazdan River. However, it is needed to examine any impacts on hydrological situation of the Hrazdan River. In addition, the Project could prevent from water level decrease of the Lake Sevan and it is possible to release surplus water to the Hrazdan River according to the necessity.
12. Ecosystem	B$^-$	B$^-$/B$^+$	**<u>Construction stage</u>** Lands in and around the construction sites have been already developed for agricultural purpose and there is no virgin nature to be damaged by the Project. However, it is needed to confirm current ecosystem in and around the project site. Moreover, impacts on fish by the project during the construction works have to be examined. **<u>Operation stage:</u>** There is a possibility that bio-diversity will be richer than present, since the Reservoir construction will provide water birds with their habitats. It is planned to divert free-water of Hrazdan River including snow water through the Arzni-Shamiram Canal to the Yeghvard Reservoir. Minimum discharge of the Hrazdan River is regulated and the Project is proposed based on the minimum discharge. Moreover, instead of all of snow water except minimum discharge, 50% of snow water at peak will used for water diversion. Given that the minimum discharge is decided considering eco-system conservation of rivers, negative impacts on the eco-system in downstream is limited. However, it is necessary to examine the impacts on fish species in Hrazdan river by the diversion of the snow melted water. Moreover, it is needed to confirm the current ecosystem of Kasakh River to be affected by the Project, since a part of Hrazdan River water will be diverted to the Kasakh River, which results in mixture of different fish species. The project could reduce dependency of the command area on the Lake Sevan as the water resource, which can contribute to prevention from water level decrease of the lake. On the other hand, excessive water level increase of the lake causes negative impacts on the eco-system, e.g. submerge of surrounding trees.
13. Topography and Geographical	D	D	**<u>Construction stage:</u>** In 1980s, parts of dike had been constructed by the Government of Soviet Union, the existing dike can be used in the construction works. Therefore, it

Environmental parameter	Evaluation		Reason of evaluation
	Before and during construction	Operation stage	
features			is not needed to change topographic features by the Project. Earth and sand for the construction will be gained within the Yeghvard Reservoir. The Reservoir will be submerged, it is, therefore, expected that no negative impacts will be caused. **Operation stage:** The Project will divert water of Arzni-Shamiram Canal instead of close of any natural rivers. Therefore, topographic change of the Hrazdan River is not expected. The water to be stored in the Yeghvard Reservoir will contain little sand, considering that the water will be diverted though the intake. Therefore, soil sedimentation at the Reservoir is not expected. Moreover, since water will not be diverted from the bottom of Reservoir to the Kasakh River through the canal, no sedimentation will be caused. It can be said that no topographic impact is expected.
14. Involuntary Resettlement/ Land Acquisition	B^-	D	**Before construction stage:** Due to the Reservoir construction, around 800ha of the Reservoir basin will be submerged, and the farmlands in the basin will be affected. Moreover, since the proposed canal will pass through the private lands, land acquisition will be necessary.
15. The poor	C	C	**Construction/Operation stage:** It is needed to confirm the situations by the field survey and hearing from the government concerned.
16. Indigenous and ethnic people	C	C	**Before construction/Operation stage:** It is needed to confirm the situations by the field survey and hearing from the government concerned.
17. Livelihood/local economy	B^-/B^+	B^+	**Construction stage:** Given that the Project will provide job opportunities for the local people, positive impact is expected. On the other hand, the Project will cause negative impacts on some people whose land will be acquired. **Operation stage:** Stable agricultural production can be implemented due to stable irrigation water for the people, while the cost for pump operation shouldered by the government ,will be reduced. It is expected that the Yeghvard Reservoir will attract tourists and the area will be developed.
18. Land use and local resource utilization	B^-	D	**Construction stage:** It is needed to acquire land for construction of reservoir and canals. Some of existing farmlands will be changed to stock yard for construction, construction office, canals and so on. **Operation stage:** No negative impact on land use and local resource utilization is expected.
19. Water Usage or Water Rights and Rights of Common	D	B^-/B^+	**Construction stage:** 1) Since the Project will take water of the Hrazdan River through existing facilities, and severe impacts on the Hrazdan River is not expected. 2) Given that the construction works will not close natural rivers and change existing canals, scale of mud water due to construction works will be small. **Operation stage:** Free water, which is discharged without used, is observed during non-irrigation season. Therefore, there is no demand for snow water in early spring. So, it can be said that water usage in the downstream of the Hrazdan River will not be influenced negatively. In some parts of the beneficiary area, irrigation by using electric pumps is operated, which needs electric fee. After the project completion, irrigation system will be changed from pump irrigation to gravity irrigation, which enables stable irrigation by using water stored at the Yeghvard Reservoir. It is needed to identify impacts on water use apart from irrigation by the snow melted water diversion from the Hrazdan River to the Reservoir.
20. Existing social infrastructures and services	B^-	D	**Construction stage:** Due to increase of construction vehicles, traffic jam can be caused. **Operation stage:**

Environmental parameter	Evaluation		Reason of evaluation
	Before and during construction	Operation stage	
			No impact on traffic is expected.
21. Social institutions	D	D	**Construction /Operation stage:** Given that there is no possibility of physical relocation and the number of the affected households will be not very large, any negative impact on decision maker in the area is not expected. Moreover, considering that most of the land acquisition will be temporary during the construction period, existing social institutions such as WUA will not be affected.
22. Misdistribution of benefit and damage	B^-	B^-	**Construction stage/:** The beneficial area and affected area are located on the different places, uneven distribution of positive and negative impacts between PAPs and beneficiaries will be generated due to the land acquisition during the construction stage. **Operation stage:** Due to the Project, the beneficiaries can enjoy the profit, while other farmers in non-project area cannot do Therefore, conflict between PAPs and beneficiaries can be caused during the operation stage.
23. Conflict	B^-	C	**Construction /Operation stage:** Due to the Project, stable irrigation water will be supplied, which does not bring about conflict on water use in the beneficial area. However, some conflict can be caused between beneficiaries and project affected persons, therefore, it is to be examined.
24. Cultural heritage	C	C	**Construction /Operation stage:** It is needed to confirm by the field survey.
25. Land scape	D	D	**Construction /Operation stage:** The areas in and around the project sites are mainly farmlands and residential area, therefore, special land scape to be reserved is not identified.
26. Gender	D	D	**Construction /Operation stage:** Negative impact on women is not expected.
27. Rights of the Child	D	D	**Construction /Operation stage:** Negative impact on children is not expected. According to the Labour Code of the Republic of Armenia, works by children under 14 years old is prohibited. There is few cases confirmed that children work as labor for agriculture and construction works and it is not recognized as a social issues in Armenia[4].
28. Hazards (Risk), Infectious diseases such as HIV/AIDS	B^-	D	**Construction stage:** There is a possibility that infectious disease HIV/AIDS could be caused by employment of workers from other areas. It is needed to confirm other cases. **Operation stage:** After the construction works, no disease is expected.
29. Work environment	B^-	D	**Construction stage:** There is a concern of accident at the construction sites. It is needed to comply the labor code for safety. **Operation stage:** No labor environmental change in the beneficial area is expected, since irrigation farming has been operated in the area.
30. Accident	B^-	B^-	**Construction stage:** There is a concern of traffic accident at the construction sites. Moreover, there is a concern of accident to construction of canals, which will be very limited. **Operation stage:** Accidents that somebody drop to the reservoir and canals can be caused, the possibility is low, though.
31. Transboundary impact, climate change	D	C	**Construction stage:** Large amount of greenhouse gas, which can cause climate change, will not be emitted by the Project.

4 It is based on the interview to Project Implementation Unit, SCWE.

Environmental parameter	Evaluation		Reason of evaluation
	Before and during construction	Operation stage	
			Operation stage: Based om amount of irrigation water demand in the Hrazdan River downstream and the regulated minimum discharge of the Hrazdan River, the project is designed. So, no severe damage to the downstream is expected. On the other hand, the Araks River flows down along the international boundary with Azerbaijan and Iran, finally flows into the Caspian Sea after the merge with the Kura River. Ratios of area of the Hrazdan River basin (around 1,200 km^2) to that of sum of Araks River basin and Kura River basin (around 188,000 km^2) is only 0.6%, which is very small[5].Therefore, transboundary impacts by the Project is not expected. On the other hand, it is needed to confirm whether there are any international treaties on use of Hrazdan River water.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected.

5-1-5-2 Terms of Reference for Environmental and Social Considerations

Concerning parameters which can cause negative and unknown impacts in the scoping mentioned above, environmental study by using desk study and field survey will be implemented as shown in Table 5-1.5.2.

Table 5-1-5.2 Terms of Reference for Environmental Examination

Environmental parameters	Study item	Method
Air quality	• Confirmation of environmental standard in Armenia • Impact to be caused during the construction stage	• Confirmation of environmental standards in Armenia • Field survey (distribution of houses, hospital and schools in and around the project sites) • Estimation of number of construction vehicles • Data collection of similar projects
Water quality	• Confirmation of environmental standard in Armenia • Water quality of rivers and irrigation canal • Water usage of the Hrazdan River • Plankton occurrence at other reservoirs	• Confirmation of environmental standards in Armenia • Field survey • Data collection of similar projects • Confirmation of other reservoirs and lakes • Water quality check of rivers and canals concerned to the Project
Waste	• Examination of waste disposal	• Data collection of similar projects for waste management • Confirmation of environmental standards in Armenia
Soil contamination	• Oil leakage from the construction vehicles • Impact on soil by agrichemical	• Estimation of number of construction vehicles • Data collection of similar projects • Laboratory works for agrichemical concentration in soil of the beneficial area
Noise and vibration	• Confirmation of environmental standards • Noise and vibration by the Project	• Confirmation of environmental standards in Armenia • Field survey (distribution of houses, hospital and schools in and around the project sites) • Estimation of number of construction vehicles • Data collection of similar projects
Ground water	• Due to irrigation land expansion, ground water can be influenced by increase of pesticide and chemical fertilizer application.	• Water quality check of nitrite, nitrate and agrochemical of ground water
Hydrological situations	• Possibility of release of surplus water to the Hrazdan River	• Examination of the possibility of release of surplus water to the Hrazdan River
Ecosystem	• Ichthyological survey of Kasakh	• Desk study and field survey of ecosystem in and around

[5] In general, ratio of river basin is equal to that of river discharge.

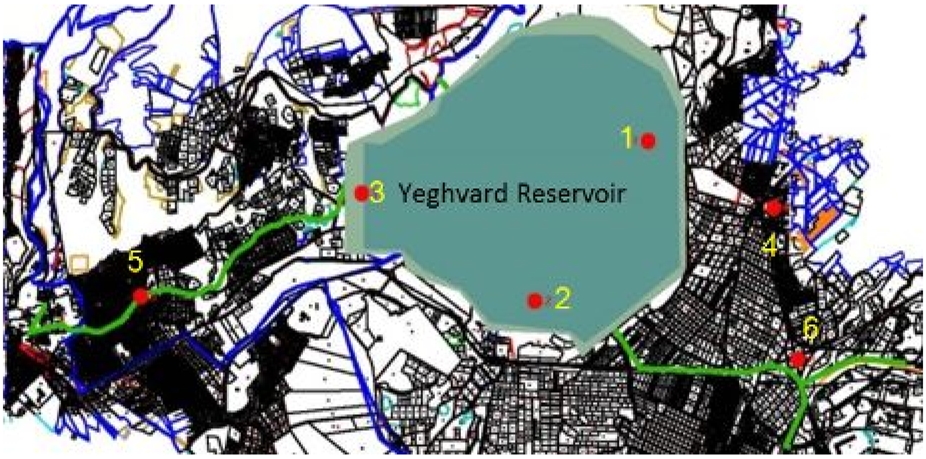
Environmental parameters	Study item	Method
	River and Hrazdan River • Impacts on ecosystem of the Lake Sevan by the water level increase • Ecosystem field survey in and around the construction sites	the Yeghvard Reservoir and proposed canals • Desk study and field survey to identify fish species in the Kasakh River and the Hrazdan River and seasonal migration and hatching period • Impacts on surrounding ecosystem of the Lake Sevan by water level increase • Impacts on surrounding ecosystem of the Hrazdan River and Kasakh River
Involuntary resettlement and land acquisition	• Identification of areas to be resettle and acquired • Preparation of abbreviated RAP	• Review of laws and decrees regarding involuntary resettlement and land acquisition in Armenia • Identification of affected area • Confirmation of land use of the area and existing structures to be affected • Socio-economic survey and preparation of abbreviated RAP
The poor	• The poor in and around the project area	• Identification of the affected area • Site survey and interview to the people • Hearing to the governmental organization concerned
Indigenous people/minority people	• Indigenous people/minority people in and around the project area	• Identification of the affected area • Site survey and interview to the people • Hearing to the governmental organization concerned
Livelihood/local economy	• Identification of affected area by involuntary resettlement and land acquisition	• Identification of the affected area • Confirmation of land use of the area and existing structures to be affected • Preparation of abbreviated RAP
Land use and local resource utilization	• Examination of area to be acquired	• Review of laws and decrees regarding land acquisition in Armenia • Identification of the affected area • Confirmation of land use of the area to be affected • Preparation of abbreviated RAP
Water usage or water rights and rights of common	• Confirmation of water distribution system of the Hrazdan River	• Hearing to the governmental organization concerned
Existing social infrastructure and services	• Traffic jam due to the construction works	• Confirmation of road conditions around the construction sites • Data collection of other similar projects
Misdistribution of benefit and damage	• Identification of areas to be resettle and acquired	• Identification of affected area • Confirmation of land use of the area and existing structures to be affected • Preparation of abbreviated RAP
Conflict	• Possibility of conflict due to misdistribution of benefit and damages	• Data collection of other similar projects • Hearing to the governmental organization concerned
Cultural heritage	• Cultural heritage in and around the project sites	• Identification of affected area • Confirmation of existing structures to be affected • Site survey and interview to the people • Hearing to the governmental organization concerned
Hazard (Risk) Infectious diseases such as HIV/AIDS	• Possibility of inflectional diseases occurrence by hiring of labors	• Data collection of other similar projects
Work environment including safety	• Possibility of accident	• Data collection of other similar projects
Accident	• Possibility of accident	• Data collection of other similar projects
Transboundary impacts and climate change	• Confirmation of international treaty on water usage of the Hrazdan River	• Hearing to the governmental organization concerned

5-1-6 Results of Environmental Examination

This sub-chapter discusses the expected environmental impacts by the Project. It is noted that the impacts will be caused by the newly constructed facilities, namely, the Reservoir, Outlet Canals and Feeder Canals. On the other hand, the rehabilitation of the existing canals such as Arzni-Shamiram Canal, Lower Hrazdan Canal will cause only very minor impacts, and the extend will be negligible, since the main works are rehabilitation such as lining of the canals and abolishment of existing pump stations. It is planned to rehabilitate the existing facilities during winter season, which will result in no disturbance of farming and water distribution. The irrigation water in the canals does not flow in winter, and mud water by the rehabilitation works will not be caused. Moreover, land acquisition or physical relocation are not necessary. Therefore, the following description focuses on the expected impacts by the newly construction works.

5-1-6-1 Air quality

For the purpose of identification of current conditions concenrning air quaity, gas emissions (SO_2, NO_2, and CO) and dust have been measured at six (6) points in and around the proposed construction site as shown in Figure 5-1-6.1. The measurement of SO_2, NO_2, and CO was done by using indicator tubes with mobile sampling pump. Dust concentration was measured by usage a mass concentration method (simple filtering).



Legend	
●	Air quality measurement point
(blue)	Area to be innundated
(light blue)	Area to be affected by reservoir
(green line)	Area to be affected by canals

No.	Measurement Points
1	Reservoir area (close to the Dike No.2)
2	Reservoir area (close to the southern border of the reservoir)
3	Reservoir area (on the Dike No.1)
4	Yeghvard city
5	Nor Yerznka community
6	Feeder canal 1 (near junction)

Figure 5-1-6.1 Air Pollutants Measurement Points

The measurement results of concentration of ambient air pollutants are presented in Table 5-1-6.1. The concentrations of gas pollutants (SO_2, NO_2 and CO) in ambient air at sensitive receptors locations haven been detected, which means that concentrations of those parameters are within the norms. The results of dust measurements range from 0.037 mg/m^3 (in the area of feeder/outlet canal) and 0.076 mg/m^3 (in Yeghvard city), which means that current conditions in and around the construction site satisfy the standard of air pollution at this moment.

Table 5-1-6.1 Results of Ambient Air Pollution

Parameter	Location	Measured value (mg/m^3)	Maximum one-time concentration (mg/m^3)	Mean daily concentration (mg/m^3)
Dust	Reservoir (1)	0.060	0.5	0.15
	Reservoir (2)	0.057		
	Reservoir (3)	0.045		
	Yeghvard	0.076		
	Nor-Yerznka	0.050		
	Feeder Canal-1	0.037		
SO_2	Reservoir (1)	Not detected (ND)	0.5	0.05

Parameter	Location	Measured value (mg/m3)	Maximum one-time concentration (mg/m3)	Mean daily concentration (mg/m3)
	Reservoir (2)	ND		
	Reservoir (3)	ND		
	Yeghvard	ND		
	Nor-Yerznka	ND		
	Feeder Canal-1	ND		
NO_2	Reservoir (1)	ND	0.0085	0.04
	Reservoir (2)	ND		
	Reservoir (3)	ND		
	Yeghvard	ND		
	Nor-Yerznka	ND		
	Feeder Canal-1	ND		
CO	Reservoir (1)	ND	5. 0	3.0
	Reservoir (2)	ND		
	Reservoir (3)	ND		
	Yeghvard	ND		
	Nor-Yerznka	ND		
	Feeder Canal-1	ND		

Source) JICA Survey Team, 2016

Remarks: Detection limits for SO_2, NO_2, and CO are 0.01, 0.05 and 0.5, respectively.

During the construction stage, in total 50 construction vehicles per day will be operated. However, most of them will be used around the Reservoir area, while 3 to 6 vehicles per day are operated around the Feeder Canals and Outlet Canals. The nearest residential area from the construction sites is Nor-Yerznka Community, it is planned that six (6) construction vehicles will be operated. However, the six vehicles will come to the community one by one, and gas emission will be limited. Proposed excavation period for the Outlet Canal 2 is 10 days, which will not result in severe dust generation, since water will be sprayed during the excavation. Moreover, moisture of soil cement should be kept at the certain level for reliability of anti-filtration, as a result, heavy dust generation can be avoided. On the other hand, in and around the Reservoir basin, most of the land use is for agricultural purpose, and the number of residential buildings around the reservoir is very limited. According to the in-situ test, all of parameters of ambient air are within the standard, especially, SO_2, NO_2 and CO were not detected. It is planned to spray water to minimize dust generation. At the residential area, which is sensitive for air pollution, the number of vehicles to be operated is very limited. It is noted that strong wind is observed in around Nor-Yerznka Community in May to June, and it is needed to keep sufficient moisture around the construction sites to minimize dust generation. Generally, air pollution by the Project will be small, and probably, the air pollution which exceeds the standard will not be caused.

5-1-6-2 Water quality

(1)Mud water

Due to the construction works, it is expected that mud water will be discharged from the construction site. However, it will be temporary and the situation will be caused during only construction period. It is needed to take countermeasures to minimize the impact to the downstream. It is needed to set up sedimentation ponds to store the mud water from the construction sites, which will make it possible to minimize the mud water discharge to the surrounding environment.

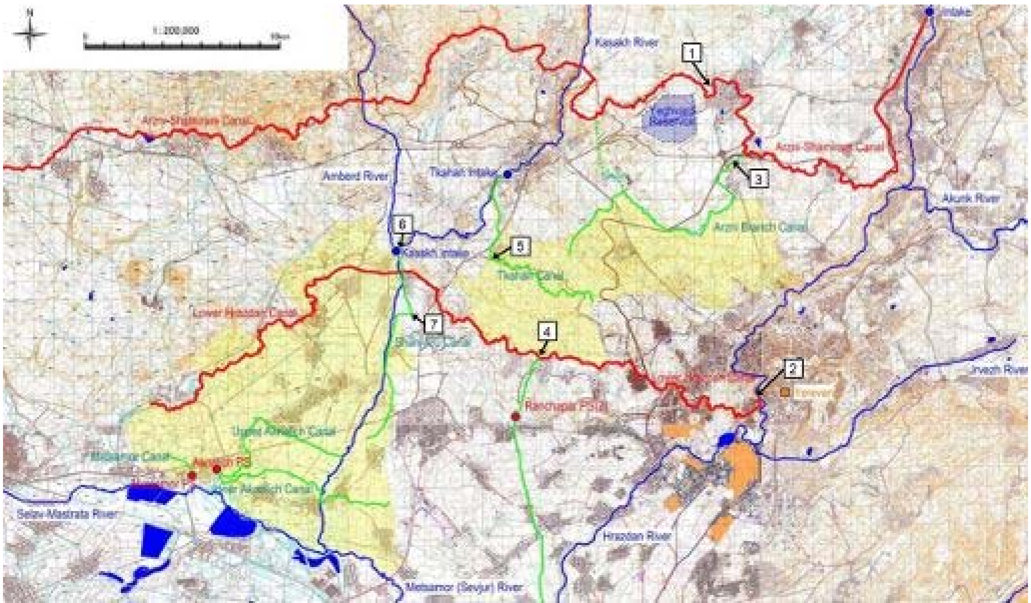
(2)Eutrophication of the Reservoir

Water source of the Reservoir is melted snow water in the Hrazdan River, and there is no waste water inflow point in the Hrazdan River before the Intake to the Arzni-Shamiram Canal. Moreover, water quality of Hrazdan River is suitable for irrigation as mentioned in Table 5-1-6.2. It means that the water quality at the Reservoir will be clean. It is planned to store water at the Yeghvard Reservoir from March to May and to divert the water for irrigation in summer season. It is expected that water flow, namely, from the Reservoir to the proposed canals, will be generated, as a result, water in the Reservoir will not be stagnant completely. Moreover, any cases that reservoir eutrophication have not been reported so far in Armenia according to the official personnel of PIU, SCWE. Therefore, it can be judged that eutrophication in the Reservoir will not be caused.

(3)Water pollution in the canal/river

In Armenia, no case of water pollution in surface water by agrichemicals has been reported so far, according to the Head of Department of Horticulture crop production and Plant protection, MOA. In his opinion, since prices of agrichemicals are relatively high for farmers in general, they cannot apply sufficient amount of agrichemicals in their fields, which results in no water pollution. On the other hand, there has been no case that agrichemical has been interfused into the canals and rivers in Armenia, according to the PIU member. As a whole, water pollution by agrichemicals is not an issue in Armenia at this moment, and this situation will not be changed after the Project. Therefore, water pollution by the agrichemicals by the Project is not expected.

For the purpose of the confirmation of water quality as irrigation water in the project area, water quality check was implemented. Considering the surface water standard in Armenia and FAO irrigation water quality standard, pH, EC (Electric Conductivity), TDS (Total Dissolved Solid), SS (Suspended Solid), Temperature, BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen), NO_3-N (Nitrate-Nitrogen), PO_4 (Phosphate), Na (Sodium), Cl (Chloride), Magnesium (Mg) and Calcium (Ca) have been determined as parameters. Sampling point is illustrated in Figure 5-1-6.2.



	Location
1	Arzni-Shamiram Canal at cross point of road
2	Hrazdan River before intake to Lower Hrazdan Canal
3	Arzni-Branch Canal before outlet under the railway
4	Lower Hrazdan Canal after outlet of pipeline from Ranchpar Pump station
5	Cross point between Tkahan Canal and road
6	Kasakh Intake at Kasakh River
7	Middle point of Shah-Aru Canal

Figure 5-1-6.2 Water Sampling Points

Table 5-1-6.2 shows the water quality test result.

Table 5-1-6.2 Results of Water Quality Test

Parameter	Unit	Sample No.							Standard	Used analytical method
		1 Canal	2 River	3 Canal	4 Canal	5 Canal	6 River	7 Canal		
Temperature	°C	11.5	13.8	10.8	16.1	11.8	12.4	13.1	-	-
TSS	mg/l	16.8	15.4	9.5	12.3	12.1	11.1	17.5	<30*	Gravimetric analysis
pH	-	7.88	7.06	7.83	8.08	8.31	8.34	8.32	6.5 – 8.4**	pH meter
DO	mg/l	13.14	9.5	10.27	16.4	13.7	10.3	10.7	>5*	DO meter in-situ
Chloride ion	mg/l (meq)	21.9 (0.62)	257.6 (7.26)	20.9 (0.59)	216.2 (6.09)	18.0 (0.51)	17.0 (0.48)	15.817 (0.45)	<142** (<4**)	Ion chromatography
Nitrate (NO_3-N)	mg/l	0.592	2.103	0.542	1.168	0.129	0.976	1.106	<5**	Ion chromatography
Mineralization	mg/l	401	1,888	362	1,740	342	333	328	<1,000*	Electrochemical analysis
Phosphates	mg/l	0.089	0.296	0.074	0.445	0.252	0.252	0.282	<0.4*	Spectrophotometric analysis
BOD	mg/l	3.24	2.98	6.46	6.58	3.3	1.67	2.85	<9*	Electrochemical analysis
COD (Cr)	mg/l	14	12	14	32	12	34	14	<40*	Dichromate oxidizability
EC	uS/cm (dS/m)	590 (0.59)	2,768 (2.768)	533 (0.533)	2,568 (2.568)	503 (0.503)	490 (0.49)	482 (0.482)	<700 (<0.7)**	Electrochemical analysis
Na	mg/l (meq)	42.77 (1.86)	284.76 (12.38)	40.06 (1.74)	263.22 (11.44)	36.44 (1.58)	34.46 (1.50)	33.42 (1.45)	69 (<3**)	ICP- Mass Spectrometry (ICP-MS)
Mg	mg/l (meq)	22.19 (1.85)	28.70 (2.39)	21.58 (1.80)	30.34 (2.53)	18.94 (1.58)	18.45 (1.54)	18.32 (1.53)	<100 (<5)**	ICP-MS
K	mg/l	9.13	7.38	7.68	8.29	7.09	6.74	6.84	-	ICP-MS
Ca	mg/l (meq)	47.02 (2.35)	64.03 (3.20)	43.06 (2.15)	63.86 (3.19)	40.61 (2.03)	40.23 (2.01)	39.20 (1.96)	<200** (<10)**	ICP-MS

Source) JICA Survey Team (2015) , sampled on 19th October 2015

*Ecological Norm (Protocol 0f Government RA, 27.01.2011 27 N 75-N),"Moderate" is applied.

** FAO Irrigation Guidelines, Table -1 "None Restriction on Use" is applied.

This analysis was done by SNCO of Environmental Impact Monitoring Center under the MNP and it has various experiences to work international organizations.

Considering the result of water quality test mentioned above, water quality is generally appropriate for irrigation water. It can be said that water quality of Arzni-Shamiram Canal is suitable for irrigation. On the other hand, salinity of the water at No.2 and No.4 sampling points is high. It is probably because that waste water from surrounding residential areas is discharged into the Lower Hrazdan Canal and Hrazdan River. The water sampling was done on October, almost end of irrigation period and there was small discharge, therefore, water quality was affected by the waste water at the point No.4. In October, main cultivated crop is wheat, which has moderate salinity tolerance according to the "Water Quality for Agriculture" (FAO), and the farmers can depend on rain in autumn. Therefore, the high salinity in the irrigation water is not an issue at this moment. Regarding sampling point No.2 (Hrazdan River), it is natural flow, and discharge is small compared with the inflow of waste water. It flows within the Yerevan City, therefore, the water was deteriorated by the effluence from the residential area.

Main irrigation water source for the Yeghvard Reservoir is Arzni-Shamiram Canal. Considering water quality in the Canal, water quality in the Reservoir will be appropriate for irrigation. On the other hand, the water in the Lower Hrazdan Canal contains relatively high salinity. However, it is noted that the sampling was done at almost end of the irrigation season, and the discharge was low. Average water discharge in the irrigation season from the end of April to mid of September is 6.9m^3/s, while the discharge in early October is 1.5 m^3/s[6]. It means that saline concentration will be low during the irrigation peak season. So far, no crop damage due to water salinity has been observed, according to the Director of Ashtarak WUA, which use the Lower Hrazdan Canal. The salinity does not have direct relation with the Project. In other words, further salinization of the water is not caused. It can be judged that no water quality deterioration due to the project is expected.

It is noted that there is saline soil called as "Alkali meadow sodium-sulfate-chloride" which is saline soil along the Araks River in the Ararat Plain (see Appendix K 4). However, the beneficial area of the Project is located on other types of soil, Moreover, the water source of the Project is snow melted water, which has low salinity. Concerning groundwater, the main direction of the ground water flow is to the southwest, toward the Kasakh River canyon and Total Dissolved Solid of the ground water is 0.21 - 0.54 g/l (≒0.34 – 0.86dS/m of EC),[7] which can be regarded fresh. Taking into consideration those conditions mentioned above, soil salinization due to the Project is not expected.

5-1-6-3 Waste

During the construction stage both household and hazardous waste (oil, fuel, iron scrap, contaminated soil, oiled clothes, wood, construction waste, etc.) will be generated. They should be classified, separately stored in marked containers and disposed in accordance with the Law on Waste at the specified place specified by the MNP. It is necessary to get permission for waste disposal from the MNP. A large amount of soil waste also will be generated, however, it will be recycled for the construction works as much as possible. As whole, the impact is temporary and can be managed by implementation of proper waste handling procedures. In case that the Reservoir becomes a sightseeing point, waste will be generated around the Reservoir.

5-1-6-4 Soil Contamination and Groundwater Pollution

(1) Oil leakage

Oil leakage from construction vehicles is expected during construction stage, however, it will be limited and temporary. Such impact can be minimized by proper and regular management of construction vehicles.

(2) Pollution of soil and groundwater by the Project

There is a possibility that application amount of fertilizer and agrichemicals (pesticide, insecticide and herbicide) will be increased due to expansion of irrigation area by the Project. There is no drainage in the command area to other areas, there is no possibility applied fertilizers and agrichemicals will be transported to other areas through surface water. However, soil and groundwater can be influenced by increase of fertilizer and agrichemical application due to irrigation farming promotion. Therefore, chemical analysis of soil and ground water was implemented to examine the impacts.

1) Analysis of soil and groundwater

(a) Agrichemical analysis in the soil

In general, agrichemical are applied to vegetables and fruits more than to wheat and feed crop such as alfalfa according to a FAO staff in Armenia. Based on the situation, nine (9) communities (Aratashen, Taronik, Baghramyan, Tsiatsan, Tsaghkalanj, Aragats, Aghavnatun, Mrgastan and Hovtamej), where vegetable and fruits trees have been intensively cultivated, were selected from the target 27 communities. In addition, one control point (no chemical application) was set for comparison in

[6] Source) Sevan-Hrazdan Jrar, Closed Joint Stock Company, SCWE
[7] Source) "Feasibility Study of the Design and Construction of a Reservoir on Hrazdan River in Armenian SSR", Report on Engineering-Geological and Hydro-Geological Surveys and Study on Yeghvard Reservoir, Part II, Book 2,1980

Taronik community. Therefore, the number of sampling points was ten (10) in total. One farmland plot that agrichemicals have been applied was identified at each community mentioned above, six (6) soil samples per each plot, totally 60 samples were taken. The soil samples were analyzed for the parameters listed in the surface water standard in EU[8], since there is no regulation for soil and water for agrichemical in Armenia.[9]

(b) Agrichemical and fertilizer analysis in the groundwater

Flow direction of the groundwater in the command area shows the same trend of that of the surface water, namely, from northern part to southern part. When applied fertilizers and agrichemicals will be infiltrated into the underground, the concentration of them could be higher in south-western part of the area. Based on the idea, ten (10) groundwater samples were taken from the private and communal tube wells in the four communities, namely, Artimet, Khoronk, Aratashen, and Griboyedov, which are located on south-west part of the command area. Concentrations of nitrate, nitrite[10] and agrichemical[11] in the groundwater were analyzed. Those sampled groundwater are mainly used for domestic purpose and irrigation, not for drinking. Furthermore, given that there are many green houses, vegetable farmlands and orchards in the four communities, it was thought that the groundwater quality in the communities has been influenced by those farming activities. Location of soil and groundwater sampling points are illustrated in Figure 5-1-6.3.

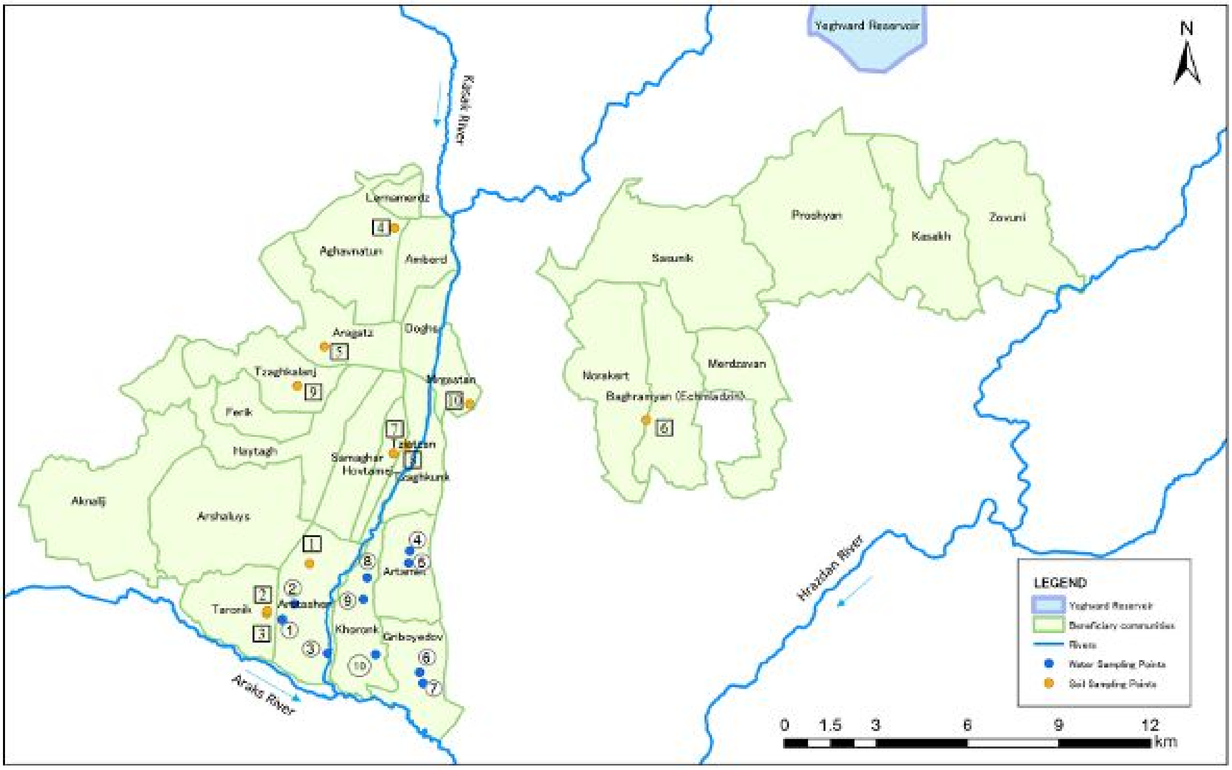


Figure 5-1-6.3 Location of Soil and Groundwater Sampling Points

8 Environmental Quality Standards for Priority Substances and Certain Other Pollutants

9 According to the Environmental Impact Expertise Center SNCO under the MNP, the EU environmental quality standard is recommended to be applied. Only qualitative analysis (detected/not detected) for some agrichemical parameters can be practiced in Armenia.

10 Mainly, chemical fertilizers contain nitrogen, phosphor and potassium, and nitrogen is the most influential for groundwater quality after the application and nitrogen fertilizers is very popular in Armenia. Nitrogen is detected as nitrate or nitrite anaerobic condition.

11 Analyzed parameters of agrichemical types are the same for soil and groundwater.

2) Results of analysis

(a) Soil analysis result

Soil analysis result is attached in Appendix-K-2. Chlorfenvinphos[12], which is one of organophosphorus pesticides, was detected from eight (8) farm plots including non-cultivated land out of 10 sampling plots. The agrichemical has strong toxicity, and its utilization has been already banned in the USA and EU countries. In Armenia, Chlorfenvinphos is not described in the officially registered agrichemical list by the MOA as of March 2016. It means that use of the Chlorfenvinphos is illegal in Armenia, however, the agrichemicals is applied in the plural communities in the command area at this moment.

The first half-life of Chlorfenvinphos is 10-45 days, and the chemical is categorized into "Moderate" in terms of degradation according to FAO[13]. In general, degradation of organophosphorus pesticides is high. Therefore, detected Chlorfenvinphos will be decomposed by ultraviolet radiation and micro-organisms in soil gradually. Moreover, water solubility of the chemical is very low, and possibility of filtration of the chemical through soil moisture would be also low. On the other hand, Chlorfenvinphos was detected in the non-cultivated field in Taronik (sample No.3) also. Given that the chemical was detected at another sampling point in Taronik and those two sampling points are located at opposite site on the road, it can be thought that the detected Chlorfenvinphos is originated from the neighboring farm plot.

Benzene was detected at all of the soil samples, however, the values are around 1μg/kg soil and Benzene is volatile chemical. It is noted that according to the EU environmental quality standard for surface water, the standard value of Benzene is not over 8μg/l it is not suitable to compare those values unconditionally, though. Taking the situations into consideration, it can be said that residue of Benzene in soil is not a big problem.

(b) Groundwater quality analysis

Result of ground water quality analysis is attached in Appendix-K-3. One sample at the private tube well in Khoronk community (sample No.8) shows high concentration of NO_3-N, 31.74mg/l, it is categorized into "Severe" in terms of use restriction according to the FAO irrigation guidelines[14]. Five (5) samples are more than 5mg/l, it is not desirable for nitrogen sensitive crops e.g. apple, apricot and grains (FAO guidelines, Rev.1, 1994). Overall, groundwater quality in the area is not significantly polluted by the fertilizer application, however, it is not very suitable for crops. It is noted that according to the WHO Guidelines for Drinking-Water Quality (Version 4, 2011), allowable nitrate concentration value is 50mg/l (11 mg/l as NO_3-N). Most of the samples satisfy the value, the groundwater in the area is not used as drinking water, though.

No agrichemicals except Benzene are detected in the groundwater samples, and the concentrations of Benzene are within the regulated value in the EU standard. Therefore, it can be said that underground is not polluted by agrichemical application so far, even though residual agrichemical is detected in some soil samples.

3) Examination of impact on soil and groundwater

(a) Impacts by fertilizer application

The MOA subsidizes fertilizer for farmers in Armenia, moreover, international donors such as United

[12] Only qualitative analysis is possible for the chemical.
[13] FAO, 2000, Assessing soil contamination A reference manual, APPENDIX 3 "Fact sheets on pesticides, Chlorfenvinphos (Birlane)"
[14] "Guidelines for Interpretation of Water Quality for Irrigation" (FAO, Rev. 1, 1994) is applied as the irrigation norm in Armenia, since no guideline of water quality for irrigation is established according to Ministry of Armenia.

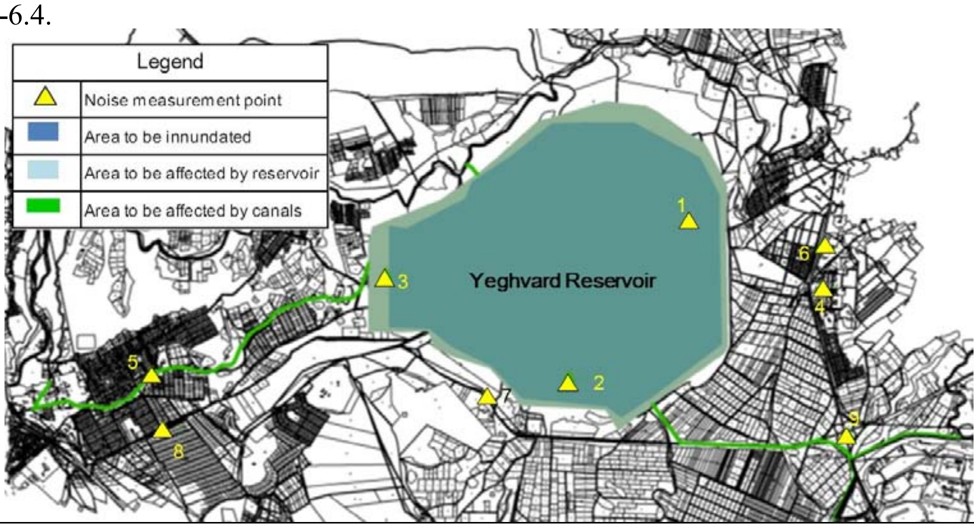
Nation Development Programme also provides nitrogen fertilizers. At this moment, nitrogen pollution of groundwater is not very severe. Therefore, it can be said that groundwater quality will not be deteriorated seriously by the Yeghvard Reservoir construction and irrigation farming promotion. However, proper amount of fertilizer application should be promoted through awareness by staff of MOA in the future. Furthermore, instead of groundwater, melted snow water will be mainly used for irrigation after the Project, conditions for nitrogen sensitive crop cultivation could be better than present.

(b) Impacts by agrichemicals

Illegal agrichemical has been detected in soil samples in plural communities, and it is an issue to be considered. Staff of MOA regularly visit agrichemical dealers for monitoring of quality, expiration date for use, types and so on of their goods, however, sale of illegal agrichemical are found every year. However, the staff do not have authority to make an order to the sellers. The agrichemical handbook, which stipulates proper amount of agrichemical to be applied or suitable application timing, is issued annually, however, only thousands of them are distributed in nationwide due to the budgetary limitation. Due to the Project, it cannot deny the increase of the illegal agrichemical, even though the illegal agrichemical application is not direct effect of the Project. Regardless of the Project implementation, enhancement of the monitoring and proper agrichemical application should be promoted. On the other hand, given that agrichemical concentration in the groundwater is acceptable level, it can be concluded that negative impact due to increase of application by the Project is not very severe.

5-1-6-5 Noise and Vibration

For the purpose of examination of impact regarding noise by the project, it is needed to confirm current conditions. Noise measurements was implemented at nine points in and around the construction site as follows. In addition, the location map of noise measurement points is illustrated in Figure 5-1-6.4.



Location	
1: Reservoir area (1) (close to the Dike 2)	6: H4 highway (1)[15] (near Yeghvard city)
2: Reservoir area (2) (close to the southern border of the Reservoir)	7: H6 highway (1)[16] (south of the Reservoir)
3: Reservoir area (3) (on the Dike 1)	8 - H6 highway (2) (south of the proposed Outlet Canal 2)
4: Yeghvard city	9 - H4 highway (2)
5: Nor Yerznka community	

Figure 5-1-6.4 Locations of Noise Measurement Points

15 H4 Road: Road between Yerevan and Yeghvard
16 H6 Road: Road between Yeghvard and Nor-Yerznka

At each point, instrumental measurements of noise levels are performed by using a Sound Level Meter (SL-834) during 10 minutes. Generally, noise levels at most sensitive receptors, namey, at Yeghvard and Nor-Yerznka communities are within the threshold limit value according to the norm. The measuremnet result is presented in Table 5-1-6.3.

Table 5-1-6.3 Results of Noise Measurements in and around of the Project Site

No.	Measurement points	Measured Noise Level		Noise standard	
		Equivalent level (dBA)	Maximum level (dBA)	Equivalent level (dBA)	Maximum level (dBA)
1	Reservoir area (close to the Dike No.2),	38.8	53.8	80	
2	Reservoir area (close to the southern border of the Yeghvard Reservoir)	41	59.6	80	
3	Reservoir area (on the Dike No.1)	39.8	56.9	80	
4	Yeghvard city	55	68.9	55*	70*
5	Nor Yerznka community	49	68.4	55*	70*
6	H4 highway (near Yeghvard city)	60	70.7	80	
7	H6 highway (south of the Yeghvard Reservoir)	58.3	78.7	80	
8	H6 highway (south of the proposed Outlet Canal 2)	58.7	80	80	
9	H4 highway	59.1	79.4	80	

Source) JICA Survey Team

*They are located in Yeghvard and Nor Yerznka communities correspondingly and for such locations 55 dBA of equivalent sound/noise level and 70 dBA of maximum sound/noise level are applied, while 80dBA (for Noise in workplaces for construction works) is applied for other places.

During the construction stage, traffic density also will be increased due to the delivery of materials and workforce and removal of soil and waste from the Project sites. The distance between the eastern dam of reservoir and the nearest residential building is approximately 400 m, however, the construction works will not be done within the Yeghvard Community, the noise and vibration by the Project will be limited. Regarding, Nor Yerznka community, disturbance by noise during the construction will be inevitable. However, the period of noise disturbance due to soil exavation will be 10 days only, and noise by back hoe operation will be expected for 30 days. Therefore, the impact will be temporary, and efforts to minimize works during night time around the residential area wil be made. It can be judeged that noise and vibration are not significant. The number of the vehicles to be operated around the communities cooncerned is very limited, the possibility that noise by the Project will exceed the standard level is very low. Still, it is needed to avoid concentration of vehicles in and around the communities.

5-1-6-6 Ground Water

As mentioned before, there is a possibility that ground water will be polluted by nitrogen fertilizers due to the irrigation area expansion after the Project completion, and promotion of proper fertilizer application is necessary in operation stage. On the other hand, the Project can reduce groundwater use for irrigation by promotion of gravity irrigation, which will result in conservation of groundwater resource in the beneficial area.

5-1-6-7 Fauna and Flora in and around the Yeghvard Reservoir

(1) Current condition of fauna

The survey on eco-system in and around the Yeghvard Reservoir and proposed canals was implemented through literature review and field survey. The survey of terrestrial animals has been conducted using the methods by Formozov (1951 and 1976), and Novikov (1953). Concerning mammals, footprints, traces of animal feeding (remains of food, stubs and so on), animals scat, nests, holes were confirmed through the field survey. Birds monitoring was conducted using binocular "Bushnell" and monocle "Kowa". The observation distance for relatively big bird species was 100-500 m. Information/data about the reptiles, amphibians and insects were obtained based on the combination of field survey and literature review. The field survey for all of the species was done on 15th September 2015 and 7th March, 2016.

The survey result, namely, identified number of species is shown in Table 5-1-6.4. Ten (10) mammals, 56 birds, one (1) Amphibian, five (5) Reptiles and 36 insects were identified. The bird diversity is rich compared with others, and four bird species are registered in the red list of Armenia. Moreover, one (1) species, namely, Egyptian Vulture *(Neophron percnopterus)* is categorized into “Endangered” in the IUCN Red list and also registered in the red list of Armenia. In addition, one snake, *Elaphe quatuorlineata* is categorized as “Near threatened” in the IUCN red list.

Table 5-1-6.4 Identified Species in and around the Project Site

Category	No. of species	No. of species registered in Red list
Mammals	10	0
Birds	56	4 species in the red list of Armenia (1 for IUCN red list)
Amphibians	1	0
Reptiles	5	1 for IUCN red list
Insects	36	0

Source) JICA Survey Team

1) Mammals

Ten (10) species of mammals were identified and they are Hedgehog, Hare, Wolf, Fox, Marten and Rodents (Hamster, Mouse, Vole and Gerbil). No species is resisted in the IUCN and Armenian red list. The identified species can be categorized into three groups as follows:

(i) Species that uses the area for transition purposes:

The group includes species with rather high activity and movement during the day, namely, wolf (*Canis Lupus*) and Red fox (*Vulpes vulpes*, see photo). They sometimes pass through the area, but rarely use it for feeding.

(ii) Species that partially uses the area:

The group includes European hare (*Lepus europaeus*), Beech marten (*Martes foina,* see photo) with less movement and activity during the day, which can live in project area or in adjacent territories. Furthermore, they can use these areas for feeding also.

(iii) Inhabitants of the project area:

The group consists of species, who permanently lives in the project area and whose movement areal is


Red fox *(Vulpes vulpes)*


Beech marten *(Martes foina)*


Least weasel *(Mustela nivalis)*

not large. They are Hedgehog (*Erinaceus concolor*), Least weasel (*Mustela nivalis,* see photo), number of small rodents. Rodents attract predator birds and sometimes even some types of mammals.

2) Birds

Out of all identified birds in the area, 17 species are nested in and around the project site. They are Red-backed Shrike (*Lanius collurio*, see photo), Hoppoe (*Upupa epops*, see photo), European roller (*Coracias garrulous*, see photo) and so on. European roller (*Coracias garrulus*), which is registered in the red list of Armenia, is nested within the project area, however, it is regarded as a migratory bird in Armenia.


European roller (*Coracias garrulus*)


Red-backed Shrike (*Lanius collurio*)


Hoppoe (*Upupa epops*)

Out of total 56 bird species, 16 species seems occasionally drop by the area for hunting, taking a rest, drinking water and so on, and they are not nested in and around the project area. These species include Black Kite (*Milvus migrans*, see photo), Green Sandpiper (*Tringa ochropus*, see photo) and so on. Some of them are migratory and rarely observed in Armenia.


Black Kite (*Milvus migrans*)


Green Sandpiper (*Tringa ochropus*)

There are four (4) bird species, which are registered in the red list for IUCN and Armenia, were identified in the area. All of them are categorized into "full mgrant" in terms of moving pattern in the IUCN, and their habitats and ecological characteristics are described below:

(i) Egyptian Vulture (*Neophron percnopterus*): registered in both IUCN red list and red list of Armenia

The species is migratory and forms a nest on ledges, caves, large trees, buildings. No nest is in the reservoir basin and seemingly it was accidentally identifeid by the survey. Probably, the project area is not suitable to nest for the species, considerining the situation in the Rservoir basin, where wheat and barley fields are extended witiout high trees.

(ii) Short-toed Eagle (*Circaetus gallicus*): registered in the red list of Armenia

Movement pattern is full migrant. It forms a nest in the low trees. No nest is in the reservoir area and probably it was accidentally identified in the survey.

(iii) Golden Eagle (*Aquila chrysaetos*): registered in the red list of Aremani

No nest is in the reservoir area and it was casually identified. It widely ranges on flat or mountainous, and open habitat area. The species forms a nest on cliff ledges, large trees and artificial structures.

(iv) European Roller (*Coracias garrulus*) : registered in the red list of Aremani

There is nest of the species in the Reservoir. The bird prefers an open countryside with forests, orchards, mixed farmlands and the project area is suitable for the species to nest. It is regarded migratory bird in Armenia.

3) Reptiles and amphibians

Concerning Reptiles which range in and around the project area, Blind snake (*Typhlops vermicularis)*, Snakes (*Eirenis collaris*, *Elaphe quatuorlineata* and *Vipera lebetina*) , Lizard (*Laudakia caucasica*) were identified. On the other hand, regarding Amphibians, only one frog (*Laudakia caucasica*) was identified. Out of snakes, *Elaphe quatuorlineata* is categorized as "Near threatened" in the IUCN red list, it is not registered in the red list of Aremenia, though. The snake is generally found in forest, cultivated area, open woodland and near water body. It tend to have very large home range[17].

4) Insects

36 species of Insects were identified. Ground beetles are dominating in the project area. Compared with the existing data list in the past, composition of insect species was drastically changed. It is probablly because that fertile top soil had been taken and earth works was done during the Soviet Unit period.

(2)Current conditions of flora

Until 1980s, vineyard had been operated in the Reservoir, and after the independence in 1991, some parts of the reservoir has been utilized as farmlands such as wheat and barley fields, while other parts have been used for grazing. At this moment, the Project area is mostly steppe zones with few trees, and wormwood and mixed herbs-wormwood are prevailing. Main species are Wormwood (*Artemisia absinthium*), Chicory (*Cichorium intybus*), Goldenrod (*Solidago virgaurea*), Scorzonera suberose (*Scorzonera suberosa*), Quackgrass (*Elytrigia repens*) and so on. Representatives of other plant families are Stinging nettle (*Urtica dioica*), Catch weed (*Galium aparine*).

Wormwood
(*Artemisia absinthium*)

Chicory (*Cichorium intybus*)

Goldenrod (*Solidago virgaurea*.)

[17] IUCN Red list

Scorzonera suberose (*Scorzonera suberosa*)

Quackgrass (*Elytrigia repens*)

Stinging nettle (*Urtica dioica)*

Catch weed (*Galium aparine)*

There are various herbs in the area, however, they are common species in Armenia. There are no flora species which are rare, threatened, endangered, vulnerable. No flora species in and around the Project site is registered in the Red Book of the Armenia and IUCN Red List.

(3)Expected impacts on fauna and flora

The reservoir area had been developed as vineyards until 1980s, and after the independence, it has been utilized as grassland and farmland for wheat and barley. Therefore, the area is not virgin land with original nature. 10 species of mammals were identified in and around the project site, and, they can be regarded as the ones which have adjusted such man-made environment so far. Those species can easily migrate to other areas which have similar characters, namely, orchards, farmland, grassland and so on around the project site. Considering the situation, the mammals in the area will not be affected by the Project very severely.

There are four (4) birds which are registered in the IUCN and Armenia red list. However, their movement patterns are categorized into as “full migratory” according to the IUCN, and all of them except European Roller are not nested in the project site. Given that European Roller prefers to mixed farmland and orchard for nesting, they can easily find new places for their nests outside of the project area, where farmlands and orchards are extensively operated. Generally, the birds as well as mammals have adapted themselves to surrounding conditions, which is not primitive natural zone, so far. Consequently, it can be said that negative impacts on the birds by the Project. Rather than that, after the works, it is expected that the reservoir is attractive for birds as water resource, especially migratory birds, which will result in biodiversity promotion.

Regarding the snake, *Elaphe quatuorlineata,* is registered in the IUCN as “Near threatened”. The species is generally identified in forest, cultivated area, open woodland and near water body, and it has very large home range and can move to other areas. Taking consideration into the characteristics, and it is not difficult for the species to find preferable habitat in the outside of the reservoir. Therefore, it can be judged that severe negative impact on the snakes by the Project is not expected. In general, severe negative impact on fauna in and around the project site is expected. Still, it is noted to consider the poisonous snake species, which ranges the Reservoir, will also escape to outside of the Reservoir, and it is needed to promote awareness of the surrounding persons how to handle the snake.

Concerning flora, no dangers species were identified according to the survey. The area in and around the Project site has been developed by human beings and used for agricultural purpose so long time, therefore, mainly, weeds and grasses, which have relationship with the people and do not represent primitive natural conditions, will be inundated by the Project. However, the species can survive in other areas, since similar natural conditions. Therefore, significant negative impact on the flora by the Project in the area is not anticipated.

5-1-6-8 Hydrological Conditions

(1) Hrazdan River

Hrazdan River is one of tributaries originated in the Lake Sevan and flows into the Araks River, which flows along the international boundary with Iran. Hrazdan River is not an international river, therefore, there is no international treaty regarding water distribution of the Hrazdan River according to SCWE. For the purpose of conservation of the river, minimum discharge considering ecology is regulated in the Decree N 927-N (2011), however, in serious drought year, irrigation is given higher priority than that of ecological conservation.

The Hrazdan River has been mainly used by irrigation and hydro power generation. Natural Hrazdan River flows down in parallel with canal as shown in Figure 5.1.6-5. At each reservoir for hydro power generation, the natural Hrazdan River and Hrazdan Canal interflow, after that, the water is diverted into Hrazdan canal and natural Hrazdan River again. As illustrated in Figure 5.1.6-5, there are seven Hydro Power Plants (HPP) between the Lake Sevan and the Yerevan Lake[18], namely, Sevan HPP, Hrazdan HPP, Gyumush HPP, Arzni HPP, Qanker HPP, Yerevan HPP-1 and Yerevan HPP-3[19]. In addition, Arzni-Shamiram canal, Artashat canal and Lower Hrazdan canal are diverted from the Hrazdan River. It is possible to divide the Hrzdan River into 3 sections, namely, 1) upstream, 2) middle stream and 3) downstream. At the point of intake for the Arzni-Shamiram Canal, upstream and middle stream can be divided, since no impact will be caused in the upstream of the intake by the Project. Moreover, downstream of the Lake Yerevan can be regarded as downstream.

According to the gate keeper of the Arzni Intake before the Argel Reservoir, the flow capacity of channel to Arzni HPP is $67m^3/s$. If the amount of discharge is $70m^3/s$ at the Argel Reservor (confluence point of canal and natural of Hrazdan River), the water is diverted to the channel to Arzni HPP at $67m^3/s$ and natural river at $3m^3/s$, respectively. Most of the water is discharged to the channel to Arzni HPP, while only minimum discharge is taken to the natural river at this moment. The same water distribution system is applied in other parts of the Hrazdan River during the irrigation season, namely, March to October.

18 An artificial lake located on Yerevan City
19 Operation of HPP-2 has been suspended many years ago.

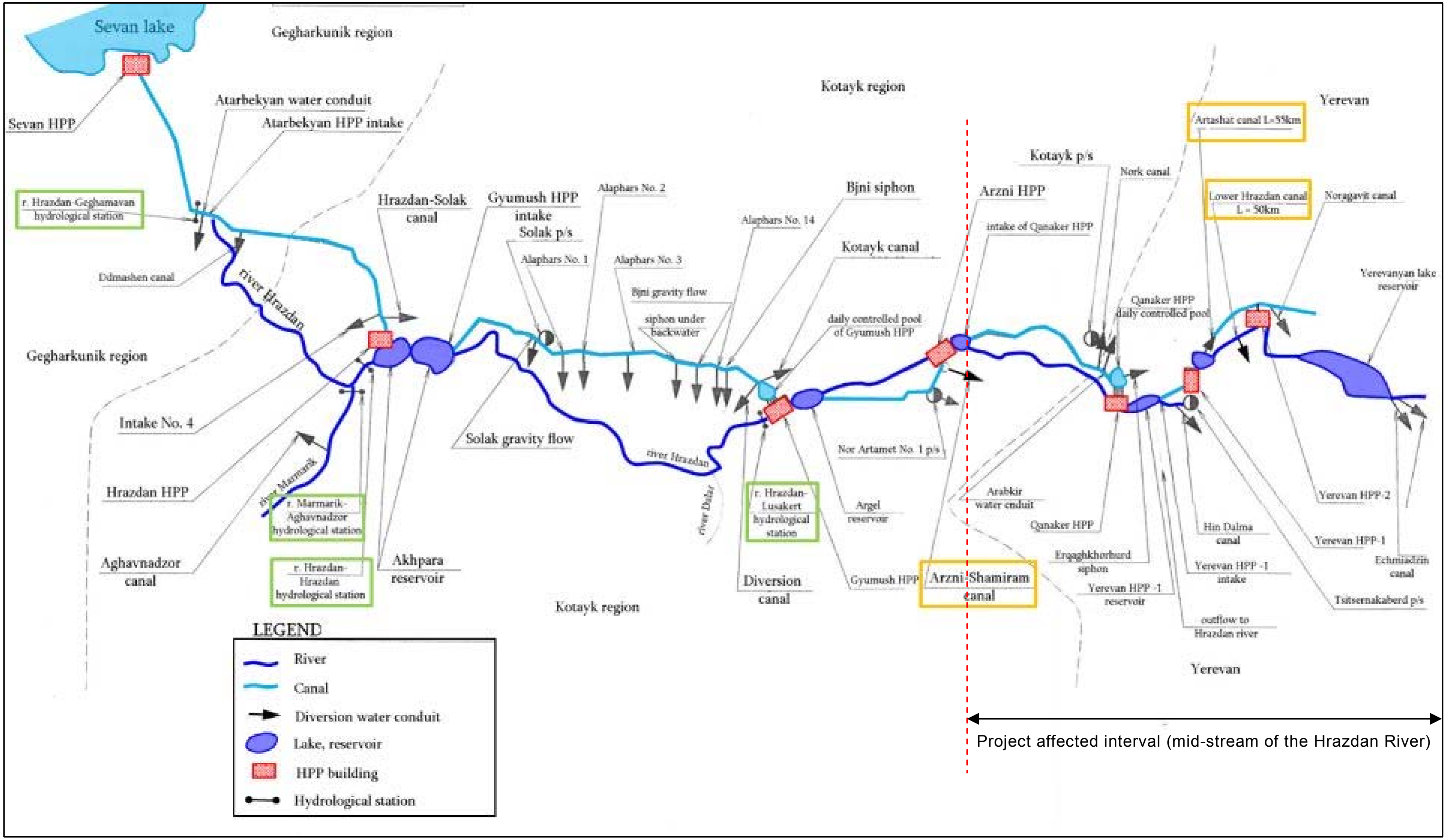


Figure 5.1.6-5 Natural River and Canal in the Hrazdan River

Lusakert Observatory is located on just upstream of the Intake for Arzni-Shamiram Canal, which is the channel for the Yeghvard Reservoir as illustrated in Figure 5-1-6.6. At the point, a water mark is fixed for measurement of water level and it is easy to observe the seasonal water level change. Therefore, focusing on the Observatory, the periodical change of water level snow melting season, namely, from February to April, has been monitored.

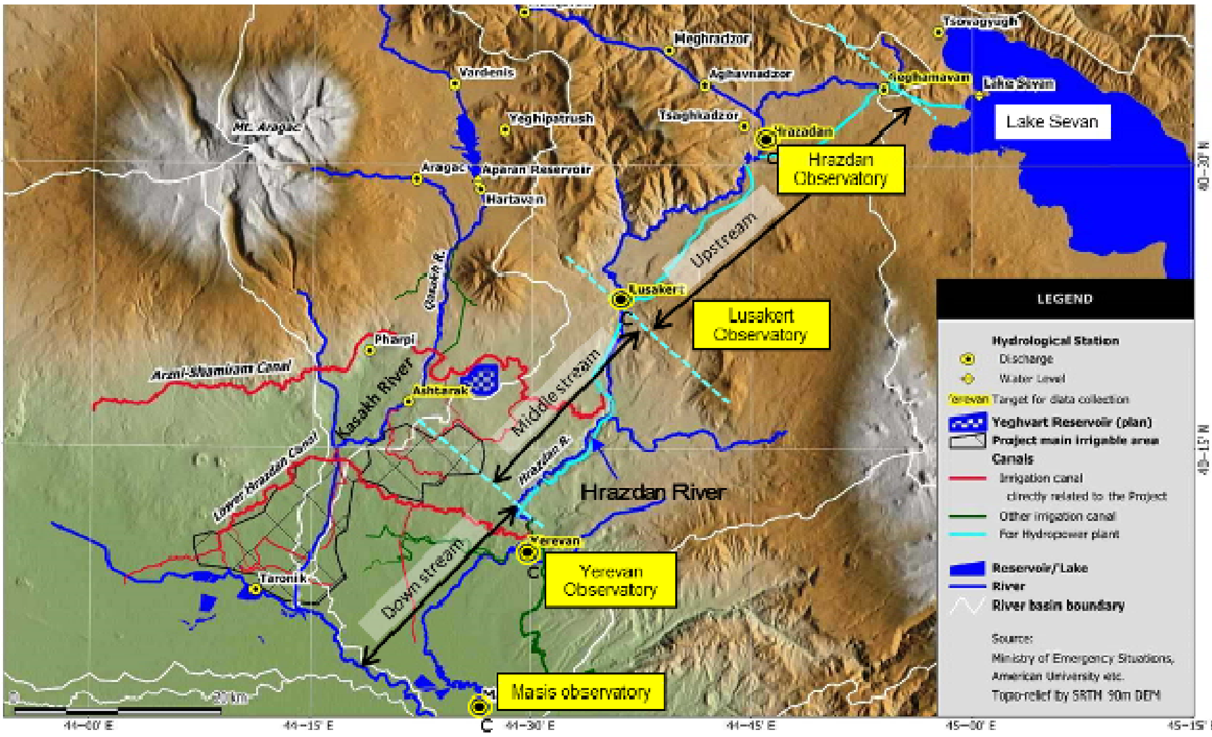
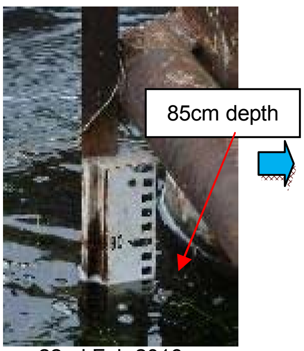
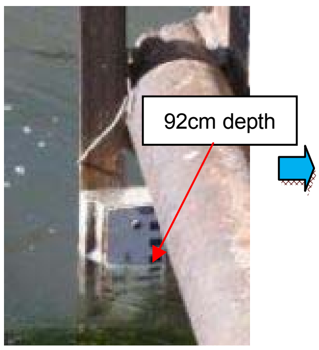


Figure 5-1-6.6 Location Map of Observatory Stations

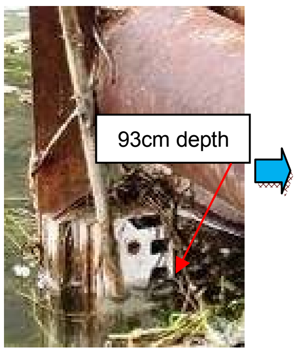
At the Lusakert Observatory (just upstream of the Gyumush HPP and Argel Reservoir), the water depth has not been changed so drastically during snow melting period as shown following photos taken in 2016, probably due to water diversion to the canal of Hrazdan River at the upstream. Rather than that, on 18th April, water level has been decreased, which implies that the discharge of natural flow in Hrazdan River is not influenced by the snow-melted water directly.



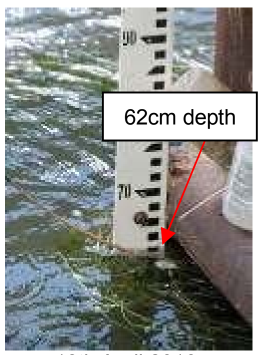
22nd Feb.2016
【water depth：85cm】



2nd March 2016
【water depth：92cm】



30th March 2016
【water depth：93cm】



18th April 2016
【water depth：62cm】

The Hrazdan River has been utilized for irrigation and power generation even now. The water of Hrazdan River is diverted to the natural flow and canal, and those flows are merged after the power generation, and such operation is repeated again and again. Ecological minimum discharge is secured for the natural flow at this moment based on the regulation. The same water management system will be continuously applied after the Project implementation, and drastic change of hydrological situation in the middle stream is not expected.

Concerning the downstream of the Hrazdan River, from the Yerevan Lake to the Araks River, there is no big-scale of canal and weir. At Masis Observatory, water depth is changed monthly, and it was highest in April and lowest in July in 2003. The lowest depth is around 2m (1.98m) in July 2003 as illustrated in Figure 5-1-6.7.

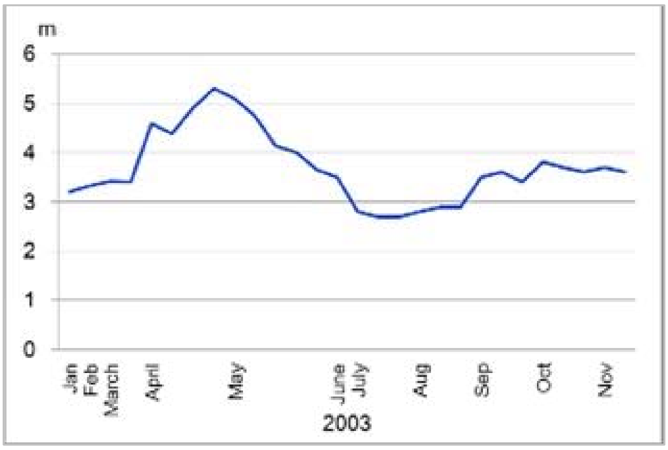


Figure 5-1-6.7 River Water Depth at Masis Station in 2003

Source) Armenian State Hydro-metrological and Monitoring SNCO

It is planned to take 103 MCM water for the Yeghvard Reservoir. The amount of 103MCM will be taken 33MCM, 45MCM and 25MCM in March, April and May, respectively. Based on the conditions, trends of discharge after the Project at Yerevan Observatory and Masis Observatory are estimated, as illustrated in Figure 5-1-6.8. The Hrazdan River discharge would be reduced by the Project, and peak season could be changed from March-June to April-May, which means the peak period could be shorter than present. However, the similar pattern/trend of the discharge peak will be still kept. On the other hand, According to the operator of the Ranchapar Pump Station No.1 in the downstream of Hrazdan River, the drainage conditions around the pump station during snow-melting season is poor, which means the Hrazdan River in the downstream keeps high water level in the season. Therefore, it can be though that the Project will not cause significant impacts on hydrological conditions in the downstream.

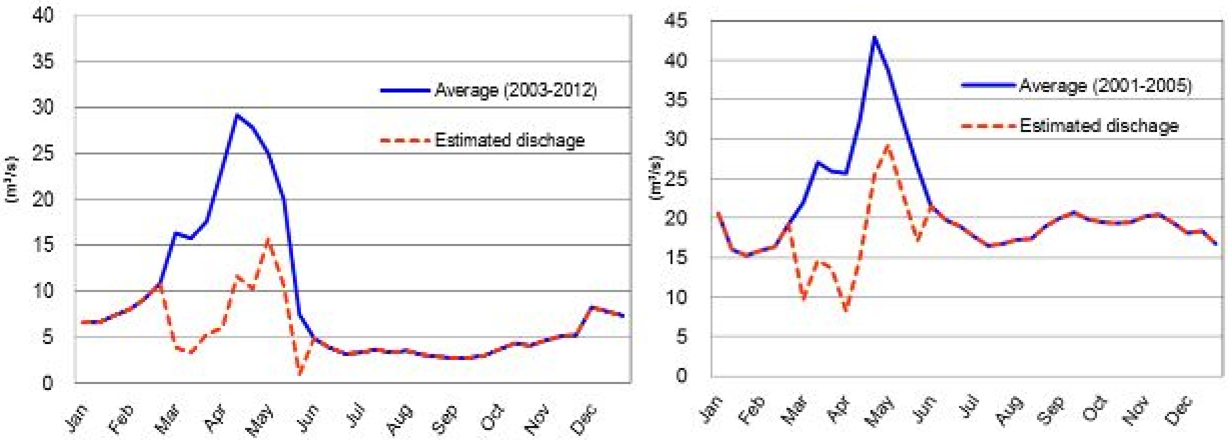


Figure 5-1-6.8 Current and Estimated Discharge (left: Yerevan Observatory, right: Masis Observatory)

Source) Armenian State Hydro-metrological and Monitoring SNCO (for blue line)

(2) Kasakh River

The river water is diverted at Tkanhan Intake into the Tkhhan Canal, and it is taken at the Kasakh Intake to the both Lower Hrazdan Canal and Shah-Aru Canal. As shown in following photo (August 2015) and Figure 5-1-6.9, almost all of river water is at the Kasakh Weir except early spring, and main stream of the river is suspended and water flow is not observed.

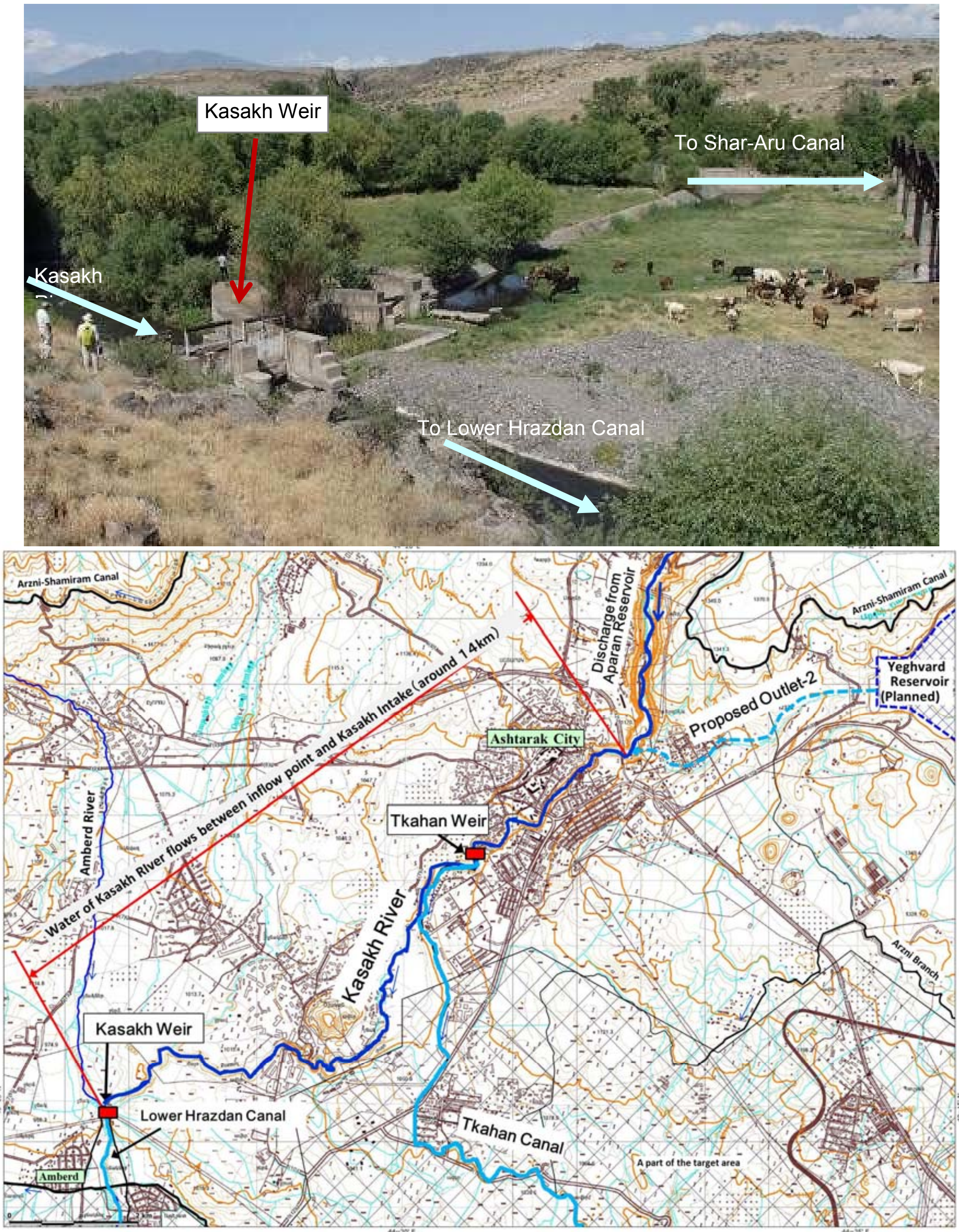


Figure 5-1-6.9 Kasakh River and Irrigation Canals

Discharge of the Kasakh River at Ashtarak Observatory, which is located on near the inflow point from proposed outlet-2, has the peak flow in April, and generally around 3m^3/s through year except that in April (See Figure 5-1-6.10). The river water flows within interval of only 14km, between the Kasakh Intake and inflow point from the Outlet-2. In other words, there is no water in downstream of the Kasakh Intake in the Kasakh River. However, due to the inflow of other streams after the Kasakh Intake, river water is sustained and finally flows into the Araks River.

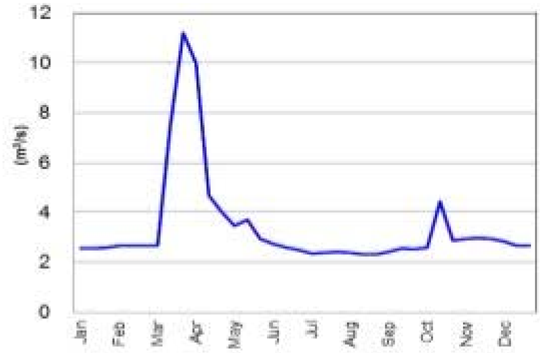


Figure 5-1-6.10 Average Discharge of Kasakh River (1983-2013)

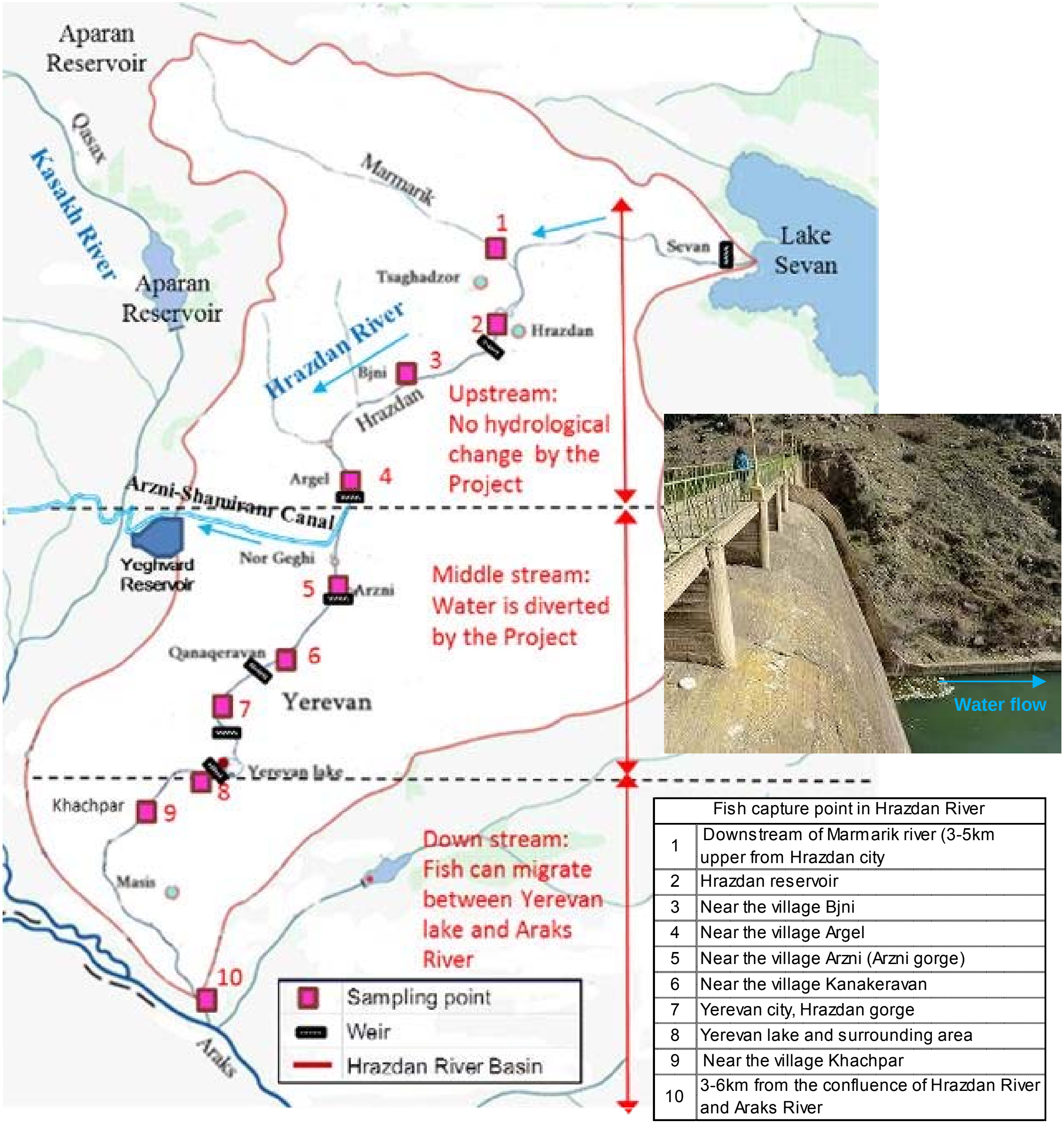
Source) Armenian State Hydro-metrological and Monitoring SNCO

5-1-6-9 Ichthyological System in Hrazdan River and Kasakh River

(1)Current ichthyological situations

1) Fish species in Hrazdan River

A series of Ichthyological surveys in the Hrazdan River was implemented in October to November 2015. Ten (10) points were identified for capture of fish in Hrazdan River as shown in Figure 5-1-6.11. It is noted that Hrazdan River has been highly controlled and utilized for irrigation and hydro power generation, and there are seven (7) weirs between the Lake Sevan and Lake Yerevan. Based on the current situation and project design, Hrazdan River can be divided into 1) upstream, 2) middle stream and 3) downstream as illustrated in Figure 5-1-6.6. Water for Yeghvard Reservoir will be diverted through Arzni-Shamiram Canal at upstream of weir in Argel (No.4), upstream is from No.1 to No4. In the midstream, existing weirs for hydropower prevent fish migration even at this moment due to no fish gate. In the downstream, fish can migrate without difficulty due to no weir.



Fish capture point in Hrazdan River	
1	Downstream of Marmarik river (3-5km upper from Hrazdan city
2	Hrazdan reservoir
3	Near the village Bjni
4	Near the village Argel
5	Near the village Arzni (Arzni gorge)
6	Near the village Kanakeravan
7	Yerevan city, Hrazdan gorge
8	Yerevan lake and surrounding area
9	Near the village Khachpar
10	3-6km from the confluence of Hrazdan River and Araks River

Figure 5-1-6.11 Fish Capture Point in Hrazdan River

In total, twenty-eight (28) species were identified in Hrazdan River by the ichthyological survey (JICA, 2015) in October and November, 2015. One fish which is listed in International Union for Conservation of Nature and Natural Resources Red List of Threatened Species (IUCN Red list) and three species are listed Armenian Red list. At the fish capture points of No.8, 9 and 10, more species were observed, it is probably because that discharge in the downstream is more than that in upstream, and there are no weir or HPP in the downstream. Considering that the water for the Yeghvard Reservoir is planned to be diverted at downstream of the Sampling point No.4, no hydrological change is expected in the upstream, therefore, ichthyological ecosystem in the area will not influenced by the Project. The fish species in the Hrazdan River is as shown in Table 5-1-6.5.

Table 5-1-6.5 Identified Fish in Hrazdan River

Point No.	Fish species	Date of survey
1.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangil* Varicorhinus capoeta sevangi)**, South Caspian sprilin (*Alburnoides eichwaldii*), Prussian carp (*Carassius gibelio*), Brown trout (*Salmo trutta fario*), Rainbow trout (*Oncorhynchus mykiss)*	Oct. 17
2.	Kura barbell (*Barbus lacerta cyri*), Kura nase (*Chondrostoma cyri)*, Chub (*Squalius orientalis)*, **Sevan khramulya (*Capoeta capoeta sevangi*)**, South Caspian sprilin (*Alburnoides eichwaldii*), Prussian carp (*Carassius gibelio*), Rainbow trout (*Oncorhynchus mykiss*), Topmouth gudgeon (*Pseudorasbora parva*)	Oct.17
3.	Kura barbell (*Barbus lacerta cyri*),**Sevan khramulya (*Capoeta capoeta sevangi*),** South Caspian sprilin (*Alburnoides eichwaldii*), Prussian carp (*Carassius gibelio*), Brown trout (*Salmo trutta fario*)	Oct.18
4.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, South Caspian sprilin (*Alburnoides eichwaldii*)	Oct.18
5.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, South Caspian sprilin (*Alburnoides eichwaldii*), Kura loach (*Oxynoemacheilus brandtii*), Prussian carp (*Carassius gibelio*), Rainbow trout (*Oncorhynchus mykiss*)	Oct.31
6.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, South Caspian sprilin (*Alburnoides eichwaldii*), Kura loach (*Oxynoemacheilus brandtii*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibfelio)*, Rainbow trout (*Oncorhynchus mykiss*)	Oct.31
7.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, South Caspian sprilin (*Alburnoides eichwaldii*), Angora loach (*Oxynoemacheilus angorae*), Kura loach (*Oxynoemacheilus brandtii*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Rainbow trout (*Oncorhynchus mykiss*)	Nov. 7and Nov.21
8.	Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Kura khramulya (*Capoeta capoeta capoeta)*, South Caspian sprilin (*Alburnoides eichwaldii*), Angora loach (*Oxynoemacheilus angorae*), Sunbleak (*Leucaspius delineatus*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Monkey goby (*Neogobius fluviatilis*), **Common carp (*Cyprinus carpio*)**, Eastern mosquitofish (*Gambusia holbrooki*).	Nov.7 and Nov. 21
9.	Blackbrow bleak (*Acanthalburnus microlepis*), Kura barbell (*Barbus lacerta cyri*), White bream (*Blicca bjoerkna transcaucasica*), Kura nase (*Chondrostoma cyri*), Gudgeon (*Gobio gobio*), Chub (*Squalius orientalis)*, **Sevan khramulya (*Capoeta capoeta sevangi*)**,Kura khramulya (*Capoeta capoeta capoeta)*, South Caspian sprilin (*Alburnoides eichwaldii*), Angora loach (*Oxynoemacheilus angorae*), Kura loach (*Oxynoemacheilus brandtii*), Sunbleak (*Leucaspius delineatus*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Monkey goby (*Neogobius fluviatilis*), Bulatmai barbell (*Luciobarbus capito*), Mursa (*Luciobarbus mursa*), **Common carp (*Cyprinus carpio)***, Rainbow trout (*Oncorhynchus mykiss*), Eastern mosquitofish (*Gambusia holbrooki*).	Oct. 10 and Oct. 24
10.	Blackbrow bleak (*Acanthalburnus microlepis*), North Caucasian bleak (*Alburnus hohenackeri*)**,** Kura bleak (*Alburnus filippii*), Kura barbell (*Barbus lacerta cyri*), White bream (*Blicca bjoerkna transcaucasica*), Kura nase (*Chondrostoma cyri*), Gudgeon (*Gobio gobio*), Chub (*Squalius orientalis)*, **Sevan khramulya (*Capoeta capoeta sevangi*)**, Kura khramulya (*Capoeta capoeta capoeta*), European bitterling (*Rhodeus amarus)*), South Caspian sprilin (*Alburnoides eichwaldii*), Angora loach (*Oxynoemacheilus angorae*), Sunbleak (*Leucaspius delineatus*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Monkey goby (*Neogobius fluviatilis*), **Armenian roach(*Rutilus rutilus schelkovnikovi)*, Asp (*Aspius aspius*)**, Bulatmai barbell (*Luciobarbus capito*), Mursa (*Luciobarbus mursa*), **Common carp (*Cyprinus carpio*)**, Common bream (*Abramis brama*), Wels catfish (*Silurus glanis*), Eastern mosquitofish (*Gambusia holbrooki*).	Oct. 10 and Oct. 24

Source) JICA Survey Team (2015)

*1. It is controversial whether Kura khramulya (*Capoeta capoeta capoeta)* is different species from *Capoeta capoeta sevangi, and Capoeta capoeta is called as* Sevan Kharamulya (*Varicorhinus capoeta sevangi*) according to Wikipedia. Sevan khramulya (it was also called as *Varicorhinus capoeta sevangi*) are identified at many points as shown in the table above, and the fish is common in many rivers in Armenia recently, while it has been decreased in the Lake Sevan rapidly and listed in the Armenian Red list.

*2. Armenian Roach (*Rutilus rutilus schelkovnikovi*) is synonym of *Rutilus rutilus.*

*3. Fish species shown in bold are endangered species as follows:

1) Common carp: Vulnerable (VU) A2ce in the IUCN Red list;
2) Sevan khramulya (*Capoetacapoeta sevangi or* Varicorhinus capoeta sevangi*):* VU A1cd in the Armenian Red list;
3) Armenian roach (*Rutilus rutilus schelkovnikovi):* Endangered (EN) B 1ab (iii) +2ab (III) in the Armenian Red list; and
4) Asp *(Aspius aspius):* VU B1ab (iii) in the Armenian Red list.

2) Fish species in Kasakh River

A series of Ichthyological surveys in the Kasakh River was implemented by JICA Team in October to November 2015. Eight (8) points were identified as the fish capture points in the Kasakh River as shown in Figure 5-1-6.12. Kasakh River passes through the Aparan Reservoir and the river discharge is influenced by the discharge from the reservoir. After the merge with the Ambed River, Kasakh River flows and merges with the Metsamor River, and finally it flows into the Araks River.

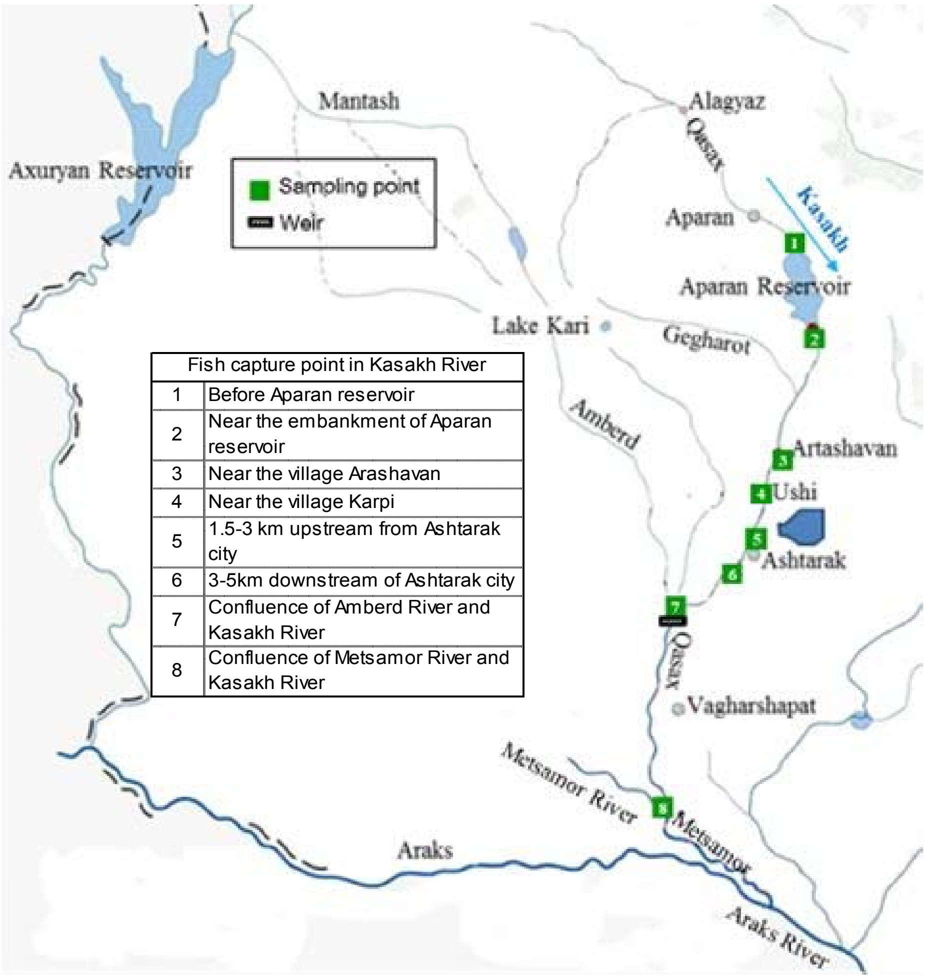


Figure 5-1-6.12 Fish Capture Point in Kasakh River

In Kasakh River, only fifteen (15) species were identified by the survey in October and November, 2015 as shown in Table 5-1-6.6. It is probably because that water of the Kasakh River has been utilized maximally for irrigation at the Kasakh Weir (sampling point), which results in no water in and after the Kasakh Intake.

Table 5-1-6.6 Identified Fish in Kasakh River

Point No.	Fish species	Date of survey
1.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Prussian carp (*Carassius gibelio*), Brown trout (*Salmo trutta fario*)	11.Oct.
2.	South Caspian sprilin (*Alburnoides eichwaldii*),Kura barbell (*Barbus lacerta cyri*), Chub (*Squalius orientalis*), **Sevan khramulya(*Capoeta capoeta sevangi*)**, Prussian carp (*Carassius gibelio*)	11.Oct.
3.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura barbell (*Barbus lacerta cyri*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*)	09.Oct.
4.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Rainbow trout (*Oncorhynchus mykiss)*	09.Oct.
5.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura barbell (*Barbus lacerta cyri*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Kura khramulya (*Capoeta capoeta capoeta)*, Prussian carp (*Carassius gibelio*), Rainbow trout (*Oncorhynchus mykiss)*	08.Nov.

Point No.	Fish species	Date of survey
6.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura barbell (*Barbus lacerta cyri*), Kura nase (*Chondrostoma cyri*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Mursa (*Luciobarbus mursa*), **Common Common carp (*Cyprinus carpio*)**, Rainbow trout (*Oncorhynchus mykiss)*	08.Nov.
7.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura bleak (*Alburnus filippii*), Kura barbell (*Barbus lacerta cyri*), Kura nase (*Squalius orientalis*), Chub(*Alburnus filippii*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Brown trout (*Salmo trutta fario*), Rainbow trout (*Oncorhynchus mykiss)*	14.Nov.
8.	South Caspian sprilin (*Alburnoides eichwaldii*), Kura bleak (*Alburnus filippii*), Kura barbell (*Barbus lacerta cyri*), Kura nase (*Squalius orientalis*), Chub(*Alburnus filippii*), **Sevan khramulya (*Capoeta capoeta sevangi*)**, Kura khramulya (*Capoeta capoeta capoeta)*, Angora loach (*Oxynoemacheilus angorae*), Topmouth gudgeon (*Pseudorasbora parva*), Prussian carp (*Carassius gibelio*), Bulatmai barbell (*Luciobarbus capito*), Mursa (*Luciobarbus mursa*), **Common Common carp (*Cyprinus carpio*)**, Rainbow trout (*Oncorhynchus mykiss)*	15.Nov.

Source) JICA Survey Team (2015)

Fish species shown in bold are endangered species as follows:

1) Common carp: Vulnerable (VU) A2ce in the IUCN Red list; and
2) Sevan khramulya (*Capoeta capoeta sevangi/Varicorhinus capoeta sevangi*): VU A1cd in the Armenian Red list.

(2) Impact on ichthyological ecosystem by the Project

1) Impact on existing ichthyological ecosystem in the Hrazdan River

Generally, spawning trigger of fresh water fish are water temperature change and generation of discharge peak. Moreover, enough water depth for spawning is necessary. When impacts on fish in the Hrazdan River are examined, it is possible to category 1) fish in the upstream of the intake for Arzni-Shamiram Canal, 2) fish in the middle stream (from the intake to the Lake Yerevan) and 3) fish in the downstream of the Hrazdan River. This matter is discussed as shown below.

(a) Fish in the upstream

The fish in the upstream will not be damaged at all, since the area is upstream of the water intake point of the Arzni-Shamiram Canal for the Reservoir.

(b) Fish in the middle stream

As mentioned before, there are natural flow and canal in the Hrazdan River, and discharge in the natural flow is small. In addition, weirs for the hydro power generation prevent fish from migration between upstream and downstream. Such conditions will not be changed by the Project. Even now, the discharge in the middle stream of Natural Hrazdan River is not drastically increased by the meltwater. At this moment, 2-3 m^3/s discharge in the natural flow in the middle stream is observed as shown in following photos and it will be kept after the Project. Therefore, it can be said that spawning conditions for fish in middle stream will not be changed and the impacts on fish will be limited.

Natural Hrazdan River on 2nd March 2016, at just upstream of Lake Yerevan
(Left: beside of a restaurant along the river, right: just downstream of the point of the photo of left)

(c) Fish in the downstream

In the downstream of the Hrazdan River, namely, from the Yerevan Lake to the Araks River, there is no big-scale of canal and weir. At Masis Observatory in the downstream, water depth is changed monthly, and it was highest in April and lowest in July in 2003. The lowest depth is around 3m in July 2003 as illustrated in Figure 5-1-6.7. Sufficient water depth for spawning will be secured in the downstream even in the lowest period, considering necessary depth for fish spawning is 0.2m to 0.5m as shown in Appendix-K-5.

Triggers for spawning are various depending on species, and they are summarized in Table 5-1-6.7. Spawning trigger for the thirteen (13) species, out of identified 28 fish species in the Hrazdan River, is a certain level of water temperature. It means that water diversion for the Yeghvard Reservoir will not give significant damages to the spawning of the 13 species. Concerning remaining species, the condition is unknown, however, even if their spawning trigger is discharge peak, they can also survive after the Project, since discharge peak will be secured as mentioned in Figure 5-1-6.8. Consequently, it can be judged that the current ichthyological system in the Hrazdan River will not be influenced by the Project significantly.

Table 5-1-6.7 Trigger for Spawning

No.	Species of fish	Trigger	Remarks
1	Angora loach (*Oxynoemacheilus angorae)*	No data	-
2	Armenian roach (*Rutilus rutilus schelkovnikovi*)	In case of Rutilus rutilus, the trigger is mainly water temperature, the suitable one is very various from more than 6℃ to 10-12℃. Roach spawned synchronously with rapid increase in temperature, whereas they had a prolonged spawning with low or with slow increase in water temperature.[*1]	Registered in the Red list in Armenia
3	Asp (*Aspius aspius*)	Above 8℃[*2]	Registered in the Red list in Armenia
4	Blackbrow bleak (*Acanthalburnus microlepis*)	No data	-
5	Brown trout (*Salmo trutta fario)*	Spawn in autumn	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.
6	Bulatmai barbel (*Luciobarbus capito)*	No data	-
7	Chub (*Squalius orientalis)*	No data	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.
8	Common bream (*Abramis brama*)	Above 15℃[*2]	-
9	Common carp (*Cyprinus carpio)*	17-18℃*[3]	Registered in the IUCN Red list
10	Eastern mosaquitofish (*Gambusia holbrooki*)	No data	It is regarded as "invasive species"[*4]
11	European bitterling (*Rhodeus amarus*)	No data	-
12	Gudgeon (*Gobio gobio*)	Above 13℃ for spawning [*2]	-
13	Kura barbel (*Barbus lacerta cyri*)	No data	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.
14	Kura bleak (*Alburnus filippii*)	No data	-
15	Kura khramulya (*Capoeta capoeta capoeta*)	If the species is synonymy of Sevan khramulya (Capoeta Capoeta Sevangi), Spawning start at 12℃and peaks at 15℃[*5].	-
16	Kura loach (*Oxynoemacheilus brandtii*)	No data	-
17	Kura nase (*Chondrostoma cyri*)	No data	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.

No.	Species of fish	Trigger	Remarks
18	Monkey goby (*Neogobius fluviatilis*)	Above 13℃[*2]	-
19	Mursa (*Luciobarbus mursa*)	No data	-
20	North Caucasian bleak (*Alburnus hohenackeri*)	Above 18～23℃ for spawning [*2]	-
21	Prussian carp (*Carassius gibelio)*	Above 14℃ for spawning [*7]	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project. However, it is regarded as an invasive species.
22	Rainbow trout (*Oncorhynchus mykiss)*	In the wild, there are rainbow trout populations that spawn in autumn and there are other populations that spawn in spring[*6]	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.
23	Sevan khramulya (*Capoeta capoeta sevangi*)	Spawning start at 12 ℃and peaks at 15℃[*3]	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project. Registered in the Red list in Armenia
24	South Caspian sprilin (*Alburnoides eichwaldii*)	No data	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project.
25	Sunbleak (*Leucaspius delineates*)	When temperature reaches 16℃[*2]	-
26	Topmouth gudgeon (*Pseudorasbora parva*)	No data	It ranges in the upstream of Hrazdan River, and it will be conserved after the Project. However, it is regarded as pest due to its high reproductive rate.[*2]
27	Wels catfish (*Silurus glanis*)	Above 20℃[*2]	-
28	White bream (*Blicca bjoerkna transcaucasica*)	Above 15℃ for spawning[*2]	-

Remarks: Highlighted fish are registered in IUCN Red list and Armenian Red list.

Source) *1: Environmental Biology of Fishes Vol. No.3, p19-227, 1987,"Reproductive biology of stream spawning roach, Rutilus-Rutilus"

*2: IUCN Red list

*3: FAO, Cultured Aquatic Species Information Programme, "*Cyprinus carpio"*

*4: Global Invasive Species Database

*5: FAO, Corporate Document Repository, Fish and Fisheries in Lake Sevan, Armenia, and in some other high altitudes lakes of Caucasus. Since Kura khramulya (*Capoeta capoeta capoeta) and* Sevan khramulya (*Capoeta capoeta sevangi) could be the same species, it is presumed that their spawning conditions are the same.*

*6: FAO, 2011, Fisheries and Aquaculture Technical Paper 561, Small-scale rainbow trout farming

*7: Pipoyan S., Ichthyofaunal of Armenia, 2012

2) Impact on existing ichthyological ecosystem in the Kasakh River

There are some species which range in both Hrazdan River and Kasakh River. The number of species in the Hrazdan River is much more than that in Kasakh River, and 15 species are common as shown in Table 5-1-6.8. Since the water of Hrazdan River will be diverted between sampling point No.4 and No.5 to the Yeghvard Reservoir, the fish which are identified at No.5 sampling point may be moved to the Kasakh River through the Yeghvard Reservoir and they could mix with the fish in Kasakh River. They are Kura barbell (*Barbus lacerta cyri*), Sevan khramulya (*Capoeta capoeta sevangi*), South Caspian sprilin (*Alburnoides eichwaldii*), Kura loach (*Oxynoemacheilus brandtii*), Prussian carp (*Carassius gibelio*) and Rainbow trout (*Oncorhynchus mykiss*). All of them except Kura loach are identified in the Kasakh River also. Considering the situation, the Project will not change the ichthyological eco-system in the Kasakh River.

Table 5-1-6.8 Comparison of Identified Fish in Hrazdan River and Kasakh River

No.	Fish Species	In Hrazdan River	In Kasakh River
1	Angora loach (*Oxynoemacheilus angorae*)	+	+
2	Armenian roach (*Rutilus rutilus schelkovnikovi*)	+	-
3	Asp (*Aspius aspius*)	+	-
4	Blackbrow bleak (*Acanthalburnus microlepis*)	+	-
5	Brown trout (*Salmo trutta fario*)	+	+
6	Bulatmai barbel (*Luciobarbus capito*)	+	+
7	Chub (*Squalius orientalis*)	+	+
8	Common bream (*Abramis brama*)	+	-
9	Common carp (*Cyprinus carpio*)	+	+
10	Eastern mosquitofish (*Gambusia holbrooki*)	+	-
11	European bitterling (*Rhodeus amarus*)	+	-
12	Gudgeon (*Gobio gobio)*	+	-
13	**Kura barbel (*Barbus lacerta cyri*)**	+	+
14	Kura bleak (*Alburnus filippii*)	+	+
15	Kura khramulya (*Capoeta capoeta capoeta*)	+	+
16	**Kura loach (*Oxynoemacheilus brandtii*)**	+	-
17	Kura nase (*Chondrostoma cyri*)	+	+
18	Monkey goby (*Neogobius fluviatilis*)	+	-
19	Mursa (*Luciobarbus mursa*)	+	+
20	North Caucasian bleak (*Alburnus hohenackeri*)	+	-
21	**Prussian carp (*Carassius gibelio*)**	+	+
22	**Rainbow trout (*Oncorhynchus mykiss*)**	+	+
23	**Sevan khramulya (*Capoeta capoeta sevangi*)**	+	+
24	**South Caspian sprilin *(Alburnoides eichwaldii*)**	+	+
25	Sunbleak (*Leucaspius delineatus*)	+	-
26	Topmouth gudgeon (*Pseudorasbora parva*)	+	+
27	Wels catfish (*Silurus glanis*)	+	-
28	White bream *(Blicca bjoerkna transcaucasica*)	+	-
	Total number of fish species	28	15

+: identified, -: not identified

Highlighted fish species are the ones identified at No.5 of Hrazdan River

The table is prepared based on the Table 5-1-6.5 and Table 5-1-6.6.

5-1-6-10 Involuntary Resettlement and Land Acquisition

Since there are no residential buildings in close proximity to the Yeghvard Reservoir and proposed Feeder/Outlet Canals construction sites, no physical relocation is expected by the Project. However, the Yeghvard Reservoir basin will be submerged and some farmlands along the proposed canals will be affected. In total, 819.36.ha will be influenced by the construction works. The detailed is described in Chapter 5-2.

5-1-6-11 The Poor

In the affected area in and around the construction site, some households which get pension and poverty allowance are identified. It is needed to pay some special attention to them, through employment of them as labors of the Project construction works with high priority and lump sum money payment.

5-1-6-12 Indigenous People/Minority People

As mentioned before, some minority groups stay in the beneficial area, and they will be able to access to irritation water more stably as the Project beneficiaries. They do not have difficulty to communicate in Armenian language and they will not be excluded from the benefit by the Project. On the other hand, in the affected area, it is confirmed that there is no minority people.

5-1-6-13 Livelihood/Local Economy

The farmers in the beneficial area will be able to stable irrigation water more than present, and crop diversification will be promoted, which will result in production increase and income improvement for each household. It is expected that such improvement can contribute to the local economy activation. On the other hand, the affected persons in and around the construction site will lose parts of their lands and livelihood measures by the Project. It is needed to provide compensation or/and considerations/support to such negatively affected people to minimize the impacts.

5-1-6-14 Land Use and Local Resource Utilization

The reservoir basin has been used for farmland and grazing. The cultivators within the reservoir will lose their farmland and which can lead to decrease of their income, and it is needed to pay considerations to the affected persons. Concerning grazing land, some parties use the reservoir basin for livestock grazing, however, they do not stay in the same place continuously, and they are moving from flat grassland to mountainous area with their livestock. According to one person who was grazing in the Reservoir basin, there are sufficient places for grazing, the loss of grassland area by the Project is not a big issue for him. Consequently, negative impacts on land use and local resource utilization will not be significant.

The people of Yeghvard Community and Nor-Yerznka Community request the Project to transport fertile top-soil of the Reservoir to their farmlands. At the construction stage, it is needed to classify the top-soil into useful soil for farming, and waste soil to be disposed. After the classification, the fertile soil will be transported, stored and distributed among the people. The procedure and method of soil transportation, storage and distribution are to be discussed at the community councils.

5-1-6-15 Water Usage or Water Rights and Rights of Common

It has been approved to take 17.7 m^3/s of water volume for 210 days (in total 320 MCM per year) from the Hrazdan River for the Arzni-Shamiram canal by the Water Resource Management Agency, under the MNP. Out of 320 MCM mentioned above, 160 MCM water from the Hrazdan River has been annually used for irrigation so far, while proposed water intake volume for Yeghvard reservoir is 103 MCM. It means that water intake of 103 MCM is within the specified volume under that water use right, and the Project will not encroach other water use right. In addition, 103 MCM water diversions for Yeghvard reservoir accounts for only 5.5% of total discharge of Hrazdan River for hydro power generation, namely, 1,875 MCM in 2013.

In Hrazdan River, around 500 million kWh is generated by seven (7) hydro power plants. If 103 MCM water is taken, 27.5 million kWh (=103/1,875*500) power generation will be affected. However, considering the total power generation in Armenia is around 7,800 million kWh annually, the affected amount is only 0.35%. Therefore, the impact by the Project on the power generation will be very limited.

5-1-6-16 Existing Social Infrastructure and Services

During the construction works, traffic jam can be caused by the increase of traffic volume. The expected number of construction vehicles is around 50 per day. The vehicles will be operated within the Reservoir basin mainly and they will be parked in the area during the night. It means that the construction works within the Reservoir will not cause severe traffic jam. On the other hand, along the proposed Outlet Canal-2, the existing road is very narrow, and temporary road closure will be needed for around 30 days, which leads to inconvenience for the residents. However, it is possible for the people to access another road and the impact will be temporary. Therefore, it can be judged that the impact will not be significant. It is recommended to decentralize the use of construction vehicles to avoid traffic jam.

5-1-6-17 Misdistribution of Benefit and Damage, and Conflict

In the Project, there are beneficiaries and negatively affected persons, and it is planned to provide compensation to the affected persons to restore their livelihood to the original level. Given that there is sufficient distance between the beneficial area and affected area, the affected persons will not have a feeling of jealousy against the beneficiaries. Moreover, no case that any conflicts between beneficiaries and affected persons due to some projects have been reported so far in Armenia according to the official personnel of PIU. Therefore, the possibility of misdistribution of benefit and damage, and conflict is very low.

5-1-6-18 Cultural Heritage

There are some cultural heritages to be conserved around the construction site, namely, Second World War victim's monument and memorial fountain. However, they are 100-200 m away from the construction sites and they will not be affected by the Project. It is noted that there is a possibility that some buried historical assets will be found during the construction works, in such case, it is needed to report the fact to the Ministry of Culture.

5-1-6-19 Hazard (Risk) Infectious Diseases such as HIV/AIDS

There could be no possibility of HIV infection during the construction works, given that there has no such case reported in Armenia so far. Moreover, malaria is not a common disease in Armenia, and case of Malaria is very few. The proposed reservoir will have enough water depth, where mosquito cannot survive in the Reservoir. Therefore, no risk of infectious diseases by the Project is expected.

5-1-6-20 Work Environment

Improper working environment for labors can cause some accident related to construction works. It is needed to distribute necessary tools, proper uniform, helmet and glasses to the construction workers, and proper work shift management of the labors is essential to minimize the accident. Working condition, such as work hours per day shall be based on the regulation in Armenia.

5-1-6-21 Accident

During the construction stage, there is a possibility of traffic accident due to the increase of traffic volumes, it is needed to control construction vehicles and to set signboard showing construction site for warning surrounding people.

5-1-6-22 Transboundary Impacts and Climate Change

A certain amount of greenhouse gas emission, such as CO_2, during the construction period is expected, however, it will be temporary and the scale will not be large, which result in no climate change. Rather than that, the Project can contribute to saving electricity through the shift from pump irrigation to gravity irrigation, which leads to reduction of greenhouse gas emission.

The Project will take 103 MCM water for the Reservoir, while annual discharge amount of the whole Hrazdan River is 1,875 MCM as of 2013, which means that the proposed water intake will not give a serious damage to the Hrazdan River. On the other hand, the flow of Hrazdan River is completed within the territory of Armenia and it is not an international river. Therefore, no international treaties on water use of Hrazdan River have been established. The river finally flows into the Araks River, which is an international river and runs through the boundary with Turkish. The area of the Araks

River basin is around 102,000 km^2, while that of Hrazdan River basin is around 1,200 km^2, namely, the ratio of Hrazdan River basin to that of the Araks River basin is only 1.2%. Considering those situations, it can be said that the impact will not cause transboundary impacts.

5-1-7 Evaluation

Based on the discussion in the previous sub-chapter, the stage-wise expected impacts by the Project are summarized in Table 5-1-7.1.

Table 5-1-7.1 Impact Examination Result

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
1. Air quality	B^-	D	B^-	D	**Construction stage:** Dust and gas emission will be caused, especially, Outlet Canal-2 is expected to pass through residential area, which leads to impacts on the area. In addition, strong wind can cause dust and give damage to Nor-Yerznka Community. **Operation stage:** Increase of vehicles is not expected, and there is low possibility of air pollution.
2. Water quality	B^-	B^-	B^-	D	**Construction stage:** Mud water from the construction site will be caused. **Operation stage:** There is no case reported that surface water is polluted by agrichemicals in Armenia[20]. Moreover, there is no drainage from the farmland in the target area, and no impact on surrounding environment through surface water, even though increase of applied amount of fertilizers and agrichemicals is expected. Irrigation water by using canals and rivers quality will not be deteriorated by the Project. Water flow direction in the Reservoir will be generated through water supply from the reservoir to the Kasakh River, thus, the water in the Reservoir will not be stagnant.
3. Waste	B^-	D	B^-	B^-	**Construction stage:** Waste from new construction sites and rehabilitation sites of existing irrigation system will be generated and proper disposal is needed. **Operation stage:** Dredging of canals is needed, however, the amount will be limited. If the Reservoir becomes a sightseeing point and some restaurants are constructed, waste will be generated. In such case, the owners should shoulder the cost for waste disposal. Regardless of tourism or other activities, it is needed t to follow laws of Armenia, and there is no special regulation for waste management in tourism.

[20] It is based on hearing to official personnel of MNP, PIU and MOA.

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
4. Soil Contamination	B^-	C	B^-	B^-	**Construction stage:** Oil leakage from construction vehicles and equipment is expected. **Operation stage:** Due to the irrigation area expansion, application of illegal agrichemical can be increased, which lead to pollution.
5. Noise and Vibration	B^-	D	B^-	D	**Construction stage:** Noise and vibration due to construction works are expected. **Operation stage:** Given that traffic increase is not expected, noise and vibration will not be caused.
6. Ground Subsidence	D	D	D	D	
7. Offensive Odor	D	D	D	D	
8. Bottom sediment	D	D	D	D	
9. Protected area	D	D	D	D	
10. Ground water	D	C/B^+	D	B^-/B^+	**Construction stage:** No impact on the ground water by the project is expected. **Operation stage:** The project can contribute to recovery of ground water resource due to shift from use of ground water to use of surface water. Irrigation area expansion can cause increase of chemical fertilizer application, which can results in groundwater pollution by nitrogen.
11. Hydrological Situation	D	C	D	D	**Construction stage:** It is not planned to suspend any natural rivers nor to change /expand existing water courses, which will not result in hydrological change. **Operation stage:** The project will divert the free water of the Hrazdan River during March to May, considering the regulated minimum discharge. Even now, most of the Hrazdan River water is used for canal, while only minimum discharge is secured for the natural flow, thus, dynamic hydrological change is not expected. In the downstream, enough depth and seasonal discharge peak will be kept, and no significant impact is expected.
12. Ecosystem	B^-	B^-/B^+	B^-	B^-/B^+	**Construction stage** Lands in and around the construction sites have been already developed for agricultural purpose and there is no virgin nature to be damaged by the Project. Thus, expected impact is not severe. Wildlife within the Reservoir will be able to escape to the outside and to survive during construction if the construction site is divided into 4 blocks. Poisonous snake species is identified in the

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
					Reservoir, and there is possibility that the snake comes to neighboring villages. It is needed to take measures against the snake. **<u>Operation stage:</u>** There is a possibility that bio-diversity will be richer than present, since the reservoir construction will attract birds. There are 4 birds register in the red list and 1 snake registered in the red list in the reservoir basin, however, they can move to other areas which have similar characteristics of the reservoir area. Concerning ichthyological system, ecological minimum discharge of the Hrazdan River secured. Even now, most of the river water is used for irrigation and power generation in the middle stream, amount of natural flow is only minimum discharge. In the downstream, necessary depth for spawning will be expected, and some rare fish species survive in Hrazdan River. Some fish species are common in Hrazdan River and Kasakh River. Therefore, if Hrazdan River water is mixed with the Kasakh River water by the water diversion through Yeghvard Reservoir, the eco-system in the Kasakh River will not be affected. The project could reduce dependency of the command area on the Lake Sevan as the water resource, however, water level of the lake is increased by only several centimeters by the Project.
13. Topography and Geographical features	D	D	D	D	
14. Involuntary Resettlement/ Land Acquisition	B-	D	B-	D	**<u>Before and during construction stage:</u>** 819.36 ha area in and around the construction site will be affected by the construction works and land expropriation is needed, however, no physical relocation is planned. **<u>Operation stage:</u>** No impact is expected.
15. The poor	C	C	B-	D	**<u>Before and during construction stage:</u>** There are some households who get poverty allowance in the affected area, they can be influenced by the Project, and it is needed to pay special considerations to such persons. **<u>Operation stage</u>** No impact on the poor people is expected.
16. Indigenous and ethnic people	C	C	D	D	**<u>Before and during construction stage:</u>** There is an ethnic minority household in the affected area. They are to be compensated for their land loss based on the law/regulation. **<u>Operation stage</u>** There are ethnic minority people in the target

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
					area, and they can access to the project benefit as well as other beneficiaries.
17. Livelihood/local economy	B^-/B^+	B^+	B^-/B^+	B^+	**Construction stage:** Given that the Project will provide job opportunities for the local people, positive impact is expected. On the other hand, the Project will cause negative impacts on some people whose land will be acquired. **Operation stage:** Stable agricultural production can be promoted by stable irrigation water. The cost for pump operation shouldered by the government, will be reduced. It is expected that the Yeghvard Reservoir will attract tourists and the area will be developed.
18. Land use and local resource utilization	B^-	D	B^-	D	**Construction stage:** It is needed to acquire land for construction of reservoir and canals. Some of existing farmlands will be changed to stock yard for construction, construction office, canals and so on. **Operation stage:** No negative impact on land use and local resource utilization is expected.
19. Water Usage or Water Rights and Rights of Common	D	B^-/B^+	D	D	**Construction stage:** 1) Since the Project will take water of the Hrazdan River and use existing facilities, new construction will be not done, impacts on the downstream of the Hrazdan River is not expected. 2) Given that the construction works will not close natural rivers and change existing canals, scale of mud water due to construction works will be small and the impact is negligible. **Operation stage:** The water use permission was given by the MNP for the Arzni-Shamiram Canal. The proposed amount of water intake for the Reservoir is within the approved volume. Therefore, the Project will not interfere with other water use of Hrazdan River water.
20. Existing social infrastructures and services	B^-	D	B^-	D	**Construction stage:** Due to increase of construction vehicles, traffic jam can be caused. **Operation stage:** No impact on traffic is expected.
21. Social institutions	D	D	D	D	
22. Misdistribution of benefit and damage	B^-	B^-	D	D	**Construction stage:** There are some person who will lose their lands in the affected area, while beneficiaries can enjoy the stable irrigation water. However, the former will be compensated for the loss. Thus, misdistribution of benefit and damage, is not expected. Operation stage: While the farmers in the project target area

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
					can enjoy the project benefit, while other farmers in non-command area cannot. Still, in Armenia, no case has been reported that non-beneficiaries envy or feel antipathy to beneficiaries, which results in conflict in between, according to the PIU official personnel. Therefore, it can be said that no big issue will be caused by the Project.
23. Conflict	B^-	C	D	D	**Construction stage:** Probably the affected persons will not have jealousy to the beneficiaries, since there is enough distance between the both groups and they will be provided with compensation. Thus, any conflicts are not expected. Operation stage: While the farmers in the project target area can enjoy the project benefit, while other farmers in non-command area cannot. Given that there is no case that conflict in between beneficiaries and non-beneficiaries has been identified so far in Armenia, according to the PIU official personnel. Therefore, it can be said that no conflict due to the Project is expected.
24. Cultural heritage	C	C	D	D	**Before and Construction stage** No cultural heritage to be conserved in and around the construction site is identified. If some assets are found during the construction, immediate report should be done. Operation stage: The Project plans to cover existing farming area that has been developed, instead of virgin land, therefore, no damage to cultural asset in operation stage is is expected.
25. Land scape	D	D	D	D	
26. Gender	D	D	D	D	
27. Children rights	D	D	D	D	
28. Hazards (Risk), Infectious diseases such as HIV/AIDS	B^-	D	D	D	**Construction stage:** Any cases of Infectious diseases such as Malaria and HIV during construction works have not been reported in Armenia.
29. Work environment	B^-	D	B^-	D	**Construction stage:** There is a possibility of accident during the construction works. Special considerations to prevent and minimize the possibility by distribution safety goods and proper labor management are needed.
30. Accident	B^-	B^-	B^-	D	**Construction stage:** There is a possibility of accident during the construction works in and around the construction site. Warning by setting signboard for the surrounding people is needed. **Operation stage:**

Environmental parameter	Evaluation at Scoping		Evaluation based on survey result		Reason of evaluation
	Before and during construction	Operation stage	Before and during construction	Operation stage	
					There is a possibility of accident in and around the Reservoir. However, the potential is very limited.
31. Transboundary impact, climate change	D	C	D	B^+	**Construction stage:** Construction vehicles are operated, which bring about greenhouse gas emission, however, it is temporary and not huge scale. **Operation stage:** The Project proposes to shift from pump irrigation to gravity irrigation, which can contribute to reduction of greenhouse gas emission. Proposed water intake is very small compared with the total discharge of Hrazdan River. Moreover, area of Hrazdan River basin accounts for only 1% of the Araks River, an international river. Consequently, transboundary impact and climate change are not expected.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

5-1-8 Mitigation Measure

Taking into consideration expected environmental impacts discussed in previous sub-chapter, Environmental Management Plans (EMPs) showing mitigation measures by stage are proposed. Based on the EMPs, monitoring plans by stage and monitoring formats are also presented. In construction stage, mitigation measures will be mainly taken by the construction company, and PIU/SCWE will supervise the measures as planned in collaboration with the private consultant. The consultant will provide technical advices to the PIU/SCWE for the supervision. In the operation stage, instead of the PIU/SCWE, MNP will be responsible for supervision while WUA/WSA and MOA will implement take countermeasures. The EMPs during construction stage and operation stage are shown in Table 5-1-8.1 and Table 5-1-8.2, respectively.

Table 5-1-8.1 Environmental Management Plan (Construction Stage)

Environmental parameters	Mitigation measures	Responsible organization	Supervising agency	Cost
1. Air quality	• Regular check and full maintenance of construction vehicles • Water spray in and around entrances of construction sites to minimize dust generation and dust diffusion • Store and handle granular materials appropriately to limit dust (e.g. protect with tarpaulins) • Prohibit open burning of construction / waste material at the site	Construction contractor	PIU/SCWE and Consultant	Included in construction cost
2. Water quality	• Disposal of waste water from construction site and labor camp before discharge into rivers • Mud water treatment at the construction site before discharge to downstream	Construction contractor	PIU/SCWE and Consultant	Included in construction cost

Environmental parameters	Mitigation measures	Responsible organization	Supervising agency	Cost
	• Repair any damage to riparian areas, including river/canal banks and river/canal beds (if any), as soon as construction is complete			
3. Waste	• Reuse of excavated soil as other construction materials as much as possible • Store flammable waste (e.g. oil, fuel, spill contaminated soil, scrap, oiled clothes), construction and municipal waste separately • Sign contracts with licensed organizations specialized in the area of hazardous and municipal waste collection from the site, treatment/recycling or disposal	Construction contractor	PIU/SCWE and Consultant	Included in construction cost
4. Soil Contamination (oil leakages)	• Proper management of construction vehicles • Proper storage of all liquid materials and lubricants	Construction contractor	PIU/SCWE and Consultant	Included in construction cost
5. Noise and Vibration	• Setting of temporary enclosure • Minimize construction work during night time • Reduce vehicle speeds (stick to recommended speeds) in residential areas • Regular check and full maintenance of construction vehicles • Notify nearby residents and businesses at least 24 hours in advance if particularly noisy activities are anticipated • For workers noise levels shall be kept below 80 dB (A), wherever possible. In case of exceeding this value, hearing protections must be provided to workers	Construction contractor	PIU/SCWE and Consultant	Included in construction cost
6. Ecosystem	• Set-up 4 blocks of the Reservoir basin and start of construction works by block in order to secure enough time for the wildlife to evacuate themselves to outside of the Reservoir area • Confirmation of nature of poisonous snake identified in the Reservoir area, and awareness of the measure against the snake to the people	Construction contractor	PIU/SCWE and Consultant	Included in construction cost
7. Involuntary Resettlement/Land acquisition	• Preparation of an abbreviated RAP • Compensation to the affected persons and special considerations to the vulnerable people and affected persons who do not have legal status	Community concerned, PIU/SCWE	PIU/SCWE Yeghvard, Nor Yerznka Ashtarak communites and Consultant	Included in project cost
8. The poor	• Attention to the poor in the affected area	Community concerned, PIU/SCWE	PIU/SCWE Communites concerned and Consultant	Included in project cost
9. Livelihood economy	• Preparation of an abbreviated RAP • Compensation to the affected persons and special considerations to the vulnerable people and affected persons who do not have legal status	Community concerned, PIU/SCWE	PIU/SCWE Communites concerned and Consultant	Included in project cost
10. Existing social infrastructures and services	• Decentralization of construction vehicles as much as possible	Construction contractor	PIU/SCWE	Included in construction cost

Environmental parameters	Mitigation measures	Responsible organization	Supervising agency	Cost
11. Land use and local resource utilization	• Preparation of an abbreviated RAP • Compensation to the affected persons and special considerations to the vulnerable people and affected persons who do not have legal status	Community concerned, PIU/SCWE	PIU/SCWE Communites concerned and Consultant	Included in project cost
12. Working environment	• Compliance with labor law and proper labor control • Proper management of sanitary conditions for labors, including hand-washing facilities and rest rooms • Provision of special uniforms, helmets, masks , goggles and so on • Preparation of first aid kits • Instruction for workers on health and safety practices	Construction contractor	PIU/SCWE	Included in construction cost
13. Accidents	• Proper management of construction vehicle operation to minimize centralization • Identify nearby medical centers to secure urgent health care for injured workers • Instruction on compliance with prescribed routes, speed, to drivers of construction vehicles • Health examination of drivers initially and periodically	Construction contractor	PIU/SCWE	Included in construction cost
14. Historical and cultural monuments	• Implementation of Chance Find Procedure and training of the construction workers • Report to the Ministry of Culture of RA, Department Protection of Monuments and Historical Sites, in case of cultural asset detection	Construction contractor	PIU/SCWE, Ministry of Culture	Included in construction cost

Table 5-1-8.2 Environmental Management Plan (Operation Stage)

Environmental parameters	Mitigation measures	Responsible organization	Supervising agency	Cost
1. Waste by tourists when restaurants and shopd are constructed around the Reservoir	• Proper disposal of waste based on the regulation regarding waste	Owners of shops and restaurants	WSA	Shouldered by the owners of restaurant and shop
2. Soil contamination due to improper agrichemical application	• Further promotion of proper application of pesticides/insecticides • Enhancement control of illegal pesticide/insecticide • Establishment of monitoring system of pesticides/insecticides in water, soil and crops	MOA	MNP	Within budget for routine work
3. Ground water pollution due to excessive fertilizer application	• Promotion of proper application of fertilizers in accordance with the application standard in Armenia	MOA	MNP	Within budget for routine work
4. Impact on fish ecosystem due to water diversion for the Yeghvard Reservoir	• Compliance with minimum discharge/ecological flow for ecosystem conservation in Hrazdan River	WUA & WSA	MNP	Within budget for routine work

5-1-9 Monitoring Plan

In the process of implementation of EMP, regular monitoring is necessary. The monitoring results will be complied as a monitoring report by the responsible organization for mitigation measurement implementation using the proposed monitoring formats below. Based on the proposed monitoring indicators in the formats, it is needed to implement monitoring. In addition, it is important to record how the implementation agency took measures against any problems in the process. The report should be submitted to the supervising agency regularly. The proposed monitoring structure by stage is illustrated in Figure 5-1-9.1.It is noted that the mitigation measures or considerations for 1) Involuntary and land acquisition, 2) The poor, 3) Land use and local resource utilization, and 4) Livelihood /local economy are discussed in Chapter 5-2 in detail, and the proposed monitoring structure for those matters in the sub-chapter.

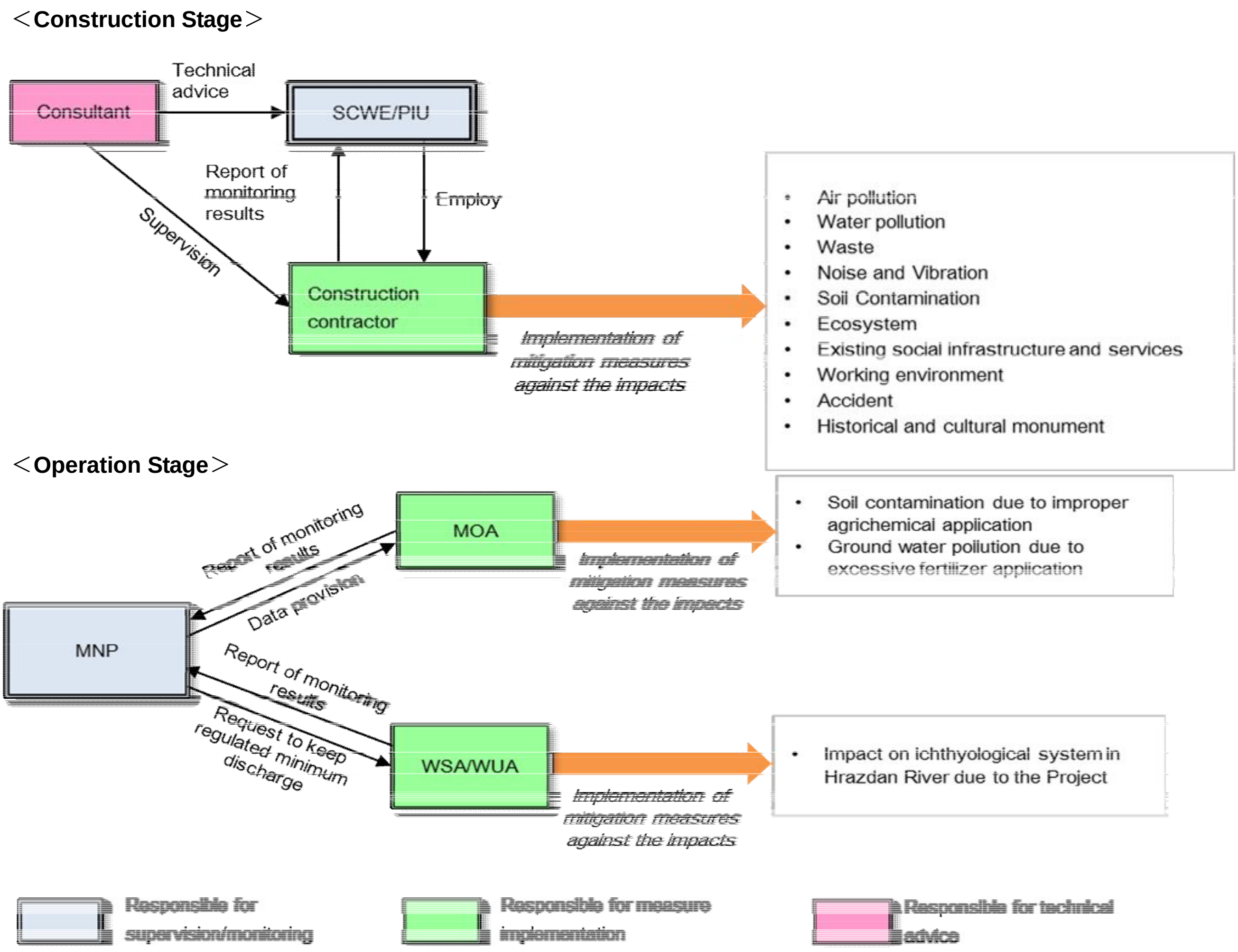


Figure 5-1-9.1 Proposed Structure for EMP Implementation and Monitoring

The monitoring plans during construction stage and operation stage are shown in Table 5-1-9.1 and Table 5-1-9.2, respectively. Draft monitoring forms during construction stage and operation stage are described in Table 5-1-9.3 and Table 5-1-9.4, respectively.

Table 5-1-9.1 Monitoring Plan (Construction Stage)

Environmental Parameter	Monitoring Item	Survey point	Standard	Frequency	Responsible Organization
1. Air quality	Dust, NO_2, CO and SO_2	At construction site and Nor-Yerznka Community	Mean daily concentration Dust:<15mg/m^3	Once per month	PIU/SCWE and Consultant

Environmental Parameter	Monitoring Item	Survey point	Standard	Frequency	Responsible Organization
		(measurement points are No 1, 2, 3, and 5 in Figure 5-1-6.1)	NO_2:<0.04 mg/m^3 CO:<3.0 mg/m^3 SO_2:<0.05 mg/m^3		
2. Water quality (mud water)	Suspended Solid (SS)	1) Outlet point from the Outlet Canal 2 to the Kasakh River 2) Outlet point from the Outlet Canal 1 to the Arzni Branch Canal	SS<30 mg/l	Once per month	PIU/SCWE and Consultant
3. Noise and vibration	Noise (dB)	At Yeghvard city and Nor Yerznka community (measurement points are No.4 and No.5 in Figure 5-1-6.4)	Allowable noise level in accordance with Armenian Norm	Once per month	PIU/SCWE and Consultant
4. Waste	Conditions of reuse of excavated soil and classification, proper disposal of garbage by field observation	At construction site and labor camp	-	Once per month	PIU/SCWE and Consultant
5. Soil contamination	Oil leakage	At construction site	-	Once per month	PIU/SCWE and Consultant
6. Ecosystem	• Sequential construction works by block • Number of accident by poisonous snakes	At the reservoir	-	• Once (when sequential construction is practiced) • As required	PIU/SCWE and Consultant
7. Involuntary Resettlement/L and acquisition*	Payment (before construction) Number of complaints and frequency	In Yeghvard community, Nor -Yerznka community and Ashtarak community	-	Quarterly before construction and yearly in construction stage	PIU/SCWE and Consultant
8. The poor*	Payment (before construction) Number of complaints and frequency	In Yeghvard community, Nor -Yerznka community and Ashtarak community	-	Quarterly before construction and yearly in construction stage	PIU/SCWE and Consultant
9. Livelihood/local economy*	Number of complaints and frequency	In Yeghvard community, Nor -Yerznka community and Ashtarak community	-	Quarterly before construction and yearly in construction stage	PIU/SCWE and Consultant
10. Existing social infrastructures and services (traffic jam)	• Conditions of traffic jam by field observation • Complaint from the residents	Around construction site	-	Once per month	PIU/SCWE
11. Land use and local resource utilization*	Number of complaints and frequency	In Yeghvard community, Nor -Yerznka community and Ashtarak community	-	Quarterly before construction and yearly in construction	PIU/SCWE and Consultant

Environmental Parameter	Monitoring Item	Survey point	Standard	Frequency	Responsible Organization
				stage	
12. Safety/Working environment	Safety and working environment by field inspection	At the construction site	-	Once per month	PIU/SCWE
13. Accident	Number of accident	In and around the construction site	-	Every time any accidents are caused	PIU/SCWE
14. Historical and cultural monuments	Number of discovered historical and cultural assets	In and around the construction site	-	When any cultural assets are uncovered	PIU/SCWE and Consultant

*Detailed monitoring plan for parameters of No.7, No.8, No.9 and No.11 are described in Chapter 5-2.

Table 5-1-9.2 Monitoring Plan (Operation Stage)

Environmental Parameter	Monitoring Item	Survey point	Standard	Frequency	Responsible Organization
1. Waste	• Proper disposal of garbage by field observation	Around the Reservoir	-	Once per 3 months	WSA
2. Soil contamination	• Check of sale conditions of pesticide and insecticide at retailers • Check of application method of pesticide and insecticide by the farmers • Establishment of monitoring system residual pesticide/ insecticide in water/soil/crops	At the project target communities	-	Once per 3 months	MNP
3. Ground water	• Check of application method of fertilizers by the farmers	At the project target communities		Once per 3 months	MNP
4. Impact on fish ecosystem due to water diversion for the Yeghvard Reservoir	Confirmation of river water discharge	At discharge observatory stations	-	3 times per year	MNP

Due to implementation of the abbreviated RAP, it is possible to mitigate expected impacts described in No.7, No.8, No.9 and No.11 in Table 5-1-9.1. Therefore, monitoring indicators for those matters can be set as “number of complaint by the affected persons” and “how the implementation agency (the Government of Armenia) takes measures against complaints” as mentioned in Table 5-1-9.3.

Table 5-1-9.3 Draft Monitoring Form (Construction Period)

(1) Response and actions by the government

Comments and response	Monitoring results
Number and contents of comments from the people	
Number and response to the comments from the government	

(2) Pollution

Environmental Parameter	Monitoring Item/standard	Measured value (min)	Measured value (max)	Survey point	Frequency
Air quality	Mean daily concentration Dust:<15mg/m^3 NO_2:<0.04 mg/m^3 CO:<3.0 mg/m^3 SO_2:<0.05 mg/m^3			At construction site and Nor-Yerznka Community (measurement points are No 1, 2, 3, and 5 in Figure 5-1-6.1)	Once per month
Water quality	SS<30mg/l			1) Outlet point from the Outlet Canal 2 to the Kasakh River 2) Outlet point from the Outlet Canal 1 to the	Once per month

Environmental Parameter	Monitoring Item/standard	Measured value (min)	Measured value (max)	Survey point	Frequency
				Arzni Branch Canal	
Noise and vibration	Complaint from the people			At Yeghvard city and Nor Yerznka community (measurement points are No.4 and No.5 in Figure 5-1-6.4)	Once per month
Soil contamination	Oil leakage			Construction site	Once per month

(3) Natural Environment

Environmental Parameter	Monitoring indicator	Monitoring results	Measures taken
Waste	• Waste classification • Waste permission by the MNP • Waste disposal point		
Ecosystem	• Whether Reservoir construction by bloc is implemented or not		

(4)Social Environment

Environmental Parameter	Monitoring indicator	Monitoring results	Measures taken
Existing social infrastructures and services	• Traffic conditions • Complaint from the people		
Historical and cultural monuments	• Whether Historical and cultural monuments are discovered		
Accident	Number of incidence		

Table 5-1-9.4 Draft Monitoring Form (Operation Period)

(1) Response and actions by the government

Comments and response	Monitoring results	Measures taken	Frequency
Number and contents of comments from the people			
Number and response to the comments from the government			

(2) Natural Environment

Environmental Parameter	Methodology	Monitoring results	Measures taken	Frequency
Waste	Regular monitoring by field observation			
Soil contamination by illegal agrichemical application in the beneficial area	Regular monitoring activities by the MOA for control of illegal agrichemical sale			
Pollution of groundwater by excessive fertilizer application in the beneficial area	Regular monitoring activities by the MNP			
Keeping ecological minimum discharge of Hrazdan River to minimize impact on eco-system	Water distribution by WSA and WUA			

5-1-10 Stakeholder Meeting

According to the JICA Guidelines, it is needed to organize a series of Stakeholder Meeting, and the necessary procedure and purpose are almost same as those in Armenia. Therefore, the Public Hearing can be regarded as Stakeholder Meeting. Based on the Law on Environmental Impact Assessment and Expertise, the 1st Public Hearing was organized at Scoping stage.

The 2nd Public Hearing on the Draft ESIA Report will be held when the Draft Final Report is submitted to the Government of Armenia. Apart from those hearing, Public Seminars to introduce the Project outline and expected environmental impact by the Project were also organized. The detailed discussion results are described in Chapter 5-2-10.

5-2 Involuntary Resettlement and Land Acquisition

5-2-1 Necessity of Resettlement and Land Acquisition

Due to the proposed facility to be constructed, land acquisition will be cause. Figure 1-4.1 illustrates anticipated affected areas.

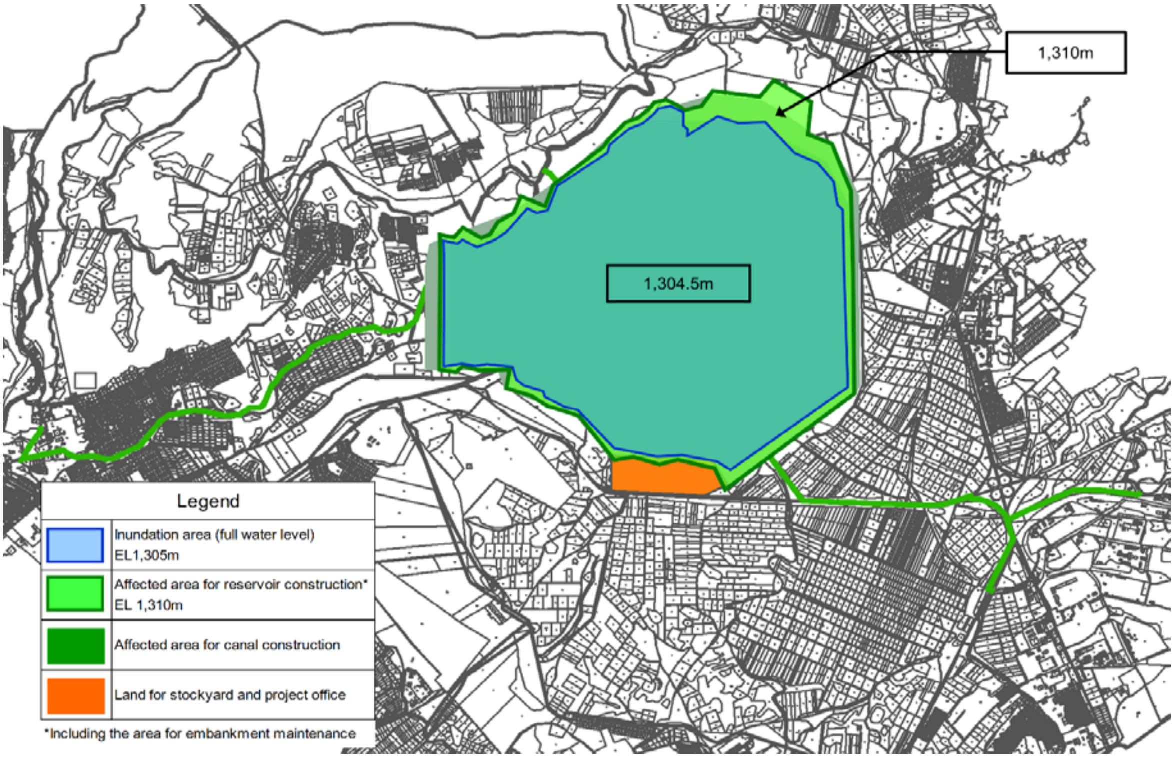


Figure 5-2-1.1 Anticipated Project Affected Area

While physical relocation will not be caused by the Project, land acquisition will be caused due to construction of the Reservoir and irrigation canals. Especially, the permanent land acquisition of 808ha is needed for construction of the Reservoir and Feeder Canal 2. On the other hand, concerning the area for Feeder Canal 1 and Outlet 1~2, the impacts are temporary during the construction period, since those canals are planned to be pipeline. However, there are some orchard plots and perennial grazing lands, they can be affected by the construction works even though the works are temporary.

5-2-1-1 Examination of Two Candidate Routes for Outlet Canal 2

At initial stage of the Survey, there were two options for the Outlet Canal 2 to divert water from the Reservoir to the Kasakh River, namely, 1) one route which passes through the orchard area, and 2) another route which passes through the natural flow. Finally, the second option, which can cause less impact in terms of land acquisition than the other route, was proposed. The detailed comparison of those two options is mentioned in Chapter 5-1-4-5.

5-2-1-2 Examination of Options to Minimize the damage to the Orchard

At the north-east of the Dike 1, a big scale of orchard with 24 ha area is located. According to the proposed project plan, approximately half of the orchard (11.4ha) will be submerged. Therefore, two options, namely, a) compensation for the damaged orchard and b) protection for the orchard by extension of Dike 1, are compared in terms of cost. Figure 5-2-1.3 shows the comparision result. Cost of compensation to the affected orchard is 17.7 million USD, which is much lower than that of dike extension, with 25.1 million USD. Therefore, it is concluded that extension of the Dike 1 is not applied.

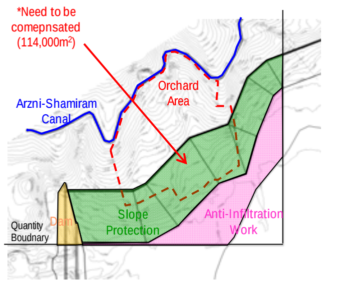
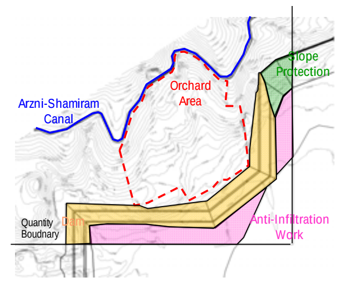
			Plan A (Compensation area is Maximum)						Plan B (Compensation area is Nil)					
Outline														
Compensation fee			Area/Volume (m^2/m^3)			Unit Cost (USD)		Sub Total (USD)	Area/Volume (m^2/m^3)			Unit Cost (USD)		Sub Total (USD)
		Tree loss	114,000	m^2	x	0.18	=	20,520	0	m^2	x	0.18	=	0
		Land loss	114,000	m^2	x	0.60	=	68,400	0	m^2	x	0.60	=	0
Construction Cost	Slope Protection	Small Dike	10,000	m^3	x	33.14	=	331,400	990	m^3	x	33.14	=	32,809
		Slope protection	314,000	m^2	x	14.31	=	4,493,340	27,000	m^2	x	14.31	=	386,370
	Anti Infiltration Work		154,000	m^2	x	14.31	=	2,203,740	170,000	m^2	x	14.31	=	2,432,700
	Dam	Core	59,000	m^3	x	4.56	=	269,040	375,000	m^3	x	4.56	=	1,710,000
		Filter	5,700	m^3	x	11.52	=	65,664	31,000	m^3	x	11.52	=	357,120
		Surface Protection	7,700	m^3	x	33.14	=	255,178	57,000	m^3	x	33.14	=	1,888,980
		Sand-and-Gravel	130,000	m^3	x	4.91	=	638,300	919,000	m^3	x	4.91	=	4,512,290
		Sand-and-Gravel (Dam Crest)	1,500	m^3	x	4.91	=	7,365	7,900	m^3	x	4.91	=	38,789
		Scoria (Dam Crest)	240	m^3	x	4.91	=	1,178	1,300	m^3	x	4.91	=	6,383
		Counter Weight	7,100	m^3	x	3.83	=	27,193	49,095	m^3	x	3.83	=	188,032
		Stripping	14,000	m^3	x	3.98	=	55,720	87,000	m^3	x	3.98	=	346,260
	Direct Construction Cost							8,348,118						11,899,733
	InDirect Cost (111% of Direct Cost)							9,266,411						13,208,704
	Sub Total							17,614,529						25,108,437
Total	(USD)							17,703,449						25,108,437
	(Million USD)							**17.7**						**25.1**

Figure 5-2-1.2 Comparison of Options to Minimize Damage to the Orchard

5-2-2 Legal and Administrative Framework

5-2-2-1 National Regulations Related to Resettlement and Land Acquisition

The Constitution of Armenia (2015) guarantees protection of ownership rights and provides that the ownership may be terminated in exclusive cases of land acquisition based on an established legislation with prior equivalent compensation for public and state interest. Land acquisition and compensation cases are envisaged in Land Code of the Articles 102 and 104, the RA Civil Code (1998), and Articles 218 to 221 of Armenian Law “On the Alienation of the Private Property for Public and State Needs” adopted on 27 November 2006. The Law was amended on 21 June 2014. Under the existing laws, the Armenian Government will issue a Decree determining the case of exclusive public and state priority needs based on the request from relevant state agencies.

Law of Armenia “On the Alienation of the Private Property for Public and State Needs” specifies the land acquisition procedures, compensation rights of titled landowners and owners of immovable property in cases of alienation of their property for public purposes. Upon enactment of the government decree on recognition of property as prevailing exclusive public interest, the authorized body shall compile minutes describing the alienated property according to the procedure, public interest requiring property alienation, deadlines defined by the government; Acquiring party, owners and those holding property rights towards the alienated property are to be compiled. Assessment of the real estate or the real estate rights shall be made in accordance with the procedure defined under the Act of the Armenia on Assessment of Real Estate in Armenia adopted in October 4, 2005. The list of main laws related to land acquisition in Armenia is shown in Table 5-2-2.1.

Table 5-2-2.1 Main Laws on Land Acquisition in Armenia

Adaption/ Amended	No. of the Law	The name of Laws (in English)
1995/ 2015	－	The Constitution of the Republic of Armenia
1998	No 1998/17	The Civil Code of the Republic of Armenia
1998	No 1988/20	The Code of Civil Procedure
2001	No 2001/17	The Land Code of the Republic of Armenia
2005	No 2005/71	The Law on Real Estate Valuation Activity
2006	No 2006/64	The Law on Alienation of Property for the Needs of Society and State
2007	No 2007/64	The Code of Administrative Procedure

5-2-2-2 JICA Guidelines on Resettlement and Land Acquisition

On the JICA Guidelines for Environmental and Social Considerations (hereinafter, "JICA Guidelines"), Resettlement and Land Acquisition are regulated as followings;

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost[1] as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

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[1] Description of "replacement cost" is as follows.

Land	Agricultural Land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and other Structures	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the Project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

XI. Eligibility of Benefits include, the PAPs (Project Affected Persons) who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based

XIII. Provide support for the transition period (between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

5-2-2-3 GAP Analysis between JICA Guidelines/ WB OP.4.12 and Armenian Legislation

Gaps between JICA Guidelines/ WB OP.4.12 and the laws on Armenia in terms of resettlement and land acquisition are analyzed as shown in Table 5-2-2.2.

Table 5-2-2.2 Gap Analysis between the Armenian Law and JICA Guidelines/ WB OP.4.12

No.	JICA Guideline/ WB O4.12	Armenian National Legislation	Gaps	Measure to fill the gaps
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives (JICA GL)	The Article 4 of the "Armenian Law on Alienation of the property for public and state needs" (hereinafter mentioned as "the Land Alienation Law") sets that "The public interest should have higher priority than the interest of the proprietor of the alienated property". However, on the social norms, involuntary resettlement and losing livelihood should be avoided as much as possible.	None	-
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken (JICA GL)	The Article 11 on "the Land Alienation Law" sets the principle to compensate at market price of property plus 15% (= full replacement cost) for losses caused by involuntary property acquisition. The financial duties (taxes, fees, mandatory payments) related to property alienation are compensated by the acquirer.	None	-
3	People who must be resettled involuntarily and	According to the Article 11 of "the Land Alienation Law", "the compensation is	None	-

No.	JICA Guideline/ WB O4.12	Armenian National Legislation	Gaps	Measure to fill the gaps
	people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels (JICA GL)	based on market price plus 15%. It can be regarded that it is to restore Project Affected Persons (PAPs)' living standard to pre-project levels.		
4	Compensation must be based on the full replacement cost as much as possible (JICA GL)	As mentioned above, the compensation is based on the market price plus 15% of the alienated property.	None	-
5	Compensation and other kinds of assistance must be provided prior to displacement (JICA GL)	In the Clause 2, Article 3 of "the Land Alienation Law", adequate compensation for the alienated property is to be given at initial stage. Compensations is provided prior to displacement and property alienation.	None	-
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public (JICA GL) For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	"The Land Alienation Law" does not set legal provision to elaborate the resettlement action plan.	It is not necessary to prepare RAP in Armenia.	Abbreviated RAP is to be prepared.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance (JICA GL)	There are no clear legal requirements to hold consultations with the affected population for resettlement and property alienation in the National Legislation.	There is no provision about preparation or RAP and consultations.	In the process of RAP preparation, it is needed to organize consultations with the PAPs.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people (JICA GL)	According to the Articles 3 and 4 of the Armenian Law on Language, all the official notifications within the land acquisition process should be proceed in Armenian Language. Public discussions should be held in Armenian language. For the ethnic minority groups, most of them can communicate in Armenian language without difficulty. Those who can understand Armenian language in the minority groups can support the PAPs in their own language.	None	-
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans (JICA GL)	There are no clear legal requirements to assure participation of affected people in RAP planning, implementation and monitoring in the National Legislation. However, at the consultation meeting in the planning process, it is possible for the PAPs to join.	There is no mention about partition of affected people into RAP preparation, implementation and monitoring.	In the consultation and monitoring process, it is proposed to involve representative of PAPs.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities (JICA GL)	Article 9 of "the Land Alienation Law" sets provisions to establish grievance mechanisms. Affected population with legal ownership have the rights to appeal the Government decisions on evaluation of properties to be	No grievance system except for complaint about property evaluation result is established in the	An accessible grievance system for the PAPs should be established.

No.	JICA Guideline/ WB O4.12	Armenian National Legislation	Gaps	Measure to fill the gaps
		alienated. However, the grievance opportunity for PAPs is limited to submission of appellation for the preliminary investigation of the property. For the other issues (stages) appropriate and accessible grievance mechanisms are not established.	National Regulation.	
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits (WB OP4.12 Para.6)	As stated in the Clause 2, Article 7 of the RA Law "the Land Alienation Law", identification of affected people (property holders) and assets is to be done at the preliminary stage. There is no provision for cut-off date and socioeconomic survey.	There is no provision for cut-off date. There is no mention about socioeconomic survey implementation.	Cut-off date cannot be set at Feasibility Stage (F/S) stage. However, it can be set at Detailed Design (D/D) stage after concluding Loan Agreement. Socioeconomic survey and census survey targeting the PAPs should be implemented at early stage of the Project. In this F/S stage, socioeconomic survey and census survey to identify the PAPs were carried out, even though it was not official.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying (WB OP4.12 Para.15)	It clearly fixed in the Clause 6, Article 11 of "the Land Alienation Law" that compensation is provided only for property owners with legal status.	In the Armenian legislation, only legal property owners are eligible for compensation.	Compensation for land loss cannot be provided to the PAPs who do not have legal status. However, they will be provided with special consideration by the Project to mitigate the impact. Compensation for tree loss should be paid to all PAPs, regardless of legal status.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based (WB OP4.12 Para.11)	The compensation strategy set by the national legislation (Article 11 of "the Land Alienation Law") includes only cash compensation regardless of livelihood and other social characteristics of the displaced people. Evaluator with license estimates the market price of land to be acquired including the land productivity.	Cash compensation for properties is principle in Armenia.	Cash compensation for land loss considering the land productivity is to be provided.
14	Provide support for the transition period (between displacement and livelihood restoration) (WB OP4.12 Para.6)	The national legislation does not envisage support for the transition period.	There is no mention in Armenian Legislation.	The Project will not cause physical relocation of local residents. Cash compensation for the land loss considering the land productivity is to be provided.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	The National legislation does not set legal mechanisms to pay particular attention to the vulnerable groups of people.	There is no mention in Armenian Legislation.	Special consideration to the vulnerable people should be paid.
16	When impacts on the entire	The National legislation does not	There is no	The number of PAPs

No.	JICA Guideline/ WB O4.12	Armenian National Legislation	Gaps	Measure to fill the gaps
	displaced population are minor, or fewer than 200 people are displaced, abbreviated resettlement plan is to be prepared (WB OP4.12 Para.25).	envisage preparation of abbreviated resettlement action plans.	mention in Armenian Legislation for RAP.	to be relocated is nil, therefore, an abbreviated RAP preparation is necessary (instead of full RAP) for the Project.

5-2-2-4 Policy for Resettlement and Land Acquisition on the Project

The policy for Resettlement and Land Acquisition on the Project was proposed as followings;

I. The Government of Armenia will use the Project Resettlement Policy (the Project Policy) for the Yeghvard Irrigation System Improvement Project specifically because existing national laws and regulations have not been necessarily designed to address involuntary resettlement according to international practice, including, JICA's policy. The Project Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to rehabilitation themselves to at least their pre-project condition. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between the Armenian legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consist with Government practices and JICA's Policy.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the Project area.

III. Where displacement of households is unavoidable, all PAPs (including communities) losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions.

IV. Compensation and rehabilitation support will be provided to legal PAPs, that is, any person or household or business which on account of project implementation would have his, her or their:

- Standard of living adversely affected;
- Right to use any land (including premises, agricultural and grazing land, right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or proceeded, temporarily or permanently;

V. All affected people with legal status will be eligible for compensation and rehabilitation assistance, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above. In case of affected people without legal status will be eligible for considerations/supports to restore the current livelihood.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process.

VII. People temporarily affected are to be considered as PAPs and resettlement plans address the issue of temporary acquisition.

VIII. The resettlement plans will be designed in accordance with the Laws related to resettlement and land acquisition and JICA's Policy on Involuntary Resettlement.

IX. The Resettlement Plan will be translated into local languages and disclosed for the reference of PAPs as well as other interested group.

X. Payment for land and/or non-and assets will be based on the principle of replacement cost.

XI. Compensation for PAPs dependent on agricultural activities will be paid by cash based on the laws in Armenia. The cost estimation of the compensation shall be done in accordance with the laws in Armenia.

XII. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly, and disabled) and ensure they are provided with special consideration in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socioeconomic status.

XIII. PAPs will be involved in the process of developing and implementing resettlement plans.

XIV. PAPs and their communities will be consulted about the Project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the rescissions that are made concerning their resettlement.

XV. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period. The funds for all resettlement activities will come from the Armenian Government.

XVI. Acquisition of assets, payment of compensation, and resettlement and start of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. (Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.)

XVII. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

XVIII. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the resettlement management system. Consultant will be hired to provide technical advices for the implementation agency during construction period.

Cut-off-date of Eligibility

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the Project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements. In the Project, after the loan agreement between the Government of Armenia and Government of Japan, namely, detailed design stage, cut-off date will be declared. This date will be disclosed to each affected village by the relevant local governments and the villages will disclose to their populations. The establishment of the eligibility cut-off date is intended to prevent the influx of ineligible non-residents who might take advantage of Project entitlements.

Principle of Replacement Cost

All compensation for land and non-land assets owned by households/shop owners who meet the cut-off-date will be based on the principle of replacement cost. Replacement cost is the amount calculated before displacement which is needed to replace an affected asset without depreciation and without deduction for taxes and/or costs of transaction as follows:

a. Productive Land (agricultural, aquaculture, garden and forest) based on actual current market prices that reflect recent land sales in the area and the price is evaluated by the professional land evaluator with license. Plus, 15% of the market values shall be included in the compensation fee.

b. Residential land based on actual current market prices that reflect recent land sales, plus, 15% of the market values shall be included in the compensation fee.

c. Existing government regulations for compensation calculations for building, crops and trees, "The Law on Alienation of Property for the Needs of Society and State" will be used where ever available. If the law does not cover properties to be affected, "Resettlement Policy Framework", which has been agreed between the Government of Armenia and ADB can referred.

d. Annual crops equivalent to current market value of crops at the time of compensation;

e. For perennial crops, cash compensation at replacement cost that should be in line with methods applied by ADB, if available, is equivalent to current market value given the type and age at the time of compensation.

5-2-3 Scope of Resettlement

5-2-3-1 Population Census Survey

The population census survey to identify PAPs was carried out in Yeghvard city, Nor-Yerznka village, and Ashtarak city, from March to April in 2016, based on the official cadastral map provided by State Committee of Real Estate Cadastral. However, it was found some illegal land users, who have cultivated in state and community lands to be affected.

(1) Illegal land users of the Project affected area for irrigation canals

In the Project, two feeder canals and two outlet canals area proposed to construct. Feeder Canal 1. Feeder Canal 2, and Outlet Canal 1 are planned to construct in Yeghvard city. There is no illegal land users in the area.

On the other hand, there are 7 illegal land users (households) with 44 family members in total in the area for Outlet Canal 2 in Nor-Yerznka village.

(2) Illegal land users of the Project affected area for the Reservoir

In the Reservoir basin, all of the illegal land users are not identified[2]. On the other hand, 53 plots under cultivation were identified within the Reservoir basin. JICA Survey Team made a survey with the local farmers to identify the cultivated plots within the Reservoir basin. As a results, 53 plots were identified. Remaining parts are natural grazing land and infertile area[3]. Therefore, it is assumed that there are 53 Project Affected Households (PAHs) in maximum, if each household cultivates one plot. According to the socioeconomic survey, the number of family members in average is 5.59 person. Then, the number of PAPs of illegal land users within the Reservoir basin can be calculated by multiplying 5.59 persons and 53 PAHs. Accordingly, it is 296 persons.

(3) Labors for cultivation within the Reservoir basin

According to the interview to one cultivator who cultivates hiring labors within the Reservoir basin. The illegal land users cultivate 1.0 ha hire labors for 4 days per year in usual. And the labors work 4 hours per day. The main works of labors are followings;

1) Plowing; 40,000 AMD/ha (including salary of labor, and rental fee for a tractor)

[2] The detailed information about the illegal land users who have cultivated within the Reservoir basin is mentioned later (see, "3-3 Socioeconomic Survey").
[3] JICA Survey Team carried out the field survey in the Reservoir basin to identify the cultivated plots, cultivated crops, and are of each cultivated plot.

2) Seeding; 10,000 AMD/ha

3) Watering; 10,000 AMD/ha

The illegal land users within the Reservoir basin hire one (1) labor for one (1) day per year, since the different labors are hired depending on the works. Some labors take on works outside of the Reservoir basin by using their own tractor, and some of them have their own farm lands. From those conditions, it can be said that the labors does not reply on the wage of works within the Reservoir basin significantly.

According to the interview, the relationship between the illegal land user and labors is not dense each other. Then, illegal land user do not have the contact number of the labors. For these reasons, there is no serious impact on the labors who are hired by illegal land users within the Reservoir basin. Thus, such labors are not included to PAPs, in the Project.

(4) Total number of PAPs

Physical relocation in the Project affected area is not required. And Table 5-2-3.1 shows the number of PAHs and PAPs counted with 418 PAPs in 75 PAHs.

Table 5-2-3.1 Numbers of PAHs and PAPs

Type of loss	No. of PAHs			No. of PAPs		
	Legal	Illegal	Total	Legal	Illegal	Total
1. Required for physical relocation						
1-1. HH (Structure owner on Gov. land)	Nil	Nil	Nil	Nil	Nil	Nil
1-2. HH (Structure owner on Private land)	Nil	Nil	Nil	Nil	Nil	Nil
1-3. HH (Tenants)	Nil	Nil	Nil	Nil	Nil	Nil
1-4. CBEs (Structure owner on Gov. land)	Nil	Nil	Nil	Nil	Nil	Nil
1-5. CBEs (Structure owner on Private land)	Nil	Nil	Nil	Nil	Nil	Nil
1-6. CBEs (Tenants)	Nil	Nil	Nil	Nil	Nil	Nil
1-7. Community owned structures including physical cultural resources	Nil	Nil	Nil	Nil	Nil	Nil
Sub-total (1)	Nil	Nil	Nil	Nil	Nil	Nil
2. Not required for physical relocation						
2-1. State or Community owned land[4]	-	60	60	-	340	340
1) Canal area	-	7	7	-	44	44
2) Reservoir area	-	53	53	-	296	296
2-2. Private owned land	15	-	15	78	-	78
1) Canal area	12	-	12	64	-	64
2) Reservoir area	3	-	3	14	-	14
2-3. Labor*	-	-	-	-	-	-
Sub-total (2)	15	60	75	78	340	418
Total (Sub-total 1~2)	15	60	75	78	340	418

Source) JICA Survey Team, March-April of 2016
Remarks) 1. In the Project, farming labors are not included to PAPs.
2. CBEs; Commercial and Business Enterprises

(5) Cut-off date

The cut-off-date has not been declared at F/S stage, since the Project follow the general way of Armenia, namely, the cut-off date is established and declared at D/D stage. However, the PAPs have been already identified by the census survey and socioeconomic survey at F/S stage. In the D/D stage, cut-off date should be established on the first date of final census survey and declared to all PAPs in advance, to prevent new residents' influx to the Project affected area. For evidences, it is proposed to take pictures of the Project affected area and PAPs before several days from cat-off date.

Information and data about the PAPs during F/S stage will be used at D/D stage. The results of census

[4] If the illegal users have cultivated one plot, there would be 53 illegal land users in maximum. Hence, the number of affected households are assumed as 53 households. In addition, according to the socioeconomic survey, the average number of family members in the Project affected area is 5.59 person. Then, the number of PAPs of illegal land users within the Reservoir area is assumed approximately 296 persons.

survey should be updated, since the situation of the Project affected area will be changed. According to the WB OP.4.12, the census survey must be carried out again, if the land acquisition has not conducted within two years from the last census survey. However, there is no regulation about such issue on the law of Armenia. Thus, it is proposed that the Project follows the regulation of WB OP.4.12, that is; the effective period of census survey is two years. It is planned to take 14 months for D/D stage, and cut-off date will be declared around 9th month of D/D stage[5].

5-2-3-2 Assets and Lands Survey

For construction irrigation canals and the Reservoir, temporary or it is needed permanent land acquisition. The results of surveys of asset and land in the Project area are shown below.

(1) Project affected area

In the Project affected area, land ownerships are classified into three categories, namely a) State Lands, b) Communal Lands of Yeghvard city and Nor-Yerznka village, and c) Private Lands. The total Project affected area is 819.36 ha. And the area affected by construction of the Reservoir is 792.48 ha, which accounts for 97 % of the Project affected area.

Table 5-2-3.2 Project Affected Area by Land Ownership

Category	Plots	Affected Area (ha)
1) State	2	54.49
2) Community	77	738.94
3) Private	25	25.93
Total	104	**819.36**

Source) JICA Survey Team, March-April of 2016

1) State owned lands

Table 5-2-3.3 shows the land use of State owned, which utilize agriculture mostly.

Table 5-2-3.3 Project Affected Area (State Owned)

No.	Land Use	Affected Area (ha)
1	Agricultural	54.42
2	Other	0.07
Total		54.49

Source) JICA Survey Team, March-April of 2016

2) Community owned lands

Table 5-2-3.4 shows the land use of Community owned, which belongs to Yeghvard city mostly.

Table 5-2-3.4 Project Affected Area (Community Owned)

No.	Location	Land Use	Affected Area (ha)
1	Yeghvard city	Agricultural	705.66
2		Residential	0.00
3		Industrial	0.00
4	Nor-Yerznka village	Agricultural	27.89
5		Residential	3.47
6		Industrial	0.00
7	Ashtarak city	Agricultural	0.00
8		Residential	1.92
9		Industrial	0.00
Total			**738.94**

Source) JICA Survey Team, March-April of 2016

5 Detailed schedule is mentioned in Chapter 5-2-7.

3) Private owned lands

Table 5-2-3.5 shows the land use of Private owned, of which total affected area of private lands in 25.93 ha. Especially, the agricultural lands will be affected by the Project. Furthermore, Nor-Yerznka village will be the most affected among the three (3) communities concerned. The Project affected are in Nor-Yerznka village is 14.44 ha with 56 % of total.

Table 5-2-3.5 Project Affected Area (Private Owned)

No.	Location	Land Use	Affected Area (ha)
1	Yeghvard city	Agricultural	10.05
2		Residential	0.00
3		Industrial	0.00
4	Nor-Yerznka village	Agricultural	14.24
5		Residential	0.20
6		Industrial	0.00
7	Ashtarak city	Agricultural	0.00
8		Residential	0.54
9		Industrial	0.90
Total			**25.93**

Source) JICA Survey Team, March-April of 2016

(2) Project affected buildings

While the Project affected area involves some industrial and residential lands on the cadastral map. The proposed facilities are designed not to cause relocation of existing buildings. Therefore, physical relocation of buildings will not be occurred.

(3) Project affected trees

Table 5-2-3.6 shows the number of Project affected trees by species. Totally, 4,855 trees will be affected by the Project.

The Reservoir basin includes a private orchard, which has 3,003 pear and 200 apple trees. As mentioned at section 1-4 (2), comparison study it was examined comparison study between loss of this orchard, and the design changing. As a result, it is required those trees should be include in the compensation to the Project.

Table 5-2-3.6 Number of Project Affected Trees

No.	Location	Ownership	Species	Total
1	Yeghvard city	Private owned	Apple	350
2	Nor-Yerznka village	Community owned (illegal land users)	Apricot	30
3			Apple	56
4			Bird cherry	19
5			Cherry	51
6			Hazelnut	9
7			Mulberry	5
8			Nuts	52
9			Oleaster	1
10			Peach	15
11			Pear	12
12			Plum	19
13		Private owned	Apricot	41
14			Apple	763
15			Bird cherry	21
16			Cherry	24
17			Grapevines	90
18			Hazelnut	1
19			Nuts	88
20			Peach	59
21			Pear	3,003
22			Plum	146
Total				4,855

Source) JICA Survey Team, March-April of 2016

(4) Project affected cultivation areas

Table 5-2-3.7 shows 3.67 ha of cultivated area affected by irrigation canal construction. The Project affected crops which belong to privates.

Table 5-2-3.7 Project Affected Cultivated Areas by Construction of Irrigation Canals

No.	Location	Ownership	Species	Total
1	Yeghvard city	Private owned	Wheat	1.04
2	Nor-Yerznka village	Private owned	Alfalfa	2.57
3			Wheat	0.06
Total				**3.67**

Source) JICA Survey Team, March of 2016
Remarks) Apart from the census survey, 53 plots of cultivated lands, which are approximately 80ha within the reservoir basin, were identified. The detailed information is mentioned later.

Table 5-2-3.8 shows the Project affected cultivation area by construction the Reservoir. The Project affects cultivated lands of 79 ha which belong to state or communities. Those crops are cultivated by the illegal land users.

Table 5-2-3.8 Project Affected Cultivated Areas by Construction of the Reservoir

No.	Plants	Area (ha)
1	Barley, Wheat	54
2	Alfalfa, Sainfoin	20
3	Plowed lands	5
Total		**79**

Source) JICA Survey Team, March of 2016

The Project affects cultivation area with 82.27 ha in total, consisting of 3.67 ha by irrigation canals construction and 79.00 ha by the Reservoir construction (see, Table 5-2-3.9).

Table 5-2-3.9 Cultivation Area of Project Affected Crops

Area	Ha
Irrigation canal area	3.67
Reservoir basin	79.00
Total	**82.27**

Source) JICA Survey Team, March of 2016

5-2-3-3 Socioeconomic Survey

To identify characteristics and economic situation of the PAPs, the socioeconomic survey was conducted. The questionnaire format and result of the survey are shown in the Appendix K-9 and 10. The survey targeted 32 households of Yeghvard city and Nor-Yerznka village, including 14 households which have cultivated within the Reservoir basin.

Table 5-2-3.10 Total Number of Project Affected Households in Socioeconomic Survey

Location	Number of Affected Households			Number and percent of socioeconomic survey covered Affected households		
	Legal	Illegal	Total	Legal	Illegal	Total
Canal area	12	7	19	9	6	15
The Reservoir basin	3	53	56	-	11	11
Both areas				3	3	6
Total	15	60	75 (100%)	12	20	32 (43%)

Source) JICA Survey Team, March-April of 2016
Remarks) 1. There are 53 households by using number of cultivated lands within the Reservoir basin.
2. There are 6 PAHs which have cultivated within the Canal area and the Reservoir area.
3. The numbers in () shows the share on all PAHs.

PAHs can be categorized into 2 groups by the locations. And there are some households who cultivate in both the Reservoir basin and area along proposed canals. Accordingly, the result of socioeconomic survey is analyzed by three (3) groups of cultivators, as followings;

1) Cultivators in only Reservoir basin (n=11)
2) Cultivators in only area along the proposed canal (n=15)
3) Cultivators in both Reservoir basin and area along the proposed canal (n=6)

(1) General characteristics of PAHs

1) Affected population and family size

The number of targeted PAHs and population were identified by the survey. There are 179 persons in 32 PAHs which were conducted socioeconomic survey in the Project. 179 consists of 91 males and 88 females. The average of household member is 5.59 persons, with 2.84 males and 2.75 females respectively, as shown in Table 5-2-3.11.

Table 5-2-3.11 Project Affected Population and Family Size

Item	Male	Female	Total
1. Cultivators in only Reservoir basin (n=11)	3.18	2.73	5.91
2. Cultivators in area along proposed canal (n=15)	2.53	2.47	5.00
3. Cultivator in Both areas (n=6)	3.00	3.50	6.50
Total (n=32)	2.84	2.75	5.59

Source) JICA Survey Team, March-April of 2016

2) Female heads of PAHs

There are three households headed by female. It is only 9 % of total PAHs, as shown in Table 5-2-3.12. The similar trend can be seen in all of three categories.

Table 5-2-3.12 Household Heads of PAHs

Item	Male	Female	Total
1. Cultivators in only Reservoir basin (n=11)	10	1	11
2. Cultivators in area along proposed canal (n=15)	13	2	15
3. Cultivator in Both areas (n=6)	6	0	0
Total (n=32)	29 (91%)	3 (9%)	32 (100%)

Source) JICA Survey Team, March-April of 2016

3) Elderly persons s of PAHs

There are 21 PAHs, which have persons who are elder than 65 years old. It is 66% of total PAHs, as shown in Table 5-2-3.13.

Table 5-2-3.13 Elderly Persons of PAHs

Item	No. of PAHs	Share of the households which have elderly persons (%)
1. Cultivators in only Reservoir basin (n=11)	7	64
2. Cultivators in area along proposed canal (n=15)	11	73
3. Cultivators in Both areas (n=6)	3	50
Total (n=32)	21	66

Source) JICA Survey Team, March-April of 2016

4) Disabled persons of PAHs

While there are 10 disabled persons in PAHs, there are 9 households (28%) which has disabled persons. The households of "3. Cultivators in Both areas" does not have disabled person, as shown in Table 5-2-3.14.

Table 5-2-3.14 Disabled Persons of PAHs

Item	No. of disabled population	No. of PAHs	Share of the households which have disabled persons (%)
1. Cultivators in only Reservoir basin (n=11)	2	2	18.2
2. Cultivators in area along proposed canal (n=15)	8	7	46.7
3. Cultivators in Both areas (n=6)	0	0	0.0
Total (n=32)	10	9	28.1

Source) JICA Survey Team, March-April of 2016

5) Educational status of PAHs

At least, all of PAPs completed elementary school. Especially, the cultivators in the both area have highest education level, as show in Table 5-2-3.15.

Table 5-2-3.15 Educational Status of PAH Heads

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)
1) None	0	0	0	0
2) Elementary	0	0	0	0
3) Primary (8, 9 grade)	1 (3%)	0	1 (7%)	0
4) Secondary general	14 (44%)	7 (64%)	6 (40%)	1 (16.5%)
5) Average Professional	9 (28%)	3 (27%)	5 (33%)	1 (16.5%)
6) Higher	8 (25%)	1 (9%)	3 (20%)	4 (67%)
Total	32 (100%)	11 (100%)	15 (100%)	6 (100%)

Source) JICA Survey Team, March-April of 2016
Remarks) The numbers in () shows the share by each categories.

(2) Financial characteristics of PAHs

1) Main income source

31 households get farm-income as main source. The one household have no farm-income, since lands of the household are fallow. The second largest answer was "livestock." This same trend can be shown in all of 3 categories, as shown in Table 5-2-3.16 and Figure 5-2-3.1.

Table 5-2-3.16 Main Income Source

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)
1) Farming	31	11	15	5
2) Aquaculture	0	0	0	0
3) House/Land lent income	2	1	1	0
4) Pension	18	6	9	3
5) Business/ Shop	1	0	1	0
6) Carpenter	0	0	0	0
7) Livestock	24	9	10	5
8) School Teacher	0	0	0	0
9) Public Officer	10	2	4	4
10) Labor for person's farmland	0	0	0	0

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)
11) Factory Labor	2	1	0	1
12) Company Worker	2	1	1	0
13) Remittance from family members	1	0	1	0
14) Others	9	3	6	0

Source) JICA Survey Team, March-April of 2016

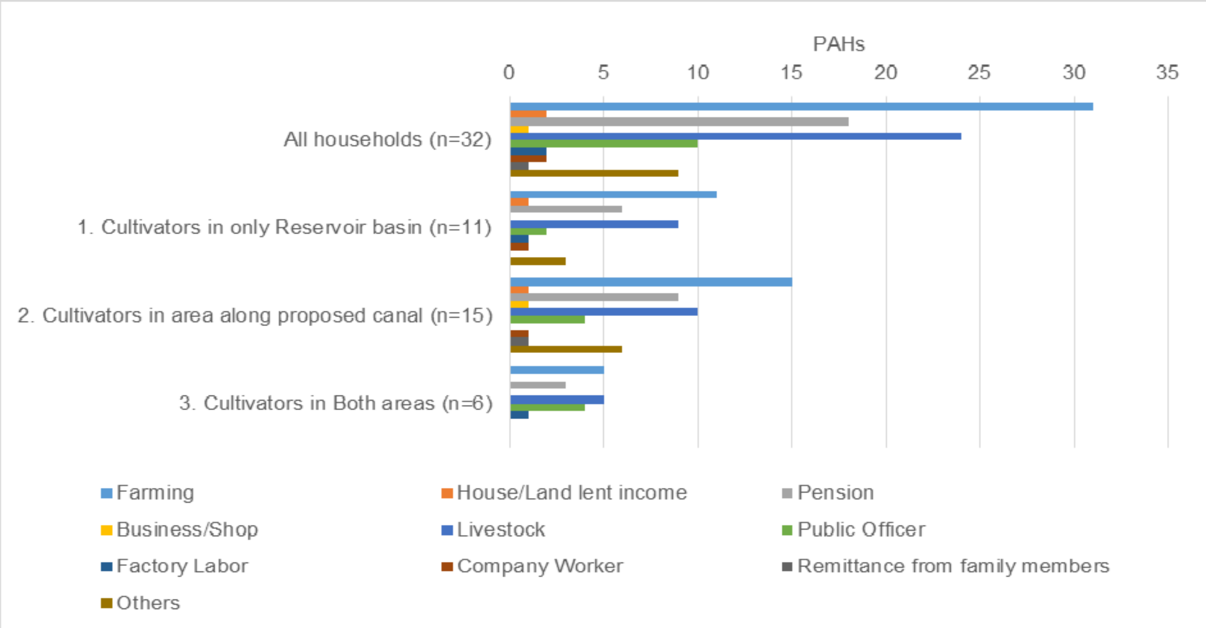


Figure 5-2-3.1 Main Income Source

2) Average annual gross income

The average annual gross income of all PAHs is 4,252,000AMD, including 2,357,000 AMD farm-income[6], 1,504,000AMD off-farm income, and 391,000AMD from livestock, as shown in Table 5-2-3.17. The PAHs of "3. Cultivators in Both areas" get the highest annual income among the three categories. Oppositely, the PAHs of "1. Cultivator in only Reservoir basin" get the lowest annual income among the three categories.

Table 5-2-3.17 Average Annual Gross Income (AMD)

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)
Farm-income				
Within the Reservoir basin	272,200	527,100	0	528,000
Within the Canal area	973,700	0	1,586,000	1,280,000
Not affected area	1,111,100	1,622,900	675,000	1,296,000
Sub-total	2,357,000	2,150,000	2,261,000	3,104,000
Non-farm income	1,504,000	936,800	1,921,700	1,500,000
Livestock	391,000	618,200	221,300	400,000
Total	4,252,000	3,705,000	4,404,000	5,004,000

Source) JICA Survey Team, March-April of 2016
Remarks) 1. Agricultural products for self-consumption, it was implemented imputation.
2. It was excluded one household, which has huge cultivated area compared with the other households, as the outlier.

[6] Some PAHs cultivate crops for their self-consumption. To measure of the finance damage by the Project, it was implemented imputation, based on the unit price of selling price for agricultural products.

Figure 5-2-3.2 shows the share of incomes source. While annual gross income of “1. Cultivators in only Reservoir basin” is the lowest among three categories, the share of farm-income from cultivation within the Reservoir basin is 14 %. And they have much higher income from cultivation in the non-affected area than in affected area.

Annual gross income of “2. Cultivators in area along proposed canal” is almost same as its average of all households. While they will lose 36 % of income from cultivation in the Project affected area, they have farm-income in non-affected area, non-agricultural income, and livestock income.

Annual gross income of “3. Cultivators in both areas” is the highest among three categories. While they will lose 37 % (11 %+26 %) of income from cultivation within the Reservoir basin and area along proposed canal, they have farm-income in non-affected area, non-agricultural income, and livestock.

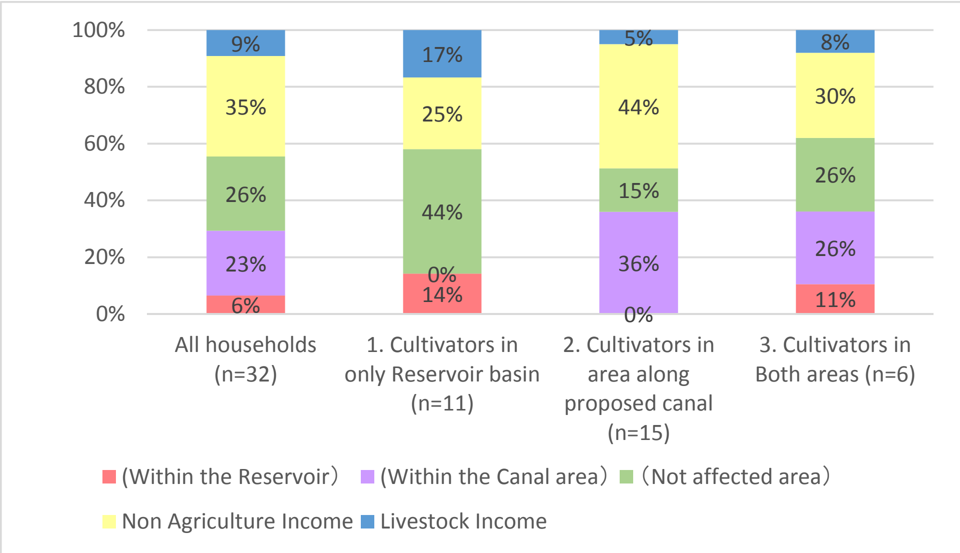


Figure 5-2-3.2 Annual Gross Income

3) Non-farm income

Expect for a household, PAHs have non-farm income and their main source is “Salary.” Other large shares are pension, income from work abroad, and livestock. The similar trend in the three categories is observed. However, the largest share of “1. Cultivators in only Reservoir basin” is “Pension,” not “Salary,” as shown in Table 5-2-3.18.

5-2-3.18 Non-farm Income

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both area (n=6)
None	1	1	0	0
Income from work abroad	4	0	4	0
Salary	12	2	6	4
Pension	9	3	4	2
Livestock	3	2	1	0
Poverty benefits	2	2	0	0
Others (pension and salary)	1	1	0	0
Total	32	11	15	6

Source) JICA Survey Team, March-April of 2016

4) Land size of Project affected area and average farm-income

As shown in Table 5-2-3.19, the average land size of cultivated area within the Reservoir is 1.89 ha/household. In addition, the average farm-income from this activity is 272,200 AMD/household. On the other hand, the average land size of cultivated area within the Canal area is 0.25 ha/household. Then, the average farm-income from this activity is 973,700 AMD/household. From the comparison between "Within the Reservoir basin" and "Within the Canal area," the profitability of farm crops of the former is much lower than latter.

Table 5-2-3.19 Average Land Size of Affected Cultivated Area and Farm-income

Item		Total (n=31)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both area (n=6)
Within the Reservoir basin	Land size (ha)	1.89	1.46	0.00	8.47**
	Farm-income (AMD)	272,200	527,100	0	528,000
Within the Canal area	Land size (ha)	0.25	0.00	0.30	0.65
	Farm-income (AMD)	973,700	0	1,586,000	1,280,000

Source) JICA Survey Team, March-April of 2016
Remarks) * It was excluded one household, which get huge amount of farm-income compared with the other households, as the outlier.
** It was included the household, which has fallow of 35 ha within the Reservoir basin.

(3) Living Conditions of PAHs

1) Cultivation years in the past

All PAHs have cultivated crops in their lands for 18.5 years in average. About "1. Cultivators in only Reservoir basin", 55% of PAHs have cultivated for over 16 years, since the immediately before or after independence of RA. On the other hand, 45% of PAHs have cultivated there for less than 10 years. About "2. Cultivator in only area along the proposed canal", all PAHs have cultivated over 6 years. Furthermore, 80% of them have used their lands over 16 years. About "3. Cultivators in Both areas," the clear trend is not observed, as shown in Table 5-2-3.20.

Table 5-2-3.20 Period of Cultivation (years)

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)
Average of total PAHs	18.5	14.9	22.6	14
1~5	4	3	-	1
6~10	5	2	2	1
11~15	-	-	-	-
16~20	4	2	1	1
21~25	13	4	8	1
<25	3	-	3	-
N/A	3	-	1	2

Source) JICA Survey Team, March- April of 2016

2) Legal status of land use

Table 5-2-3.21 shows the legal status for land use of PAHs. There are 11 PAHs of "1. Cultivators in only Reservoir basin" and 3 PAHs of "3. Cultivators in Both area", who cultivate within the Reservoir basin. In addition, there are 6 PAHs of "2. Cultivators in area along proposed canal." Thus, there are 20 PAHs who have cultivated the Project affected area without legal status.

Table 5-2-3.21 Legal Status of Land Use

Item		1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivators in Both areas (n=6)*
1. Within the Reservoir basin		11	-	6
	Legal	-	-	3
	Illegal	11	-	3
2. Within Canal area		-	15	6
	Legal	-	9	6
	Illegal	-	6	-

Source) JICA Survey Team, March- April of 2016

Remarks) The total of “3. Cultivator in Both areas” is 12 PAHs, since 6PAHs have cultivated in the both area.

(4) Others

1) Expectation to the Project

As shown in Table 5-2-3.22, 25 PAPs (78%) anticipate that the Job opportunity will be increased during the construction period. Especially, the most APs of “1. Only Reservoir basin” anticipated it.

Table 5-2-3-3.22 Anticipated Impacts by the Project

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivator in Both area (n=6)
1) Water quality in the Community will be damaged	6	4	1	1
2) Nothing	1	0	1	0
3) Job opportunity will be increased during the construction period.	25	10	11	4
7) Others (promotion of tourism, etc.)	7	4	2	1

Source) JICA Survey Team, March – April of 2016
Remarks) This question applied plural answered.

2) Expected Benefits by the Project

As shown in Table 5-2-3.23, the most of PAPs expect to access to stable water in the community more easily than before. In addition, PAPs hope the development of some industries around the Reservoir area.

Table 5-2-3.23 Expected Benefits by the Project

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivator in Both area (n=6)
1) Stable water using in the Community	15	6	4	5
2) Solution for lack of agricultural water	15	7	6	2
3) Improvement of irrigation system	9	5	2	2
4) Promotion of industry	11	7	2	2
5) Reduction of water fee	6	3	3	0
6) None	6	1	4	1
7) Others (promotion of tourism, etc.)	4	2	1	1

Source) JICA Survey Team, March – April of 2016
Remarks) This question applied plural answered.

3) Concerns on the Project

As shown in Table 5-2-3.24, the most of PAPs have concerns about risk on safety/ seismicity by the Project. Then, PAPs, who have cultivated in the Project affected area are worry about compensation for land loss.

Table 5-2-3.24 Concerns on the Project

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivator in Both area (n=6)
1) Risk on Safety/ Seismicity	17	6	7	4
2) Financial damage due to land loss	13	5	5	3
3) Implementation of compensation	15	5	7	3
4) Increasing of water price	1	1	0	0
5) Others	1	0	0	1

Source) JICA Survey Team, March – April of 2016
Remarks) This question applied plural answered.

4) Understanding on the Project

As shown in Table 5-2-3.25, 24 PAPs (75 %) understand that they should stop cultivation within the Reservoir basin, when the Project is re-stated.

Table 5-2-3.25 Understanding on the Project

Item	Total (n=32)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivator in Both area (n=6)
Already known	24	8	11	5
Not Known	8	3	4	1

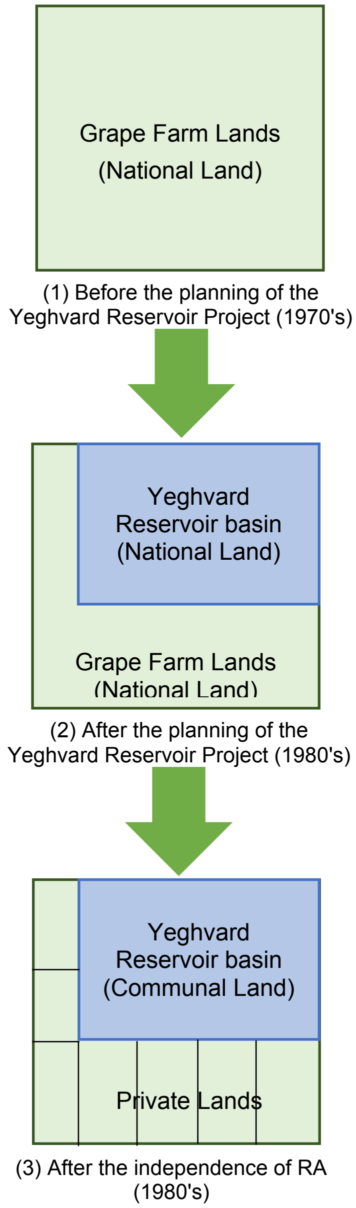
Source) JICA Survey Team, March – April of 2016

5-2-3-4 Social and Cultural Characteristics

(1) Transition of land ownership within the Yeghvard Reservoir basin

1) Period of Soviet Union

In the period of Soviet Union, all of the lands belonged to the State. Before the Yeghvard Reservoir construction project (1970’s), collective farming, called as Kolkhoz, had been operated in the farmlands of Yeghvard Community, including Yeghvard Reservoir basin (see, figure right (1)). In the farmlands, grape had been cultivated and the farmers had gotten fixed monthly salary by works. The farmers had been engaged in farming activities in rotation within the grape garden.



(1) Before the planning of the Yeghvard Reservoir Project (1970's)

(2) After the planning of the Yeghvard Reservoir Project (1980's)

(3) After the independence of RA (1980's)

In 1980’s, due to the plan of the construction of the Yeghvard Reservoir, cultivation within the Reservoir basin was suspended (see, figure right (2)). On the other hand, the farmers had continued cultivations outside of the range of the Reservoir basin. In addition, their salary was not changed, since it was fixed by the State. Therefore, the impacts on the surrounding households were not serious.

In 1984, because of the financial problems, the Government of Soviet Union stopped the construction of the Yeghvard Reservoir.

2) After independence of Armenia

In 1991, the Armenia gained independence from the Soviet Union. After that, the Government of Armenia distributed the lands of outside of the Yeghvard Reservoir basin to the people as the private lands (see figure right (3)). The average land distribution was 0.5 ha per household, if the number of family members was 3 or less, while the numbers of household members was 4 or more, they could get 1.0 ha or more. On the other hand, the lands for the Yeghvard Reservoir became communal lands which belong to Yeghvard city.

Since the construction of the Yeghvard Reservoir has been suspended even after the independence, the surrounding people re-started crop cultivation within the Reservoir basin, considering the soil within the Reservoir is fertile. They do not have the legal rights to cultivate there. However, Yeghvard city has given silent consent to them until now, since it is not sure whether the construction of the Reservoir will be re-started or not. According to Yeghvard city, approximately 30~40 farmers have cultivated, as of June in 2015.

3) Current farming conditions

As of April in 2016, land ownerships within the Reservoir basin are categorized into 3 types, namely, a) State Lands[7], b) Communal Lands of Yeghvard city, and c) Private Lands. Most of the lands are communal lands (see, Figure 5-3-3.3). In addition to that, there are some private lands (four plots),

[7] The current State lands belonged to Nor-Yerznka village before, however, it became state lands for construction of the Reservoir.

which were sold by the Yeghvard city to individuals by auctions.

The farmers who cultivate within the Reservoir basin has been changed so often, since some of them have handed over or have leased lands to others, or stopped cultivation.

(2) Identification of farmers of the Reservoir basin

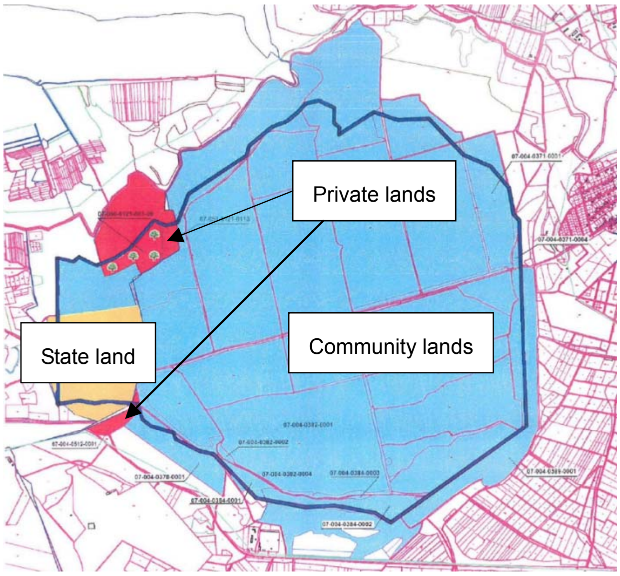


Figure 5-2-3.3 Current Land Ownership within the Reservoir Basin

Yeghvard city, Nor-Yerznka village, and Yeghvard WUA do not have information about the farmers who have cultivated within the Reservoir basin. As well as, the farmers in the Reservoir don't communicate with neighbor farmers well, since they don’t go to the field every day. It means that there is no data/information related to the actual cultivators and the number of them within the Reservoir basin. Therefore, a site survey to identify the number of farming plots in the Reservoir was implemented by JICA Survey Team. As a result, as of April in 2016, 53 farming plots covering 80ha were identified. It could be assumed that there are maximally 53 farmers, if one farmer cultivates each plot. In the survey process, 14 illegal cultivators within the Reservoir basin were identified.

In the Project, the Stakeholder meetings and public seminar are noticed in the newspapers, web-site and on the board of communities concerned and Yeghvard WUA. The purpose is to enhance understanding of the persons concerned about the Project.

(3) Current situation within the Reservoir basin

Basically, the cultivated lands those are located on where it can access to water resource easily. In particular, the most of cultivated lands are located in the northeastern part of the Reservoir where it is close to the Arzni-Shamiram canal. On the other hand, there are few cultivated lands in the central part of the Reservoir basin, because the fertile top soil in the part has been already excavated in the period of Soviet Union. In the same period, ditches were constructed for water distribution to grape all over the Reservoir basin. Presently, the farmers use the existing ditch or construct new one by themselves for their cultivation (see, Figure 5-2-3.4).

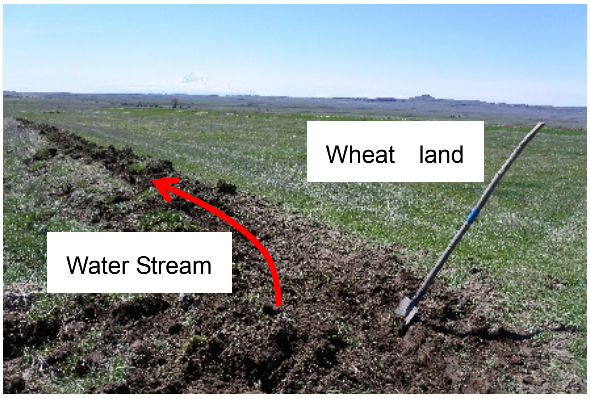
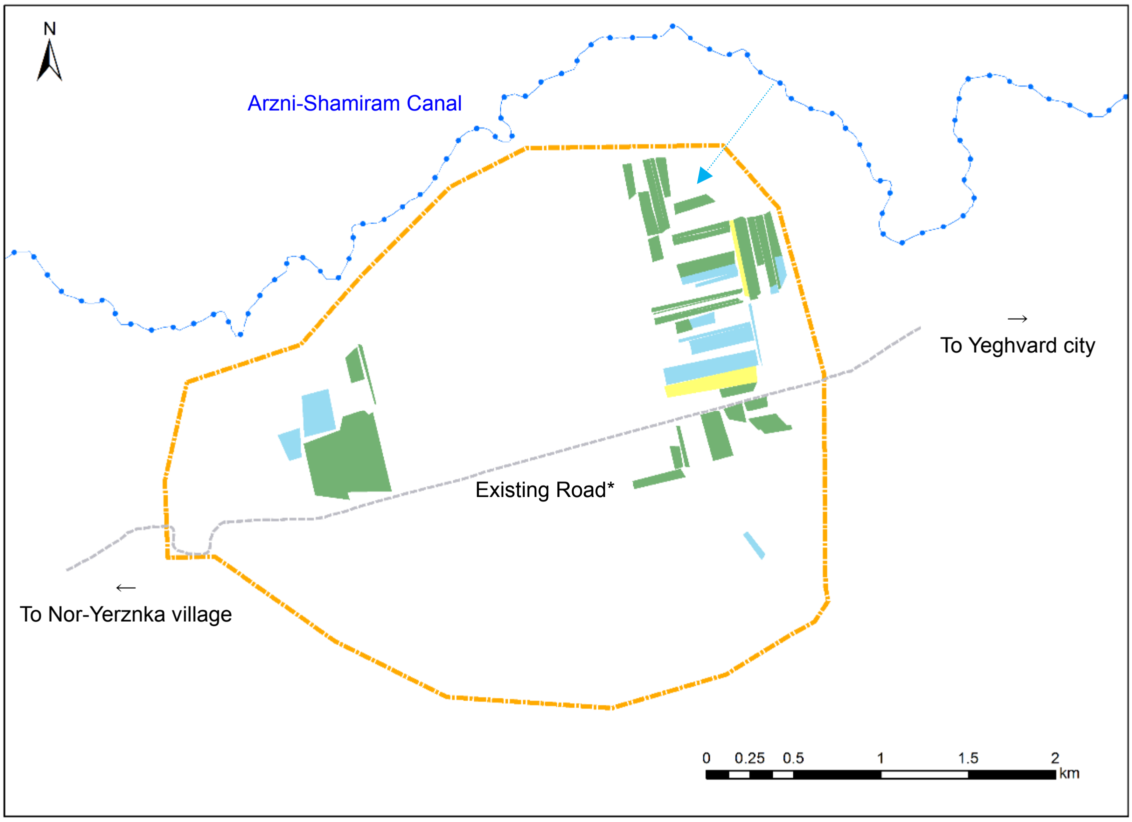


Figure 5-2-3.4 Maintained Ditch and Wheat Land

As mentioned above clause (2), 53 plots are cultivated. And the area is 80 ha (see, Figure 5-2-3.5). There is a big plot whose area is 17 ha in the western part of the Reservoir basin and the plot is managed by one household. Except for the big plot, the average of cultivated lands area of 52 plots in the Reservoir basin is estimated at approximately 1.2 ha per household.



Crops	Plots	ha
Barley, Wheat	36	54
Alfalfa, Sainfoin	15	20
Plow ed lands	2	5
Total	53	79

Figure 5-2-3.5 Cultivated Lands within the Reservoir Basin

*It was maintained for construction of Yeghvard Reservoir in the Soviet Union Period.

(4) Cultivated crops within the Reservoir basin

Main cultivated crops in the Reservoir are wheat, barley, alfalfa and sainfoin (legume pasture), the cultivation areas of wheat and barley accounts for around 70% of the whole farmland area in the Reservoir basin. Alfalfa and sainfoin are perennial crops which can be harvested for 4-6 years, while wheat and barley are one-year crops. The profits from those crop productions are very low compared with those of vegetables and orchard, only 5%-20%. The reasons why such low profitable crops are cultivated is the area that 1) Yeghvard City gave an instruction to the farmers not to plant perennial crops such as fruit trees in case of re-start of the Yeghvard Reservoir Construction, and 2) water resources in the Reservoir are not sufficient.

5-2-3-5 Vulnerable People

Armenia has a social welfare program for the poor, namely, “Family Benefits System (FBS)”. According to the socioeconomic survey, there are two households, which get FBS. Each of them cultivated 1 ha and 0.6 ha, respectively within the Reservoir basin for their self-consumption, and they do not own their private farmlands outside of the Reservoir. If the Project is started, they will lose their measures to gain their daily food. Hence, it is proposed to hire them with high priority as the construction labors. Apart from them, there are elder households who get pension and disabled households who get disability benefits. In addition, there are some women headed households. Those of them are also categorized into the vulnerable people, and they also will have high priority to be employed as workers by the Project. Moreover, as the ADB construction has done, allowance to them will be provided. On the other hand, there are no ethnic minority people in the affected area. Therefore, it is not necessary to consider such people.

5-2-4 Compensation Measures

5-2-4-1 Compensation for Loss

(1) Contents of compensation

In the Project, while physical relocation is not required, the land acquisition is needed. Based on the meetings with the implementation agency, namely, PIU/ SCWE, the basic compensation measures were drafted to provide compensation/ consideration. In addition, as described in “5-2-10 Public Consultation,” the contents on drafted compensation measures was presented to PAPs at Public Seminars, and it was basically accepted by the participants. The detailed contents are mentioned below;

1) Land loss

Compensation for land loss will be done to the PAPs who have legal status. In the Project affected area, it was identified three (3) categories of land, such “agricultural”, “residential”, and “industrial[8].” Based on those categories, the market prices are evaluated by the evaluator who has the license from the Government of Armenia. Furthermore, the market price is fixed based the accessibility and productivity. This market price can cover the amount that PAPs to purchase the new lands which have equal values as previous lands. After comparing between the market and official prices (see, Table 5-2-4.1), the higher price, namely, market price is adopted.

Table 5-2-4.1 Comparison of Official Price and Market Price

	Official price (AMD/m^2)	Market price (AMD/m^2)
Agriculture (crop)	36.5-118.5	460
Agriculture (pasture)	6.75	460
Orchard	43.5-180	880
Residential area	2,940	3,800-8,700

Source) 1. Official price of lands: State Committee of Real Estate Cadaster,
2. Market price of lands: JICA Survey Team, 2016 (estimated by the licensed land evaluator)

The amount for compensation, including 15 % plus of the market price is applied and the amount of compensation can be though as full replacement cost.

While there are some illegal land users in the Project affected area, all of illegal land users within the Reservoir basin have not been identified. Also, since the illegal land users are changing by years, it is very difficult to compensate to actual PAPs who cultivate in the Reservoir basin.

According to the PIU member, the Vedi project founded by AFD, didn’t compensate to the illegal land users, since the PAPs understood the area is for the Vedi project from the beginning. On the other hand, the road construction project founded by ADB, compensated to the illegal land users, since the project area was not decided in early stage and the illegal PAPs were not aware the project.

In case of the Yeghvard Reservoir Project, while it was stopped in the Soviet Union period, Yeghvard city has instructed the illegal land users not to cultivate perennial crops. Furthermore, it is known that the cultivation in state or communal land is illegal, generally. As the result of socioeconomic survey,

[8] The buildings will be demolished, however, the area will be affected by the Project.

76 % of illegal land users within the Reservoir area have already know that they should stop cultivation within the Reservoir area, when the Project is restarted. From these reasons, it will not be difficult to gain consensus from the PAPs. Hence, though the Project will not compensate to the illegal land users within the Reservoir basin, it is recommended to employ the illegal land users as workers during construction stage with priority.

Regarding the illegal land users who have cultivated trees in area along the proposed canal, they do not have any rights nor permission for cultivation in the communal lands, as same as illegal land users within the Reservoir basin. Hence, they will not be compensated for affected land by the Project.

2) Crop loss

Compensation for perennial crop loss will be paid to the PAPs, who have legal status to be affected by the Project. In case of annual crop, the cultivator can stop cultivation based on the announcement about construction schedule. Hence, the compensation for annual crop loss will not be provided to PAPs.

The amount is calculated for expected harvest at market price by crop. Regardless of whether land is affected permanently or temporary, loss of perennial crop is compensated to PAPs who have the legal status. On the other hand, crop compensation will not be provided to the illegal land users. In the Project affected area for irrigation canal, there is no crop of illegal land users, while there are crops within the Reservoir basin. However, according to the socioeconomic survey, they have cultivated unprofitable crops, as barley or wheat.

Furthermore, if they cultivate annual crops within the Reservoir basin, the Project will not affect their cultivation, since the Project will announce at least before construction starts one year. In case of perennial crops, while the Project will affect their cultivation, according to the officer of Yeghvard city, they have instructed PAPs not to cultivate perennial crops within the Reservoir area with considering restarting its construction. Somebodies followed the instruction, while others did not. Hence, it is suggested not to compensate for the crop loss to avoid any conflicts among those legal and illegal land users.

3) Tree loss

Compensation for tree loss will be paid to the all PAPs, who will be affected by construction of the Reservoir and/ or irrigation canals. Regardless of whether the land is affected permanently or temporary, loss of tree is compensated.

Within the Reservoir area, while there is no trees which belong to illegal PAPs, in the area for irrigation canals, there are orchards of illegal land users. The profitability of trees are higher than crops, and the impact of tree loss will be significant. Therefore, regardless of legal status, all PAPs should be compensated.

4) Loss of livelihood means

Since there is no regulation regarding compensation for illegal land users in the law of Armenia, illegal land users will lose the parts of their livelihood means by the Project. Thus, it is proposed the employment for construction works should be given to the illegal land users in the Project. The detailed methodology is discussed in section 5-2-4-2.

5) Special attention for vulnerable people

In the Project, all PAPs which get FBS, disabled benefits or headed by female or eldered people are regarded as the vulnerable people. According to ADB project, the vulnerable people can get allowance as same as amount of 6 months of minimum salary and be hired with high priority as a labor for the construction works. The same approach is proposed in the Project.

6) Temporary land loss

While temporary land acquisition for pipeline and stockyard is needed, there is no specific regulation for temporary land loss in Armenia. Generally, since compensation rates for temporary land loss are fixed based on the negotiations with the land owners before making compensation agreement, the rate cannot be set at least in this F/S stage. Therefore at present, it is proposed to apply the same compensation rate for temporary land loss as the permanent land loss. It means that sum of the higher amount of market price and official price for land, and 15 % of the land price is proposed as compensation rate.

(2) Cut-off date

While at this F/S stage, the cut-off date has not been established, it should be established at D/D stage, before implementation of final census survey. In addition, at least one year before from starting construction, it is needed to announce PAPs not to cultivate in the Project affected area, for the next year. It is proposed that the announcement is done as soon as possible, after exchange of the Loan Agreement.

5-2-4-2 Methods for Recovering Livelihood Means

As mentioned section 5-2-4-1 (1) (4) and 5)), the vulnerable people and the illegal land users will lose the parts of their livelihood means. Hence, it is necessary to provide some supports. In the Project, it is proposed to hire them with high priority during the construction period.

As the result of socioeconomic survey, 11 PAHS of “1. Only Reservoir basin,” have 1.46 ha cultivated lands (see, Table 5-2-3.19) on average. Two households which get FBS are classified into this category. When the construction of Reservoir is started, those PAHs will lose the income from cultivation within the Reservoir. Then, the scale of their remaining lands will be less than 1.0 ha, namely, 0.28 ha as shown in Table 5-2-4.2.

Table 5-2-4.2 Average Cultivated Land Size of PAHs within the Reservoir Basin

Item	Total (n=31)	1. Cultivators in only Reservoir basin (n=11)	2. Cultivators in area along proposed canal (n=15)	3. Cultivator in Both area (n=6)
Within the Reservoir basin	1.89	1.46	-	8.47**
Within the Canal area	0.25	-	0.30	0.65
Outside the Project affected area	0.58	0.28	0.15	2.52

Source) JICA Survey Team, March-April of 2016

Remarks) * It was excluded one household, which get huge amount of farm-income compared with the other households, as the outlier.

** It was included the household, which has fallow of 35 ha within the Reservoir basin.

On the other hand, Table 5-2-4.3 shows that the most of farmers in Armenia have small scale farmlands which are less than 1.0 ha. In Kotayk Marz[9], 46.3% of the households have cultivated lands which are less than 1.0 ha. That is to say, the scale of their remaining land become close to the general trend of Kotayk Marz.

[9] Yeghvard city and Nor-Yerznka village belong to Kotayk Marz.

Table 5-2-4.3 Cultivated Land Size by Marz

Marz	Less than 1.0 ha		1.0ha-5.0 ha		More than 5.0 ha		Total
	No. of Households (1,000HH)	Share (%)	No. of Households (1,000HH)	Share (%)	No. of Households (1,000HH)	Share (%)	No. of Households (1,000HH)
Yerevan	5.4	79.4	1.4	20.6	0.0	0.0	6.8
Aragatsotn	17.2	46.4	17.9	48.2	2.0	5.4	37.1
Ararat	21.4	43.2	25.3	51..1	2.8	5.7	49.5
Armavir	23.3	46.3	24.3	48.3	2.7	5.4	50.3
Gegharkunik	21.4	46.4	22.3	48.4	2.4	5.2	46.1
Lori	15.0	47.0	15.1	47.3	1.8	5.6	31.9
Kotayk	17.4	46.3	18.2	48.4	2.0	5.3	37.6
Shirak	13.0	46.3	13.6	48.4	1.5	5.3	28.1
Syunik	5.9	46.5	6.1	48.0	0.7	5.5	12.7
Vayots Dzor	5.1	46.4	5.3	48.2	0.6	5.5	11.0
Tabush	11.4	46.5	11.8	48.2	1.3	5.3	24.5
Total	156.5	46.6	161.3	48.1	17.8	5.3	335.6

Source) JICA Report, 2008 (original data from Ministry of Agriculture)

If the PAPs will continue their farming after the Project implementation, they have to purchase new lands, since their farmlands outside of the Reservoir are very small. At this moment, the average cultivation area within the Reservoir is 1.46ha as shown in Table 5-4-2.2. It is noted that the cultivated crops in the Reservoir basin are wheat, barley, alfalfa and so on, which produce low profits. The benefit per unit area is 5-20% of those of vegetables and fruit trees as shown Table 5-2-4.4. It means that current benefits from the 1.46ha in the Reservoir basin are low. Therefore, if the PAPs can purchase 1.0ha new farmland and they harvest vegetables and fruit trees, it can compensate for the loss of land within in the Reservoir and 1.0 ha of new land can be regarded as sufficient.

Table 5-2-4.4 Profit by Crop

Crop	Net profit (AMD/ha/year)
Wheat	96,520
Barley	102,900
Tomato	2,009,000
Cucumber	2,777,000
Eggplant	2,625,000
Bell pepper	2,645,000
Cabbage	3,125,000
Onion	2,152,000
Watermelon	2,310,000
Potato	1,263,000
Alfalfa (1st year)	△ 81,528
Alfalfa (after 2nd cropping year)	494,000
Alfalfa (7 years cropping)	411,782
Grape (adult tree)	514,000
Apricot	803,000
Apple	951,000

Source) JICA Survey Team (based on the data from MOA)

Except for one household[10], all PAPs hope to continue their agricultural activities after the starting construction of the Project. If vulnerable people and illegal land users are hired as labor in the Project, it is supported that they can get 216,573 AMD/ month (see, Table 5-2-4.5)

[10] The household answered “cannot answer” to this question.

Table 5-2-4.5 Average Monthly Nominal Salary of Workers (AMD)

Marz	Combined work	Worker with contract or civil-law agreement	
		included income tax	excluded income tax*
Total	135,764	127,858	95,894
Agriculture, forestry and fishery	81,250	-	-
Mining industry and exploitation of open mines	219,700	119,897	89,923
Processing industry	167,548	172,941	129,706
Supply of electricity, gas, steam and high quality air	1,902,754	171,906	128,930
Water supply, sewerage, waste management and recycle	151,400	141,051	105,788
Construction	339,439	**216,573**	**162,430**
Wholesale and retail trade, repair of vehicles and motorcycles	184,689	158,223	118,667
Transportation and storage economy	217,433	174,794	131,096
Organization of accommodation and public food	134,309	87,866	65,900
Information and communication	147,888	131,587	98,690
Financial and insurance activity	420,211	130,809	98,107
Activity related to real estate	394,076	120,498	90,374
Specialty, scientific and technical activity	89,391	93,360	70,020
Administrative and supportive activity	143,403	48,964	36,723
State governing and defense, obligatory social safety	95,361	108,638	81,479
Education	99,367	99,007	74,255
Healthcare and social service of population	120,332	169,020	126,765
Culture, entertainment, recreation	141,601	135,275	101,456
Other services	166,669	115,340	86,505

Source) National Statistical Service of the RA, "Socioeconomic Situation of the RA, January-February 2016"

Remarks) The income tax is around 25%.

It is assumed that the term of construction stage is for four years. Thus, the amount of income by construction is as following;

162,430 AMD/month * 12 months * 4 years = **7,796,640 AMD** — (1)

Average farm-income in non-affected area of "cultivators in only Reservoir basin" is estimated at 1,622,900 AMD/HH/year as shown in Table 5-2-3.15. Thus, the amount of income by agriculture in the periods is as following;

1,622,900 AMD/HH/year * 4 years = **6,491,600 AMD** — (2)

The market price of agricultural land, which is adopted in this RAP, is **4,600,000 AMD/ha** – (3).

The cost for property registration is **23,500 AMD**[11] — (4)

Table 5-2-4.6 shows consumer expenditure of monthly average per capita, namely, 34.742 AMD.

Table 5-2-4.6 Monthly Average Consumer Expenditures per Capita (AMD)

	2010	2011	2012	2013	2014	Average
On food goods	16,125	18,552	18,500	19,146	20,283	18,521
On non-food goods	4,439	5,022	6,159	6,568	7,442	5,926
On service	8,082	9,011	10,262	11,073	13,045	10,295
Total	28,646	32,585	34,921	36,787	40,770	**34,742**

Source) National Statistical Service of Armenia, "Statistical Yearbook of Armenia, 2015"

The annual average of consumer expenditure per capita is as following;

34,742 AMD/month/capita * 12 moths = 416,904 AMD/year/capita

In the project affected area, the average of PAH family members is 5.59 persons (see, Table 3-3.2). Then the average per household for four (4) years is as following;

416,904 AMD/year/capita * 4 year * 5.59 persons = **9,321,973 AMD/year/household** — (5)

[11] The details mentioned latter.

Table 4-2.7 shows the calculation of household's balance sheet in case of purchase of new agricultural land. If the PAPs work as labor in the Project for four years, the income can cover their livelihood means, including purchasing new agricultural land. In addition, the remaining income after purchasing new agricultural lands is assumed 342,767 AMD. This amount is approximately 15 % of average gross income of all PAPs, referring to the socioeconomic survey. Hence, this methods for recovering livelihood means is proper.

Table 5-2.4.7 Estimated Household's Balance (for 4 years)

Item	AMD
1. Incomes	
Construction (1)	7,796,640
Agriculture in non-affected Area (2)	6,491,600
Sub-total (1)~(2)	14,288,240
2. Expenditures	
New land (3)	△4,600,000
Property Registration Fee (4)	△23,500
Expenditures (5)	△9,321,973
Sub-total (3)~(5)	△13,945,473
Total	**342,767**

It is noted that any farmers can find out new farmlands by themselves through intermediaries, acquaintances, or internet, if necessary, and it is not very difficult for them. However, when those people ask some advices for new land purchase, PIU/ SCWE could provide necessary information, through cooperation with communities or regional branch of State Committee of Real Estate Cadaster which have information on new farmlands.

According to the socioeconomic survey result, most of the affected farmers want to continue farming activities, and the consideration to employ them during the construction works with high priority, which enables them to purchase new farmland, can be judged as reasonable.

5-2-4-3 Resettlement Sites

It is not necessary to prepare resettlement sites, since the relocation is not assumed in the Project.

5-2-4-4 Entitlement Matrix

Taking consideration into the JICA Guideline and Armenian regulations, entitlement matrix of the Project is shown in Table 5-2-4.8.

Table 5-2-4.8 Entitlement Matrix

Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/ Guideline	Responsible Organization
1. Loss of land				
Loss of agricultural land	Legal land owners	Cash compensation at the market price (or official rate, higher of them) +15 %	1) Identification of land owners by State Committee of Real Estate Cadastral 2) Land evaluation and cost estimation by evaluators with license 3) Explanation of payment procedure for the PAPs (Project Affected Persons) and negotiation with the PAPs 4) Payment of cash compensation under the Law	PIU/SCWE
2. Loss of income sources				
2.1 Crop loss[12]	Legal land owners	Perennial Crop compensation for expected harvest in cash at market rate	1) Identification of land owners by State Committee of Real Estate Cadastral 2) Evaluation and cost estimation by	PIU/SCWE

[12] Since it is planned to notice of the timing the construction start to the PAPs and request them to stop the cultivation as soon as possible after the concluding loan agreement, it is not needed to compensate for annual crop. .

Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/ Guideline	Responsible Organization
			evaluator with license 3) Explanation of payment procedure for the PAPs and negotiation with the PAPs 4) Payment of cash compensation under the law	
2.2 Tree Loss	All PAPs regardless of legal status	Cash compensation at market rate based on type, age and productive value of the trees	1) Identification of land owners by State Committee of Real Estate Cadastral 2) Evaluation and cost estimation by evaluator with license 3) Explanation of payment procedure for the PAPs and negotiation with the PAPs 4) Payment of cash compensation under the law	PIU/SCWE
3. Loss of livelihood means				
loss of livelihood means (agriculture)	Illegal land users	Employment priority in project-related jobs	1) Identification of land users by WUA and communities concerned 2) PIU/SCWE is to push the contractor to employ the identified cultivators as workers with high priority 3) Employment by contractor	PIU/SCWE, WUA, Communities concerned
4. Special attention				
Vulnerable people*	1) Recipient PAHs of poverty benefits, disabled benefits, or 2) PAHs headed by Female or Elder people	1. Allowance equivalent to 6 months of minimum salary[13] 2. Employment priority in project- related jobs	1) Identification of vulnerable people by communities concerned 2) Explanation of payment procedure for the PAPs and negotiation with the PAPs 3) Payment of allowance under the law 4) PIU/SCWE is to push the contractor to employ the vulnerable people as works with high priority 5) Employment by contractor	PIU/SCWE, Communities concerned
5. Others				
Temporary land loss	Legal land owners	1. For land; Cash compensation at the market price (or official rate, higher of them) + 15% 2. For crop; Crop compensation for expected harvest in cash at market rate. 3. For tree; Cash compensation at market rate based on type, age and productive value of the trees	1) Identification of land owners by State Committee of Real Estate Cadastral 2) Evaluation and cost estimation by evaluator with license 3) Explanation of payment procedure for the PAPs and negotiation with the PAPs 4) Payment of cash compensation under the law	PIU/SCWE

Remarks) Category for Vulnerable people will be re-considered at D/D stage, with Ministry of Labor and Social Affairs.

5-2-5 Grievance Redress Mechanism

While there is no provision about grievance redress mechanism on the law of Armenia, it should be established in order to deal with the discontent or disapproval to the proposed compensation measures. International donors such as WB and ADB have already implemented some projects in Armenia, and they proposed new grievance redress mechanism by project, for instance, establishment of Grievance Redress Committee. However, such committees did not function well so far, since it was not close to the PAPs physically and mentally. On the other hand, although the most accessible organizations for PAPs are communities and WUAs in the Project, they do not have function to settle down issues related to land acquisition. Thus, it is not practical to establish the new committee within those

[13] It is regulated on the “Law on minimum monthly salary”. As of April in 2016, it is fixed at 55,000 AMD.

organizations for grievance redress, and it is recommended to use existing system for the Project.

The most practical way is that PIU handles grievances, since PIU has some experts who are in charge of environmental and social consideration, including the matters on resettlement and land acquisition. Those experts can receive grievances from the PAPs, and solve the matters. However, PIU is not very accessible for the PAPs, since it does not have the field office near by the Project affected area. On the other hand, considering that communities and WUAs are the most accessible for the PAPs, they can play role as liaison between PIU staff and the PAPs. Thus, it is proposed to involve them in addition to PIU for the grievance redress mechanism in the Project. Apart from that, it is possible for the PAPs to take grievances into the court, since Armenian people know how they can apply to the court, in general. It is noted that if a complainant goes to the court directly, it will not take time for the settlement, however, it is needed to pay commission charge. On the other hand, if a complainant gets consultation with the communities, WUAs and/ or PIU, it is free of charge but will take time to settle the issues.

Considering necessary cost, time and accessibility, three patterns for the grievance redress mechanism can be applied in the Project as illustrated in Figure 5-1-5.1. The PAPs will choose the most convenient and accessible way for them. The implementation agency, namely, PIU/ SCWE, and PAPs have already basically accepted the proposed system for grievance redress at the meetings including Public Seminars. In addition, at the final Public Consultation, which is planned to be held, such information would be announced to the participants again.

(1) Pattern 1

The PAP can lodge his/ her grievance to the community or WUA which is the most accessible for him/ her. Within 7 working days after the community or WUA receives grievance, the officer must submit the complaint to the PIU.

After PIU receives the grievance, PIU must respond to the PAPs within 15 working days. If PIU cannot solve the issue or the PAP doesn’t accept the PIU’s response, the PAP can proceed to the court. If he/ she wins at the court, the commission fee will be refunded. However, if he/she loses at the court, commission fee will be shouldered by the complainant.

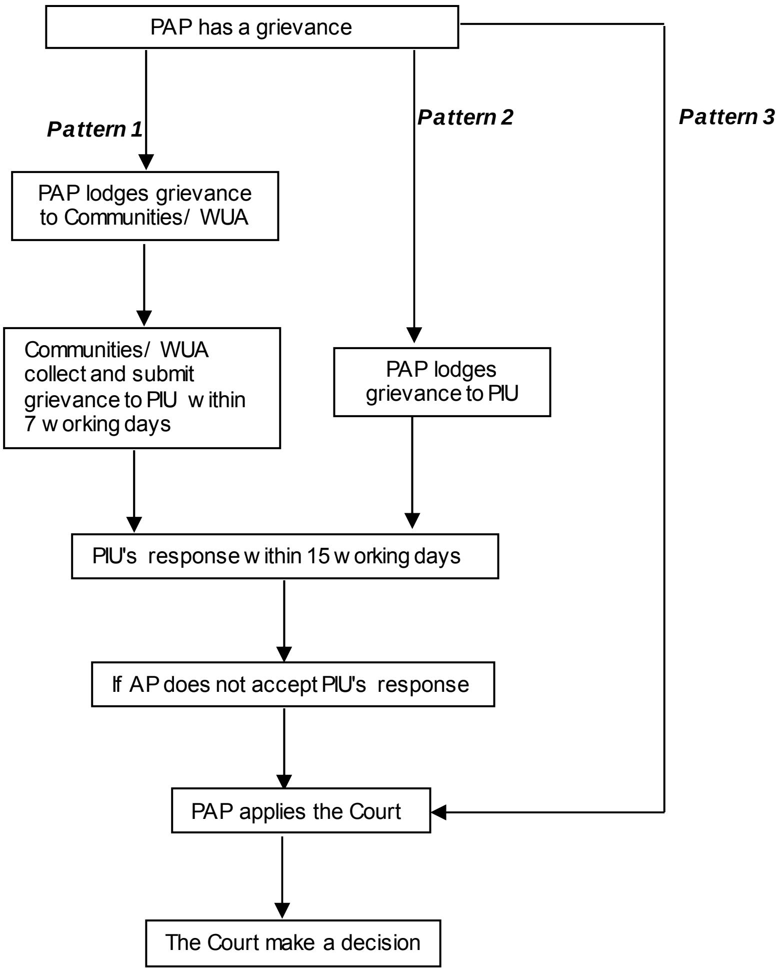


Figure 5-2-5.1 Grievance Redress Mechanism

After grievance lodging, the court should review the expropriation cases, carry out the hearing and make decision whether the land can be acquired or not. In addition, the court also should decide how much the fair price for compensation is. Then, the Project and the PAP need to follow the decision of the court.

(2) Pattern 2

The PAP can lodge his/ her grievance to the PIU directly. The process for the grievance redress by PIU will be same as that in Pattern 1. If the PAP does not accept PIU's response, he/ she can proceed to the court. The process for the grievance redress by the court will be same as that in Pattern 1.

(3) Pattern 3

The PAP can lodge his/ her grievance to the court directly. After grievance lodging to the court, the process for the grievance redress by the court will be same as in that Pattern 1.

5-2-6 Implementation Structure

Figure 5-2-6.1 shows the implementation structure for RAP of the Project.

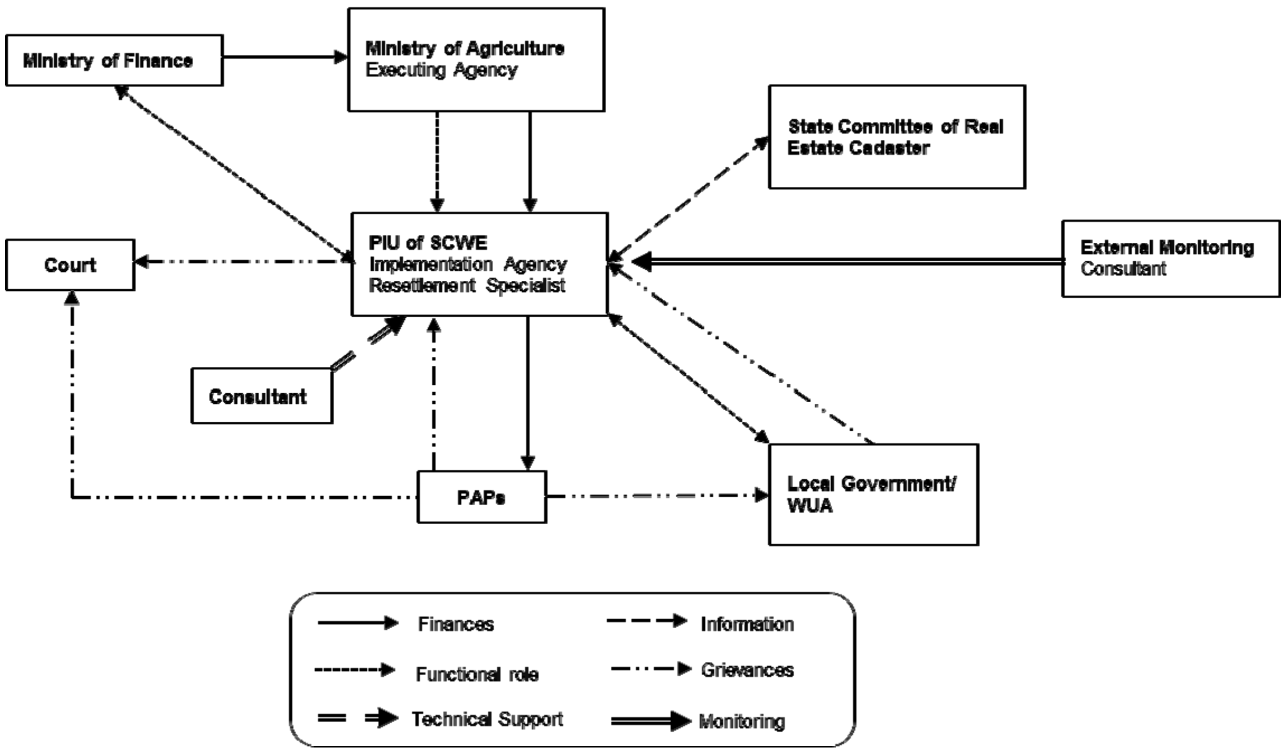


Figure 5-2-6.1 Implementation Structure

(1) Ministry of Agriculture (MOA)

MOA is the Executing Agency for the Project. It implements general functions for the Project including coordination with the concerned organizations.

(2) PIU of SCWE

PIU of SCWE is the organization which is in charge of implementation of the proposed RAP in the Project. Especially, PIU is requested to cover the final RAP preparation, implementation of the RAP, coordination with concerned organizations. Based on the proposed cost for compensation and support to the PAPs, PIU will apply the necessary budget allocation to the Government. The social expert of PIU is responsible for the general management of the planning and implementation of the RAP.

(3) Local organizations

Yeghvard city, Nor-Yerznka village, Ashtarak city, Yeghvard WUA, and Ashtarak WUA are concerned, they are expected to support the PIU for identification of PAPs and payment of compensation to the PAPs. And if the PAPs needs, the organizations are expected to give advices PAPs to solve issues. When the local government/ WUA cannot solve those issues by themselves, they are needed to report it to PIU.

(4) Consultants

At the D/D stage, the consultant is required to implement the updating/ finalizing of this RAP and he/ she provides technical support for RAP implementation of PIU, based on the results of census, assets, and socioeconomic surveys.

(5) External monitoring consultant

After D/D completion, it is required to confirm the progress of compensation payment, living conditions of PAPs by interview to representative of the PAPs by the external monitoring consultant.

(6) Other organization concerned

1) Ministry of Finance (MOF)

The budget for the implementation of the RAP will be allocated to the PIU by the MOF after the approval of the final RAP by the Government of RA.

2) State Committee of Real Estate Cadastral

To identification of PAPs, the information of cadastral map is provided by the State Committee of Real Estate Cadastral.

3) Court

According to the Law in RA, all PAPs can lodge their grievance, if they need. The court is required to review the acquisition cases, carries out a hearing and judges about the land acquisition and compensation.

4) PAPs

Representative of the PAPs, are requested to participate into the monitoring system. To be concrete, when the consultant take interviews, the representative of the PAPs will provide the information of the progress of compensation payment, living condition of PAPs, and so on.

5-2-7 Implementation Schedule

While implementation schedule has not been fixed yet at this moment, after the Loan Agreement between Government of RA and Government of Japan, the Project will be started soon. There will be several steps to be followed during the preparation and construction. The proposed implementation schedule of the RAP after the Loan Agreement is as shown in Figure 5-2-7.1.

Activities / Month		D/D Period (14 months)														Construction (4 years)
		Facility Design								RAP preparation						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Loan Agreement of the Project	x															
Facility design		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Cut-off date										x						
Final census										x	x					
Disclosure of final census result												x				
Compensation agreement													x			
Compensation														x		
Land expropriation															x	
Monitoring and grievance redress														←	—	→

Figure 5-2-7.1 Implementation Schedule

5-2-8 Cost and Financial Resources

This chapter presents the estimated compensation cost. The compensation cost shall be shouldered by the Government of RA. Table 5-2-8.1 shows the compensation cost for private land loss. 15% plus of market price is applied for the compensation cost estimation. In the Project, the following market price were estimated by the evaluator who has the license.

Table 5-2-8.1 Cost Estimation for Private Land Loss

Community	Land Use	Affected area (m^2) (1)	Market Price (AMD/m^2) (2)	Applied Value (AMD/m^2) (3)=(2)*115%	Compensation Cost (AMD) (4)=(1)*(3)
Yeghvard	Crop	100,496.59	460	529	53,162,696
Nor-Yerznka	Crop	14,588.27	440	506	7,381,665
Nor-Yerznka	Orchard	102,773.53	880	1,012	104,006,812
Nor-Yerznka	Pasture land	25,000.00	460	529	13,225,000
Nor-Yerznka	Residential area	2,021.21	3,800	4,370	8,832,688
Ashtarak	Industrial area	9,014.43	7,000	8,050	72,566,162
Ashtarak	Residential area	5,370.00	8,700	10,005	53,726,850
Total (AMD)					**312,901,892**
Total (USD) 1 USD = 486.99 AMD					*64,253*

Source) 1. Market price of lands: JICA Survey Team, 2016 (estimated by the licensed land evaluator)
2. Area to be affected: JICA Survey Team, 2016 (estimated by the licensed land evaluator)

In addition, Table 5-2-8.2 shows the fee for property registration.

Table 5-2-8-2 Cost Estimation for Property Registration

Community	Land Use	No. of Plot (1)	Fee for Property Registration (2)	Total Cost (AMD) (3)=(1)*(2)
Private Land				
Yeghvard	Crop	7	23,500	164,500
Nor-Yerznka	Crop	8	23,500	188,000
Nor-Yerznka	Orchard	3	23,500	70,500
Nor-Yerznka	Pasture land	1	23,500	23,500
Nor-Yerznka	Residential area	2	75,000	150,000
Ashtarak	Industrial area	2	95,000	190,000

Community	Land Use	No. of Plot (1)	Fee for Property Registration (2)	Total Cost (AMD) (3)=(1)*(2)
Ashtarak	Residential area	2	75,000	150,000
Yeghvard	Crop (partly acquired)	1	3,000	3,000
Ashtarak	Residential area (partly acquired)	2	26,000	52,000
Ashtarak	Industrial area (partly acquired)	1	26,000	26,000
Communal and State Land				
Yeghvard (community)	Farmland	54	3,500	189,000
Yeghvard (community)	Farmland (partly affected)	6	3,000	18,000
Nor-Yerznka (community)	Farmland	5	3,500	17,500
Nor-Yerznka (community)	Farmland (partly affected)	1	3,000	3,000
Nor-Yerznka (State)	Residential area	1	2,500	2,500
Nor-Yerznka (community)	Residential area	11	36,000	396,000
Ashtarak (community)	Residential area	5	36,000	180,000
Ashtarak(community)	Residential area (partly affected)	5	26,000	130,000
Ashtarak (State)	Residential area	1	35,000	35,000
Ashtarak (State)	Residential area (partly affected)	1	26,000	26,000
Total (AMD)				**2,014,500**
Total (USD) 1 USD=486.99AMD				*4,137*

Source) 1. Law on state Registration of Property Rights
2. Law on the State Duties

Table 5-2-8.3 (1), (2) and (3) show unit cost of tree, number of affected trees, and cost for tree loss, respectively. Since it takes 2 to 6 years for the fruit trees to grow to produce fruits, considering tree species and ages, the unit price were determined by the calculation of evaluator who has the official license (see, Table 5-2-8.3 (1)).

Table 5-2-8.3 (1) Unit Price of Seeding

Type of Tree	1st year	2nd year	3rd Year	4th year	5th year	6th year	Years to produce fruit*
Apricot	2,260	3,930	5,600	7,270	8,940	10,610	6
Pear	1,760	3,210	4,660	6,110	7,560	9,010	6
Nutswood	2,396	4,896	7,396	9,896	12,396	14,896	4
Plum	1,760	3,210	4,660	6,110	-	-	4
Cherry	1,260	2,710	4,160	5,610	-	-	4
Oleaster	2,760	4,430	6,100	7,770	9,440	-	-
Hazel nuts	2,396	4,896	7,396	9,896	12,396	14,896	6
Mulberry	2,260	3,930	5,600	7,270	-	-	4
Apple	1,260	2,710	4,160	5,610	7,060	8,510	6
Bird cherry	1,600	2,137	2,674	3,211	-	-	4
Peach	1,600	2,137	2,674	-	-	-	3
Grape	1,010	2,680	4,350	6,020	-	-	4

Source) JICA Survey Team, 2016 (estimated by the licensed land evaluator)

Remarks) Years to produce fruit depend on tree species.

Table 5-2-8.3 (2) Number of Affected Trees

Type of Tree	1st year	2nd year	3rd Year	4th year	5th year	6th year
Apricot	0	6	0	0	0	65
Pear	0	0	0	4	0	3,011
Nutswood	0	0	2	0	0	138
Plum	0	0	4	161	-	-
Cherry	0	0	0	75	-	-
Oleaster	0	0	0	0	1	-

Type of Tree	1st year	2nd year	3rd Year	4th year	5th year	6th year
Hazel nuts	0	0	0	4	0	6
Mulberry	0	0	3	2	-	-
Apple	0	350	0	0	0	819
Bird cherry	0	0	0	40	-	-
Peach	0	0	74	-	-	-
Grape*	0	12	0	78	-	-

Source) JICA Survey Team, 2016 (estimated by the licensed land evaluator)

Table 5-2-8.3 (3) Cost Estimation for Tree loss

Type of Tree	1st year	2nd year	3rd Year	4th year	5th year	6th year	Total
Apricot	0	23,580	0	0	0	689,650	713,230
Pear	0	0	0	24,440	0	27,129,110	27,153,550
Nutswood	0	0	14,792	0	0	2,055,648	2,070,440
Plum	0	0	18,640	983,710	-	-	1,002,350
Cherry	0	0	0	420,750	-	-	420,750
Oleaster	0	0	0	0	9,440	-	9,440
Hazel nuts	0	0	0	39,584	0	89,376	128,960
Mulberry	0	0	16,800	14,540	-	-	31,340
Apple	0	948,500	0	0	0	6,969,690	7,918,190
Bird cherry	0	0	0	128,440	-	-	128,440
Peach	0	0	197,876	-	-	-	197,876
Grape*	0	32,160	0	469,560	-	-	501,720
Total (AMD)							**40,276,286**
USD 1 USD = 486.99 AMD							82,705

Source) JICA Survey Team, 2016 (estimated by the licensed land evaluator)

The cost for crop loss is as shown in Table 5-2-8.4.

Table 5-2-8.4 Cost Estimation for Crop Loss

	Area (m^2) (1)	Yield (kg/m^2) (2)	Unit price (AMD/kg)* (3)	Compensation cost (AMD) (4)=(1)*(2)*(3)
Alfalfa	25,700	0.73	53	994,333
Total (AMD)				**994,333**
USD 1 USD = 486.99 AMD				*2,042*

Source) 1. Yield; JICA Survey Team, 2016 (estimated by the licensed land evaluator)
2. Unit price; Farmer's costs of agricultural products as given by the National Statistical Service of the Republic of Armenia for 2010-2014

If all of the communities concerned agree at the voluntary provision of the communal land (including Reservoir basin) for the Project, compensation to them will not be necessary. On the other hand, if the communities do not agree at the proposal, it is needed to provide compensation for the communal land loss (Reservoir basin and area along the proposed Outlet Canal-3). In case of compensation to the communities, the cost can be estimated as shown in Table 5-2-8.5.

Table 5-2-8.5 Cost Estimation for Communal Land Loss

Community	Land Use	Affected Area (ha) (1)	Unit Price (AMD/m^2) (2)	Applied Value (AMD/m^2) (3)=(2)*115%	Compensation Cost (AMD) (4)=(1)*(3)*10,000
Yeghvard	Agriculture (crop)	705.66	460	529	3,732,941,400
Nor-Yerznka	Agriculture (orchard)	27.88	880	1,012	282,145,600
	Residential Area	3.47	3,800	4,370	151,639,000
Ashtarak	Residential Area	1.92	8,700	10,005	192,096,000
Total (AMD)		**738.93**			**4,358,822,000**
Total (USD) 1 USD = 486.99 AMD					*8,950,537*

It is necessary to provide special consideration to the vulnerable persons who are affected by the Project. Table 5-2-8.6 shows the number and percentage of vulnerable people out of the 32 PAHs, which are targeted of socioeconomic survey.

Table 5-2-8.6 Number and Percentage of Vulnerable PAHs which are Targeted of Socioeconomic Survey

Item	No. of household	Share in total PAHs (%)
1) Recipient household of “poverty benefits”	2	6.25
2) Recipient household of “disability benefits”	3	9.38
3) Headed by female	3	9.38
4) Headed by elderly person	3	9.38

Source) JICA Survey Team, March-April of 2016

The actual number of the cultivators in the Reservoir basin is unknown, however, it can be estimated at 53 households, considering there are 53 plots at most. Therefore, the total number of project affected households can be thought as 75 (=53+22[14]).

Table 5-2-8.7 shows the results of calculation for potential vulnerable PAHs in the Project affected area by using the result of the socioeconomic survey.

Table 5-2-8.7 Potential Vulnerable PAHs within the Reservoir Basin

Item	Total no. of PAHs (1)	Share in total PAHs (%) (2)	Vulnerable PAHs within the Reservoir Basin (3)=(1)*(2)
1) Recipient household of “poverty benefits”	75	6.25	4.68
2) Recipient household of “disability benefits”	75	9.38	7.04
3) Headed by elderly person	75	9.38	7.04
4) Headed by female	75	9.38	7.04
Total			Approximately 26

Source) JICA Survey Team, March-April of 2016

The vulnerable persons is calculated as shown in Table 5-2-8.8.

Table 5-2-8.8 Allowance to the Vulnerable Persons

Item	No. of household	Unit Price (AMD/month)	Payment Period	Total (AMD)
Allowance to the vulnerable person	26HHs	55,000*	6 month	8,580,000

Source) Law on minimum monthly salary

Remarks) Since ADB project provided minimum monthly salary for 6 months to the vulnerable persons, the Project follows the same methodology.

Based on the cost estimation mentioned above, total compensation cost is as shown in Table 5-2-8.9.

Table 5-2-8.9 (1) Total Compensation Cost of the Project (Excluding the Communal Land Loss)

Item	Compensation Cost (AMD)
Private Land Loss	312,901,873
Property Registration	2,014,500
Tree Loss	40,276,286
Crop Loss	994,333
Allowance to the vulnerable persons	8,580,000
Total (1)	364,766,992
Contingency* (2)=(1)*0.20	72,953,398
Grand Total (AMD) (3)=(1)+(2)	**437,720,390**
Grand Total (USD) *1 USD = 486.99 AMD*	898,828

14 There are 15 PAHs with legal status and 7 PAHs which have cultivated within canal area without legal status.

Table 5-2-8.9 (2) Total Compensation Cost of the Project (Including the Communal Land Loss)

Item	Compensation Cost (AMD)
Private Land Loss	312,901,873
Property Registration	2,014,500
Tree Loss	40,276,286
Crop Loss	994,333
Allowance to the vulnerable persons	8,580,000
Communal Land Loss	4,358,822,000
Total (1)	4,723,588,992
Contingency* (2)=(1)*0.20	944,717,798
Grand Total (AMD) (3)=(1)+(2)	**5,668,306,790**
Grand Total (USD) *1 USD = 486.99 AMD*	11,639,473

Remarks) Based on the Resettlement Action Plan of Sustainable Urban Development Investment Program–Tranche 2 (ADB, 2015), contingency of the compensation cost of the Project is set at 20%.

5-2-9 Monitoring Structure and Monitoring Form

For carrying out of the RAP, it is required the internal and external monitoring by different organizations, as shown below;

(1) Internal Monitoring

The internal monitoring is carried out by PIU and private consultants for RAP implementation. In the internal monitoring process, following indicators could be proposed:

- Number of people raising grievances in relation to the Project and number of unresolved grievances;
- Progress of compensation payment;
- Whether the payment is properly done; and
- Change of the living conditions of PAPs.

(2) External Monitoring

The purpose of the external monitoring is examine the impacts on the PAPs objectively. The external monitoring is carried out by private consultants hired by the PIU/SCWE, who are independent from internal monitoring, to confirm whether the compensation, considerations, grievance redress and so on are properly implemented in accordance with the RAP.

(3) Monitoring Form

It is needed to confirm whether the proposed RAP is implemented as planned through the monitoring. Verification of payment, grievance handling, and conflict settlement have to be managed. During the compensation and construction stage, the monitoring will be practiced on monthly basis and it is implemented by the PIU/SCWE in collaboration with the private consultants. The consultants must provide technical advices to the PIU/SCWE, and the result should be complied as a monitoring report. After the construction completion, i.e., in the operation stage, the living conditions of the PAPs should be monitored bi-annually by PIU/SCWE by using format shown in Table 5-2-9.1.

Table 5-2-9.1 Sample of Format for Monitoring

Public Consultation

No.	Date	Place	Contents of the consultation/ main comments and answers
1			
2			

Resettlement Activities	Planned Total	Unit	Progress in Quantity			Progress in %		Expected Date of Completion	Responsible Organization
			During the Quarter	Till the Last Quarter	Up to the Quarter	Till the Last Quarter	Up to the Quarter		
Preparation RAP									PIU/ SCWE
Employment of Consultants		Man-month							
Implementation of Census Survey (including socioeconomic survey)									
Approval of RAP			Date of Approval:						
Finalization of PAPs List		No. of PAPs							
Progress of Compensation Payment		No. of PAHs							
Lot 1		No. of PAHs							
Lot 2		No. of PAHs							
Lot 3		No. of PAHs							
Lot 4		No. of PAHs							
Progress of Land Acquisition (all lots)		ha							
Lot 1		ha							
Lot 2		ha							
Lot 3		ha							
Lot 4		ha							
Progress Asset Replacement		No. of PAHs							
Lot 1		No. of PAHs							
Lot 2		No. of PAHs							
Lot 3		No. of PAHs							
Lot 4		ha							
Progress of Relocation of People (all lots)		No. of PAHs							
Lot 1		No. of PAHs							
Lot 2		No. of PAHs							
Lot 3		No. of PAHs							
Lot 4		ha							

5-2-10 Public Consultation

It was decided to hold the series of stakeholder meetings on ESIA and RAP at the same time. The venues to hold the Stakeholder Meetings are Yeghvard city and Nor-Yerznka village, since their get impacts by the Project mostly.

Following the Armenian law on Environmental Impact Assessment and Expertise, public consultation shall be organized at two stages. Before the start of the environmental impact assessment survey (Scoping Stage), the first Public Consultation should be organized, and the project outline and environmental expected impacts would be presented. In addition, before the submission the draft of ESIA Report, the second Public Consultation would be organized to share the environmental impact assessment results and gain comments from the participants. At the same time, it is needed to get feedback from the participants about socioeconomic survey results and compensation policy.

5-2-10-1 Arrangement of Public Consultation

Armenia has been a member country of the Aarhus Convention which has regulated the access-ability to the environmental information, since 2002. In Armenia, there are 15 Aarhus Centers, which was founded by Organization for Security and Cooperation in Europe (hereinafter, "OSCE"), in each Marzs. Especially, Ministry of Territorial Administration and Emergency Situations and MNP had been involved with their establishments. And Aarhus Center has promoted information disclosure and public involvement, with supporting of the Armenian Governmental organizations, including SCWE. Moreover, the centers have taken charge of arrangement for Public Consultation. Actually, SCWE requested Aarhus Center of Yeghvard City to support for holding of the first Public Consultation. SCWE, the Survey Team, and Aarhus Center of Yeghvard City worked together.

According to the Law on Environmental Impact Assessment and Expertise, seven working days before of Public Consultation, information of public consultation shall be noticed. On 8th October 2015, public notice was presented at the newspaper (see, Appendix K-11) and website of Aarhus center. And Table 5-2-10.1 shows the contents of the Public Notice which would be organized on 20th October 2015. And the same contents were published on the website of Aarhus Center.

Table 5-2-10.1 Contents of the Public Notice

A public hearing (consultation) about the document of “Application of the Initial Assessment of Environmental Impact of the Yeghvard Irrigation System Improvement Project” will be held on 20th October, 2015, at 15.00 - 18.00 at the Yeghvard Municipality Conference hall (address: Yeghvard, 1Yerevanyan street) as follows:	
Undertaker	State Committee of Water Economy, MOA, Armenia
Venue of the public Consultation	1 Yerevanyan str., Yeghvard, Conference Hall of the Municipality
Possible environmental impact	Some environmental impacts due to the project are expected.
Time, date, location and method to learn about the application mentioned above	The initial assessment application is uploaded in website of following addresses: ・State Committee of Water Economy (Yerevan, Vardanants deadlock 13A) – www.scws.am ・Yeghvard Municipality info@yegvard.am, and ・Yeghvard Aarhus Center - www.aarhus. Furthermore, you can contact the offices mentioned above every day at 14.00-18.00 from the day of public notice to the deadline mentioned below, if you want to make the comments and suggestions on the application.
The deadline for submitting comments and suggestions on the application	7 working days after, counting from the date of public notice.
Responsible officer for discussions	Yeghvard Municipality
E-mail address and telephone number of Responsible Officer	E-mail address info@yegvard.am Tel. (0224) 2 11 10

5-2-10-2 Public Consultation on the Project Outline by SCWE

On 20th October 2015, the Public Consultation on the Project Outline was organized at Yeghvard City office. This Public Consultation was organized by the Project, and general project outlies was explained to the participants.

Table 5-2-10.2 shows the comments and questions from the attendances. Seemingly, the attendants do not oppose to the Project.

Table 5-2-10.2 Discussion at the Public Consultation on the Project Outline (20th October 2015)

No.	Speakers	Questions/ Comments	Respondents	Answers
1.	Director of Vagharshapat WUA	How is the stakeholder territory of the project distributed among WUA? How much territory will be served by each of 4 WUAs?	Hydro-technical Engineer of PIU	Mentioned that the studies are still being carried out, but the areas being served are known. The biggest areas are in Khoy and Vagharshapat WUAs.
2.	Director of Yeghvard WUA	How about the progress and results of geological survey for determination of water permeability of the bottom of Yeghvard reservoir?	Team leader of the Survey Team	We started the investigations in June. The geological survey and the ground water survey were implemented. The preliminary data show that the permeability coefficient is high and the water may easily infiltrate through the existing layer. Therefore, it is necessary to take anti-filtration measures. The type of impervious material and the method of application will be determined as a result of survey. The expenses related to reservoir construction are mostly dependent on the type of impervious layer.
3.	Mayor of Ashtarak City	How much is the approximate budget for Yeghvard irrigation system improvement project and is it planned to create a recreation zone near the reservoir?	Hydro-technical Engineer of PIU	As it was mentioned by Mr. Tsumura, the project budget depends on the method and material of impervious layer. The budget will be calculated after selection of the abovementioned. Regarding the creation of recreation zone near the reservoir, it is not a subject of this project and is not being considered by the survey team.
4.	Director of Ashtarak WUA	Some areas of the 27 communities are located on higher altitude than Yeghvard reservoir. How will the irrigation be done for them? Do you plan to construct new canals?	Hydro-technical Engineer of PIU	New canals will not be constructed. The water from Yeghvard reservoir will flow to Arzni-Branch canal and Kasakh river, and will be guided to stakeholder communities by the use of existing system.
5.	Social Expert of PIU	How is the status and ownership of the lands of the territory of reservoir?	Social Specialist of ATMS Solutions LLC	Mentioned that the issues of alienation and compensation of the lands are being considered in the frames of F/S of Yeghvard irrigation system improvement project. At this moment the studies are still being carried out and there are no final results. However, there will be several explanations. Particularly, the actual reservoir is located on community lands that belong to Yeghvard and Nor-Yerznka communities. This means that large scale resettlement is not envisaged. However, in case of feeder and intake canals, resettlement issue may arise. However, the canal routes have not been determined yet. Detail information will be provided to the Client soon.
6.	Mayor of Ashtarak City	Is there an issue of transportation of topsoil? Is it completely transported? If there is such an issue, then you have to consider it.	Hydro-technical Engineer of PIU	Most part is transported to Ashtarak to establish gardens. There is a few humus in the territory.
7.	Deputy Mayor of Yeghvard City	As I know the Japanese company is mainly implementing technical surveys. Do you have any preliminary data on the possible impact on the environment?	Environmental Consideration of the JICA Survey Team	The environmental impact assessment of Yeghvard irrigation system improvement project is on-going. Impacts on ecosystem, especially to the fishes of Hrazdan and Kasakh rivers, are examined. Besides, underground water and soil contamination by pesticides/fertilizer in the beneficial areas are studied.

No.	Speakers	Questions/ Comments	Respondents	Answers
8.	Director of Vagharshapat WUA	If the water of Kasakh river will flow to Yeghvard reservoir, is there a possibility, that the irrigation of the territories served by "Khoy" and "Vagharshapat" WUAs will depend on reservoir?	Hydro-technical Engineer of PIU	Water of Kasakh river will not be used. Only the additional surplus water will be directed to the reservoir. The reservoir will store 90 MCM of water, which will be used by WUAs (Khoi, Vagharshapat, Yeghvard and Ashtarak). The water will be stored in the reservoir during non-irrigation season, mainly during spring floods.
9.	Deputy Chairman of SCWE	What are possible social and environmental risks during construction of reservoirs and if they are typical for Yeghvard reservoir?	Environmental Consideration of the JICA Survey Team	Regarding the social impact, in case of construction of canals, the issue of alienation and compensation will arise. The lands in the actual reservoir area are not private. However, the people who cultivate there will have to leave their lands. As for natural environmental impact, there will be air pollution because of large-scale construction works with various types of machines and vehicles. As the reservoir will be filled by the water from Hrazdan river, which will then flow to Kasakh river, the ecosystems of Hrazdan and Kasakh rivers will possibly mix with each other. In case of such projects, it is very difficult to avoid environmental impact completely, however, our goal is to minimize it.
10.	Resident of Yeghvard City	How many years will the construction of Yeghvard reservoir last?	Hydro-technical Engineer of PIU	The F/S stage of Yeghvard irrigation system improvement project will be finished in May 2016. 1-1.5 years will be required for agreement of it. After that, 4-5 years will be required for construction of the reservoir.
11.	Resident of Yeghvard City	Is there any initial calculation of minimum and maximum depths of the reservoir to be constructed?	Hydro-technical Engineer of PIU	According to the initial calculations the maximum depth is going to be 15 m. The minimum depth is going to be 1.5 meters. It means that 6 MCM will always remain in the reservoir.

As Table 5-2-10.3 shows attendants, the total numbers of the attendants was 35. 17 persons out of 35 are from SCWE, PIU, JICA Survey team member, Aarhus Center staff and the environmental consultants for ESIA and RAP preparation, while 18 persons out of 35 are from beneficial communities, 4 WUAs concerned to the Project, and additional 2 WUAs.

Table 5-2-10.3 Participant List of the Public Consultation on the Project Outline (20th October 2015)

No.	Name	Position	Organization
1.	Volodya Narimanyan	Deputy Chairman	SCWE, MOA
2.	Viktor Martirosyan	Advisor of Chairman	
3.	Khoren Tsarukyan	Hydro-technical Engineer	PIU, SCWE, MOA
4.	Marina Vardanyan	Social Expert	
5.	Martiros Nalbandyan	Environmental Expert	
6.	Kazumitsu Tsumura	Team Leader	The Survey Team of JICA
7.	Rie Kitao	Environmental Consideration	
8.	Shohey Natsuda	Social Consideration (1)	
9.	Ayumi Shiga	Social Consideration (2)	
10.	Gevorg Gevorgyan	Assistant/ Interpreter	
11.	Luiza Manyan	Assistant/ Interpreter	
12.	Khristine Goroyan	Assistant/ Interpreter	
13.	Ruzanna Manyan	Head Officer	Aarhus Center
14.	Anush Beybutyan	Coordinator	
15.	Artak Ter-Terosyan	Environmental Specialist, Director	ATMS Solutions LLC, Local ESIA Consultant
16.	Suren Gyunrjinyan	Social Specialist	
17.	G.Sahakyan	Cameraman	
18.	Karen Harutyunyan	Deputy Mayor	Yeghvard city
19.	-----	Resident (Head of Library)	
20.	-----	Resident (Librarian)	
21.	-----	Resident (Librarian)	
22.	-----	Resident	
23.	Armen Antonyan	Mayor	Ashtarak city
24.	Armen Sargsyan	Head of Community	Hovtamej Community
25.	Suren Baghdasaryan	Deputy Head of Community	Zovuni Community

No.	Name	Position	Organization
26.	Sedrak Khachatryan	Head of Community	Kashakh Community
27.	V.Mkhitaryan	Representative	Sasunik Community
28.	G.Shahgeldyan	Representative	Arshaluys Community
29.	A.Movsesyan	Representative	Aragats Community
30.	MIhran Hovhannisyan	Director	Yeghvard WUA
31.	Sedrakyan Sedrakyan	Director	Vagharshapat WUA
32.	Arsen.Khachatryan	Director	Ashtarak WUA
33.	Sargyan Sargsyan	Director	Khoy WUA
34.	Hovik Gevorgyan	Director	Parpi WUA*
35.	Armen Karapetyan	Director	Nairi WUA*

Remarks: 1. Parpi WUA and Nairi WUA are outside of project beneficiary and affected areas.
2. In Armenia, generally, there are one or plural communities under one community. Both Yeghvard and Ashtarak are categorized into city, those cities have one community each, Yeghvard City is sometimes called as Yeghvard Community. Communities are politically managed by “Head”, while City is headed by ”Mayor”.

5-2-10-3 Public Seminar on the Project Outline in Nor-Yerznka Village

Given that the number of participants from the communities, namely, general residents, at the public consultation is limited, a seminar was organized to promote the local residents to attend more to supplement the public consultation on 5th November, 2015 in Nor-Yerznka village.

Nor-Yerznka village is located on west of the Yeghvard Reservoir, and parts of the village could be affected by the Project. At the arrangement of the seminar, the Project side tries to enhance women’s participation in the seminar in terms of gender balance, since women’s participation rate in the Public Consultation was low. On the other hand, it is noted that Head of Nor-Yerznka village is female.

At the seminar, the project outlines and expected impact by the Project were explained by the Project Coordinator of PIU/SCWE, Mr. K.Tsarukyan, using the same presentation material as the one at the Public Consultation was used. Moreover, the location map illustrating the affected area in the village was also presented to the participants. It is noted that two routes for Outlet Canal-2, namely, 1) northern route which passes through orchard and houses and 2) southern route passes through natural stream, were proposed at that time, both route on the map ware presented[15]. The participants made some questions and comments as shown in following table. As a whole, no objection against the Project was presented, however, some issues to be examined were raised.

Table 5-2-10.4 Discussion at the Public Seminar in Nor-Yerznka Village (5th November 2015)

No.	Speaker	Question and Comment	Answer
1.	Head of the village	Proposed northern route for Outlet Canal passes through the graveyard, and it is very difficult to expropriate the lands around the route On the other hand, another option, namely, southern route passes through natural stream, which results in small impacts on the residents. The community supports the Project, if southern route is selected.	-
2.	Resident	My concerns are counteraction of the Reservoir and earthquake proof.	Japan has experienced many natural disasters, Japanese engineer’s design is reliable. It is planned to implement quake-resistance study during the survey.(Mr. Khoren Tsarukyan, PIU)
3.	Resident	Impact on the community by water leakage from the Reservoir is also a concern.	After the completion of the reservoir construction, it is planned to maintain the Reservoir continuously and take measures against any problems. The Project is not first reservoir construction project. Your concern has been already examined in other reservoir construction projects so far, and you do not have to be worry about the issue. Safe reservoir construction is examined. (Mr. Khoren Tsarukyan, PIU)
4.	Resident	What is the reason for intake from the Arzni-Shamiram Canal? Do you have a plan to use the irrigation water of the canal?	It is planned to use free water of the Hrazdan River through the Arzni-Shamiram Canal, and to store the water at the Yeghvard Reservoir. (Mr. Khoren Tsarukyan, PIU)

[15] Ultimately, the northern route was not proposed as the Project component.

No.	Speaker	Question and Comment	Answer
5.	Resident	I think the free-water is only one million tons.	According to current estimation, amount of the free water is 90 million tons and the water will be stored during 2-3 months. (Mr. Khoren Tsarukyan, PIU).
6.	Head of the Village	Nor-Yerznka Community uses Aparam Canal and Arzni-Shamiram Canal for irrigation. Is it possible for the community to use the store water at the Yeghvard Reservoir?	The Project plans to divert the stored water at the Reservoir to the Kasakh River for irrigation of Ararat Plain. Beneficial communities are Kasakh, Zovuni, Proshyan and so on. (Mr. Khoren Tsarukyan, PIU)
7.	Resident	Is it planned to use canals to discharge the Reservoir water to the Ararat Plan?	Kasakh River will be used for water distribution to the Ararat Plain. (Mr. Khoren Tsarukyan, PIU)
8.	Resident	When river water is used, around 20% of the water will be lost?	In general, water loss in river is observed even in natural conditions. However, free water, which is planned to be diverted to the Kasakh, can be used without loss. Mr. Khoren Tsarukyan, PIU)
9.	Resident	Existing roads are included in the affected areas, and how the roads will be changed after the construction works?	After the pipelines are buried, the roads will be restored to the original conditions. (PIU, Mr. Khoren Tsarukyan Mr. Khoren Tsarukyan, PIU)
10.	Resident	I think that capacity of the Reservoir becomes smaller than that before.	Original plan of reservoir capacity was 230 MCM, while current planned capacity is around 90 MCM.(Mr. Khoren Tsarukyan, PIU)
11.	Head of the Village	How do you evaluate the compensation rate? Is it based on the market price or official price t?	Based on the law/regulation, land evaluation and compensation will be implemented. (Mr. Artak Ter-Torosyan, ATMS Solutions LLC) The Reservoir basin is owned by State/Community, therefore, compensation for the loss in the reservoir will not be a big issue. Regarding temporary land acquisition, compensation for the loss during the construction period will be provided. (Mr. Khoren Tsarukyan, PIU)
12.	Resident	Which place is the highest point of water pressure by the Reservoir?	Nor-Yerznka Community side in the Reservoir is relatively higher. (Mr. Khoren Tsarukyan, PIU)
13.	Resident	If the Reservoir capacity is 90 MCM, how deep in the reservoir?	Around 15-16m depth. Since the reservoir area is wide, water depth is not very huge. It is noted that the standard of quake-resistant during Soviet Union period was not very strict, however, new standard becomes strict than before. The quake-resistant design/measure is examined in collaboration with the Academy at this moment. (Mr. Khoren Tsarukyan, PIU)
14.	Resident	When will the construction works start?	It is F/S stage at this moment and after the F/S completion, Loan Agreement (L/A) will be exchanged. After the L/A, it will take 1.5 years for Detailed Design (D/D). After the D/D completion, the construction works will be started. (Mr. Khoren Tsarukyan, PIU)
15.	Resident	Climate change due to the construction works is expected?	It is recommended to ask the environmental expert for the issue. (Mr. Khoren Tsarukyan, PIU)
16.	Head of the Village	Are there any environmental impacts on Nor-Yerznka Community?	During construction stage, heavy construction vehicles will be used, which can cause air pollution. (Mr. Khoren Tsarukyan, PIU)
17.	Resident	What kinds of materials will be used during construction stage? Do you have a plan to use oil?	It is planned to reduce the impacts on natural environment by the construction materials as much as possible. (Mr. Khoren Tsarukyan, PIU)
18.	Head of the Village	There can be some dangerous situations by the Project. However, due to the increase of soil moisture, I think that Nor-Yerznka Community can be rich.	Indirect impact such as increase of agrichemical application amount will be examined. (Mr. Khoren Tsarukyan, PIU)
19.	Resident	The most important matter for the Community is safety, namely, quake-resistant measures of the Reservoir. Permeability examination during the construction stage is necessary.	If no measure is taken, all of the 90MCM water for the Reservoir will be infiltrated into the soil. Therefore, any measures have to be done. At this moment, anti-infiltration works are examined, and main construction cost will be for the works. In the Reservoir basin, most of area consists of sand and clay, while only a part of northern part of the Reservoir basin is rock. (Mr. Khoren Tsarukyan, PIU)
20.	Resident	Do you have a plan to transport of the fertile top-soil within in the Reservoir basin to other areas?	Some parts of top-soil in the Reservoir basin had been already transported during the Soviet Union period. If necessary, before the construction works, transportation of the top-soil will be examined. (Mr. Khoren Tsarukyan, PIU)
21.	Resident	The most important matter for the Community is safety. If safety is considered and secured, we will support the Project.	—
22.	Resident	Water leakage will give damage to not only Nor-Yerznka Community, but also Zovuni Community.	—
23.	JICA Survey	We would like to some female participants to	It seems that everybody regards the Project as very good

No.	Speaker	Question and Comment	Answer
	Team	express their opinions.	one. However, there can be a possibility that dangerous situations in the Community will be caused by the Project, and I cannot support the Project completely. (a female resident)

At the seminar, official personnel of the PIU, the Survey team members, private environment experts (ATMS Solutions LLC), staff of Aarhus Center, the Community Head, and fifteen (15) residents including WUA Deputy Head participated. Attendant list of the seminar is as shown in Table 5-2-10.5.

Table5-2-10.5 Participant List of the Public Seminar in Nor-Yerznka Village (5th November 2015)

No.	Name	Position	Organization
1.	Alina Sahakyan	Head of the Community	Nor-Yerznka Village
2.	Haikush Nazaryan	Community office worker	Nor-Yerznka Village
3.	Lolita Tonotyan	Community office worker	Nor-Yerznka Village
4.	Artur Tonyan	Deputy Head	Ashtarak WUA
5.	-----	Resident	
6.	-----	Resident	
7.	-----	Resident (a vehicle Operator)	
8.	-----	Resident (Director of Culture House)	
9.	-----	Resident (School Director)	
10.	-----	Resident (Librarian)	
11.	-----	Resident	
12.	-----	Resident	
13.	-----	Resident (Farmer)	
14.	-----	Resident	
15.	-----	Resident	
16.	-----	Resident	
17.	Khoren Tsarukyan	Hydro-technical engineer	PIU, SCWE, MOA
18.	Kazumitsu TSUMURA	Team Leader	JICA Survey Team
19.	Ayumi SHIGA	Environmental and Social Consideration	JICA Survey Team
20.	Gevorg GEVORGYAN	Interpreter	JICA Survey Team
21.	Ruzanna Manyan	Coordinator	Aarhus Center
22.	Artak Ter-Torosyan	Director	ATMS Solutions LLC

5-2-10-4 Public Consultation on the Project Outline by the MNP

Based on the law in Armenia, the Public Consultation by the MNP on application of the Initial Environmental was held in Yeghvard municipality on 23rd December 2015. The Public Consultation was organized under the responsibility of the MNP, for the purpose of confirmation of the result of the Public Consultation, which had been already done by the Project. The opening remarks were done by Mr. K. Harutyunyan, Deputy Mayor of Yeghvard city and Ms. A. Drnoyan, the specialist of "Environmental Impact Expertise Center" SNCO. The discussion at the Public Consultation by the MNP is as shown below:

Table 5-2-10.6 Discussion at the Public Consultation on the Project Outline by MNP (23rd December 2015)

No	Speaker	Question and Comment	Answer
1.	Resident	What water will be used to fill the reservoir? Will the water of Sevan Lake be used? Is there enough water reserve, which will ensure irrigation of agricultural lands during irrigation period?	Water of Hrazdan river will be used to fill the reservoir through Arzni-Shamiram canal during springtime before irrigation season. Regarding the irrigation water reserves, 90MCM water will be reserved annually, which is quite huge amount for irrigation of lands. (Mr. Khoren Tsarukyan, PIU)
2.	Resident	You mentioned during presentation that the construction of reservoir will solve social issues. What kind of labor issues will be solved and is a fishing industry planned?	Currently our task is to construct the reservoir for the purpose of irrigation of lands. Regarding the recreation zone, maybe in the future fishing industry and recreation zone will also be considered, but such works are not envisaged in current project. (Mr. Khoren Tsarukyan, PIU)
3.	Resident	Is there a possibility to create a recreational zone around the reservoir?	
4.	Resident	What will happen to the humus (top soil) after removal during reservoir construction works? Will it be provided to land users of that territory?	The removed humus will be used for agriculture. (Mr. A. Ter-Torosyan, Environmental expert of ATMS Solutions LLC) Answers of such questions related to humus will be given in the main stage of environmental impact assessment and alternative options for solution of those issues may be proposed. All the proposals and

No	Speaker	Question and Comment	Answer
			remarks will be taken into consideration. (Ms. A. Drnoyan)
5.	Resident	What kind of compensations will be provided to the owners of lands in the territory of reservoir?	Beside the laws of the Republic of Armenia there are international regulations, according to which, the land user, who has no ownership of the land, will not receive compensation as a land owner, but investments he made for cultivation of the land will be compensated. (Mr. M. Vardanyan, Chief accountant of "Welfare and housing fund" office)
6.	Resident	Will there be independent experts in the stage of assessment of environmental impact?	Independent experts are also being involved during the main stage of expertise, but this is still an initial stage and no independent expert is involved. (Ms. A. Drnoyan)

Table 5-2-10.7 Participant List of the Public Consultation by MNP (23rd December 2015)

No.	Name	Position	Organization
1.	K.Harutyunyan	Deputy-Mayor	Yeghvard city
2.	A.Drnoyan	Specialist	"Environmental Impact Expertise Center" SNCO, MNP
3.	N.Karapetyan	Leading specialist of Yeghvard City	Yeghvard City
4.	R.Manyan	Coordinator	Yeghvard Aarhus center
5.	M.Vardanyan	Specialist of social affairs	PIU, SCWE, MOA
6.	D.Zakaryan	Hydrologist	PIU, SCWE, MOA
7.	K.Tsarukyan	Hydro-technical engineer	PIU, SCWE, MOA
8.	A.Ter-Torosyan	Director	ATMS Solutions LLC
9.	A.Vardanyan	Chief accountant	"Welfare and Housing Fund" office
10.	A.Aleksanyan	Clerk	"Welfare and housing fund" office
11.	-----	Resident of Yeghvard Community	
12.	-----	Resident of Yeghvard Community	
13.	-----	Resident of Yeghvard Community	
14.	-----	Resident of Yeghvard Community	
15.	-----	Resident of Yeghvard Community	
16.	-----	Resident of Yeghvard Community	
17.	-----	Resident of Yeghvard Community	
18.	-----	Resident of Yeghvard Community	
19.	-----	Resident of Yeghvard Community	
20.	-----	Resident of Yeghvard Community	
21.	-----	Resident of Yeghvard Community	
22	-----	Resident of Yeghvard Community	

5-2-10-5 Public Seminars on Environmental and Social Impacts by the Project

It is not a duty for any project undertakers to organize public consultations for Category A projects more than twice. However, the Project could cause land acquisition and several dozen people will be affected, and expected impacts by the Project should be presented to the people at early stage, so that, the Project can be implemented smoothly. Based on the concept, the public seminars to explain about anticipated impacts were organized on 31st May 2016 prior to the official public consultation on the ESIA report. The most affected areas by the Project are Yeghvard Community and Nor-Yerznka Community, and the seminars were held at those municipality offices. Public notice were presented at two (2) community offices mentioned above and four (4) WUA offices concerned (see the photos of public notice in Appendix 6) to encourage the people concerned to participate in the seminar as much as possible.

At the seminars, as a whole, there were no objection against the Project, and the participants are interested in compensation policy, transportation of fertile top-soil in the Reservoir basin, anti-infiltration works and involuntary communal land provision. It is noted that both heads of communities hope governmental support, e.g. small scale of project, in case of voluntary communal land provision. The discussions and participant lists at Nor-Yerznka Community and Yeghvard Community are shown in Table 5-2-10.8, Table 5-2-10.9, Table 5-2-10.10, and Table 5-2-10.11, respectively.

Table 5-2-10.8 Discussion at the Public Seminar in Nor-Yerznka Village on Environmental and Social Impacts (31st May 2016)

No.	Speaker	Question and Comment	Answer
1.	Resident	What benefit will Nor Yerznka community receive from the reservoir? I think we have a privileged use of water, however, people don't get water even now.	If you have water shortage issue, please apply to PIU and explain your problem, they will record it. At this moment, we are in the F/S stage. We will implement further study in next stage (D/D). (Khoren Tsarukyan / PIU)
2.	Alina Harutyunyan/ Head of Community	We have gathered today in order to discuss issues related to the reservoir. If you have some other issues related to PIU, we will discuss it later.	Today's topic of discussion is environmental and social impacts by the Project, in terms of positive and negative impact. (Khoren Tsarukyan / PIU)
3.	Resident	How long does it take for the construction works?	Around 4 years (Khoren Tsarukyan / PIU)
4.	Resident	What if I do not agree with the compensation amount? (***1)**	It is today's main subject to be discussed. If you do not agree, we may decide not to pass the pipeline through your land (Khoren Tsarukyan / PIU)
5.	Alina Harutyunyan/ Head of Community	How many meters of width is necessary for burying the pipeline (φ1,600mm) which will pass through the community?	In general, 15m width for one-side (excluding canal) is secured for the proposed pipeline, still, in this Project, more than 15 m width for the pipeline is secured for safety side. It is noted that this is F/S stage and it will be finally decided during D/D stage. Everything will be done in accordance with the law. (Khoren Tsarukyan / PIU)
6.	Alina Harutyunyan/ Head of Community	Are you going to use existing dam or implement some additional works related to the dam?	Yes. It will be a high quality dam by using existing dam and additional works. The specialists from Japan have a rich related experience. We will take all the possible measures to ensure the safety of the dam. (Khoren Tsarukyan / PIU)
7.	Resident	There are many sandy areas in the reservoir basin. According to my experience, sprayed water is immediately absorbed into the soil. So, there will be a problem of infiltration.	We have carried out many surveys. The most severe issue is the anti-infiltration works. We have planned to implement anti-infiltration works to solve the issue. (Khoren Tsarukyan / PIU)
8.	Resident	Do you have a plan to construct a spill way?	No, the water is going to be discharged into Kasakh river through Outlet canal pipeline. In case of Yeghvard reservoir, we do not have the issue of catastrophic discharge facilities, because it is not going to be constructed on the river. In case of river, it is necessary to construct spill way.(Khoren Tsarukyan / PIU)
9.	Resident	But what if we have an earthquake?	We are going to design an emergency action plan where all the issues and scenarios will be considered. (Khoren Tsarukyan / PIU)
10.	Resident	How deep will the reservoir be?	10-15m (Khoren Tsarukyan / PIU)
11.	Alina Harutyunyan/ Head of Community	Why does the section related to fertile soil contain only the name of Yeghvard community?	It is possible to discuss the matter, If you have the land within the Reservoir. (Artak Ter-Torosyan / ATMS Solutions) There is not going to be any biased towards any of the communities. There will be multi-party supervision not only by PIU, SCWE, Ministry of Agriculture (Suren Gyurjinyan / ATMS Solutions)
12.	Resident	You said that it will take 4 years for the construction works. Have you considered that we have very strong wind from end of May to end of June? And all the construction dust will be blown away to Nor Yerznka community. So, it can be a kind of environmental impact on the village by the Project.	We will certainly take it into account **(*2)** (Artak Ter-Torosyan / ATMS Solutions)
13.	Alina Harutyunyan/ Head of Community	I have a concern related to donation of the community lands to the state. If the land is taken from the community, at least some investments should be made in the community by the state. We do not want money. If the state can implement some small scale project for the community, it is OK. We need improved irrigation systems. Please mention this issue in your minutes of meeting because we have made some investments in many lands and donated them to the state.**(*4)**	The law is on your side. According to law, you can receive compensation.**(*3)** (Suren Gyurjinyan / ATMS Solutions) The community should defend your own interests. You can demand any supports from the state. (Suren Gyurjinyan / ATMS Solutions) I think this should be mentioned in the minutes of meeting and it can be taken into account later (Marine Vardanyan / PIU)
14.	Resident	In the presentation, construction of a new pipeline which will pass through the	Yes, it is planned in the Project. If your land is located under this pipeline, you will get water. (Khoren

No.	Speaker	Question and Comment	Answer
		community is proposed. Is it possible to connect the new pipeline with an existing pipeline which provides water to Ashtarak canal?	Tsarukyan / PIU)

*1: The question No.4 mentioned above was made before explanation of compensation policy, and the speaker understand the policy after the explanation.

*2: It is possible to minimize dust generation by water spray at the construction site.

*3: There is a case that the State provided compensation for communal land loss in Armenia (RAP for Construction of Road Links of Yerevan Western Ring Road, ADB, 2015). However, in the Project, it has yet to be decided whether the communities concerned to the Project will provide the communal land to the State voluntarily. This issue will be discussed after the Loan Agreement.

*4: It is possible to request to the Government to provide some small scale projects for the community. However, it is not fixed whether the Project will be implemented, therefore, after the loan agreement, such negotiation will be done between the community and the government.

Table 5-2-10.9 Participant List of the Public Seminar in Nor-Yerznka Village (31st May 2016)

No.	Full Name	Position	Organization
1	Alina Harutyunyan	Head of Community	Nor Yerznka Community
2	Lolita Tonoyan	Chief Specialist	Nor Yerznka Community
3	Yupik Rzgoyan	Chief Specialist	Proshyan Community
4	-----	Resident, Nor Yerznka	
5	-----	Resident, Nor Yerznka	
6	-----	Resident, Nor Yerznka	
7	-----	Resident, Nor Yerznka	
8	-----	Resident, Nor Yerznka	
9	-----	Resident, Nor Yerznka	
10	-----	Resident, Nor Yerznka	
11	-----	Resident, Nor Yerznka	
12	-----	Resident, Nor Yerznka	
13	-----	Resident, Nor Yerznka	
14	Artur Tonyan	Deputy Head	Ashtarak WUA
15	Khoren Tsarukyan	Hydro-technical Engineer	PIU
16	David Zakaryan	Hydrologist	PIU
17	Marine Vardanyan	Social Expert	PIU
18	Ruzan Khojikyan	Program Coordinator in Armenia	JICA Armenia Liaison Office
20	Ayumi Shiga	Social Consideration	JICA Survey Team
21	Gevorg Gevorgyan	Assistant	JICA Survey Team
22	Kristine Goroyan	Assistant	JICA Survey Team
23	Luiza Ohanian	Assistant	JICA Survey Team
24	Artak Ter-Torosyan	Environmental Specialist	ATMS Solutions LLC
25	Suren Gyurjinyan	Resettlement Specialist	ATMS Solutions LLC

Table 5-2-10.10 Discussion at the Public Seminar in Yeghvard City on Environmental and Social Impacts (31st May 2016)

No.	Speaker	Question and Comment	Answer
1.	Karen Harutyunyan / Deputy Mayor	There are many poisonous snakes in the Reservoir basin. When the construction works are started, they will escape to outside of the Reservoir. We should not allow them to hurt people. The reservoir is surrounded by communities. Wherever the snakes go, we will face danger. Please consider the countermeasure against the issue.	At the moment, we do not have any ready-made solutions. We will try to find an optimal solution to the issue. (Artak Ter-Torosyan / ATMS Solutions)
2.	Karen Harutyunyan / Deputy Mayor	Currently, Hrazdan River and Kasakh River are not connected each other. If fish from the Hrazdan River are flushed to the Kasakh River through Yeghvard Reservoir, fish in both rivers can be mixed. Any ecological problems will be caused?	We are going to take the water at Arzni-Shamiram intake from the Hrazdan River. Around the intake point in Hrazdan River, 6 fish species are identified, and 5 species out of them are also identified in Kasakh River. Hence, it will not be a big issue. (Rie Kitao / JICA Survey Team)
3.	Karen Harutyunyan / Deputy Mayor	What if only a part of the land is to be alienated?	If the owner of the alienated land can prove that the remaining part of land (not to be alienated) also cannot be used any more since it is useless, he/she can demand compensation for whole land. In case of large lands, there is a principle of partial

No.	Speaker	Question and Comment	Answer
			alienation. But in case of small lands, we have adopted the principle of alienating the whole area of the land. (Suren Gyurjinyan / ATMS Solutions)
4.	Garush Simonyan / Kasakh Community	We also have a problem of the difference of market price of the lands before and after construction of the reservoir.	Armenian legislation stipulates a very clear price determination methodology. Unit price of land is market price plus 15%. The land price should be determined before the construction. According to the regulation, a professional land evaluator with license makes measurement of the affected area, and set the market price. A notification is sent to the owner. If the owner does not agree the price, he/she can appeal to the court. Governmental decree simply states which area of land should be alienated for public interest, however, there is no provision of market price in case of alienation. (Suren Gyurjinyan / ATMS Solutions)
5.	Karen Harutyunyan / Deputy Mayor	Isn't the Government responsible for determining the market price?	No. Government will not determine the land price. Land evaluators will do that. (Suren Gyurjinyan / ATMS Solutions)
6.	Garush Simonyan / Kasakh Community	Can the resident insist on getting land as compensation instead of money?	He can negotiate and come to an agreement. He cannot take the case to the court. Experience shows that the amount of compensation is almost always acceptable for the land owner. (Suren Gyurjinyan / ATMS Solutions)
7.	Garush Simonyan / Kasakh Community	When the Reservoir is constructed, the land price will be increased. If compensation is done before construction, the land price can be lower than that after the project completion.	We have to follow the law for land price estimation regardless of land price increase or decrease. (Suren Gyurjinyan / ATMS Solutions)
8.	Sargis Hovhannisyan / land owner /officer of community	I have two pieces of lands in the affected area, in one land, 2 year-old apple trees are planted, while 8 years apple trees are planted in another land. How the compensation will be done?	One of the lands (8-year-old trees) is out of the affected area. Regarding the other one, you will get compensation for the land, as well as for your expenses made for the apple trees. (Suren Gyurjinyan / ATMS Solutions)
9.	Karen Harutyunyan / Deputy Mayor	Which company will construct the reservoir? Is there going to be an international or a local tender?	Irrespective of international or local contractor, we will suggest the contractor to hire the local population as much as possible. We will also suggest the contractor to provide job opportunity for local women, for instance, to employ women as cook for labors. (Marine Vardanyan /PIU)
10.	Karen Harutyunyan / Deputy Mayor	Those who get a pension at this moment can receive allowance by the Project. It means that they receive both the pension and allowance.	That is why we have introduced some additional criteria, namely families headed by single mothers, old people and families that have disabled members. If you can suggest any other criteria, we are ready to discuss it. (Suren Gyurjinyan / ATMS Solutions)
11.	Karen Harutyunyan / Deputy Mayor	We provide community lands to the state but don't get anything in return. So, we would like to get some benefits. For instance, we could have free irrigation system for 10-15 years.**(*1)**	I would suggest that you negotiate on some social projects, for instance, construction of a school (Suren Gyurjinyan / ATMS Solutions)
12	Karen Harutyunyan / Deputy Mayor	Are you going to completely use the stored water at the reservoir during the irrigation period?	No, it is going to keep a "dead" water level. In the area close to Nor Yerznka, the water depth will be 2-3m, while it will be around 0.5m near Yeghvard Community. (Khoren Tsarukyan / PIU)
13.	Karen Harutyunyan / Deputy Mayor	In such case, a swamp can be formed?	No, because the water will flow all the time. The water is continually stored and discharged for irrigation. Therefore, water will not be stagnant and no swamp will be formed. (Khoren Tsarukyan / PIU)
14.	Karen Harutyunyan / Deputy Mayor	What kind of anti-infiltration measure do you plan to use?	We plan to use bentonite sheet and soil-cement. This soil-cement will be kind of a weak concrete. And the slopes will be protected from wave action and infiltration.

No.	Speaker	Question and Comment	Answer
			(Khoren Tsarukyan / PIU)
15.	Garush Simonyan / Kasakh Community	Are the ground waters affected by the Project?	The ground waters range in very deep layer, at around 120-130m, the water is filtrating into the ground, finally to the Kasakh River. After anti-infiltration works by the Project, stored water at the Reservoir almost will not permeate into the soil. Thus, no impact on the ground water by the Project is expected. (Khoren Tsarukyan / PIU)
16.	Karen Harutyunyan / Deputy Mayor	How the fertile top soil of the Reservoir basin will be managed by the Project?	We should have a discussion with the communities and decide the method of fertile layer transportation and the destination.**(*2)** (Khoren Tsarukyan / PIU)
17.	Garush Simonyan / Kasakh Community	What if, for instance, my land is evaluated and given a lower price than my neighbor's land?	If you do not agree with the price determined for your land, you have some options, and finally you can take the case to court.**(*3)** (Suren Gyurjinyan / ATMS Solutions)

*1: Whether the communal land will provided voluntarily cannot be determined at F/S stage. After the loan agreement, it will be discussed between community concerned and the Government.

*2: In case of any projects which would disturb fertile top-soil, it is needed to transport the soil to outside of the area based on decrees in Armenia. However, there is no mention who is requested to transport the fertile soil and how the soil is distributed among the stakeholders in the decrees.

*3: Three patterns for lodging of complaints are proposed in the Project, it is possible to consult with the communities concerned and PIU prior to court.

Table 5-2-10.11 Participant List of the Public Seminar in Yeghvard City (31st May 2016)

No.	Name	Position	Organization
1	Karen Harutyunyan	Deputy Head	Yeghvard City
2	Lilit Harutyunyan	Officer	Yeghvard City
3	Narine Karapetyan	Officer	Yeghvard City
4	Sona Karapetyan	Officer	Yeghvard City
5	Narine Harutyunyan	Officer	Yeghvard City
6	-----	Resident, Kasakh Community	
7	-----	Resident of Yeghvard Community	
8	-----	Resident of Yeghvard Community	
9	Khoren Tsarukyan	Hydro-technical Engineer	PIU
10	Marine Vardanyan	Social Expert	PIU
11	David Zakaryan	Hydrologist	PIU
12	Ruzanna Manyan	Coordinator	Aarhus Center, Yeghvard City
13	Anush Beybutyan	Coordinator	Aarhus Center, Yeghvard City
14	Ayumi Shiga	Social Consideration	JICA Survey Team
15	Rie Kitao	Environmental Consideration	JICA Survey Team
16	Gevorg Gevorgyan	Assistant	JICA Survey Team
17	Kristine Goroyan	Assistant	JICA Survey Team
18	Luiza Ohanian	Assistant	JICA Survey Team
19	Artak Ter-Torosyan	Environmental Specialist	ATMS Solutions LLC
20	Suren Gyurjinyan	Resettlement Specialist	ATMS Solutions LLC

Since the number of farmers who participated in the public seminar in Yeghvard Community on 31st May was limited, additional seminar in Yeghvard WUA office to get feedback from the PAPs was organized. The discussion at the seminar and participant list are as shown in Table 5-2-10.12 and Table 5-2-10.13.

Table 5-2-10.12 Discussion on the Draft ESIA Report at the Public Seminar in Yeghvard WUA (3rd June 2016)

No.	Speaker	Question and Comment	Answer
1.	Resident	How large was the Reservoir area during the Soviet Union period and how large is current proposed area of Reservoir?	During the Soviet Union period, it was around 1,000 ha, at this moment, the planned area is around 800 ha. (Khoren Tsarukyan / PIU).
2.	Resident	Are only cereal crops cultivated in the reservoir area?	Both cereal and fodder crops are cultivated. (Suren Gyurjinyan / ATMS Solutions)
3.	Resident	How much is the minimum monthly salary rate in Armenia?	Currently, it is 55,000 AMD per month (Suren Gyurjinyan / ATMS Solutions)
4.	Resident	In case we need to apply to the court for solution of some issues, who is going to pay for court expenses?	The person who applies to the court should pay when he/she applies. But if the applier wins the case, the expenses will be reimbursed to him/her. (Suren Gyurjinyan / ATMS Solutions)
5.	Resident	Is the community land compensated by the	This issue should be solved through negotiations

No.	Speaker	Question and Comment	Answer
		State? If there are any vulnerable people (regardless of directly affected or not affected by the Project), what kind of compensation can be provided to them?	between the State and the community. If the State provides compensation for communal land loss, it will be provided to the community, not to vulnerable people in the community, In general, vulnerable people are provided by social support program, like renovation of schools, some cultural houses, etc. It means that the State already has special supporting to such kind of people. (Suren Gyurjinyan / ATMS Solutions)
6.	Resident	When will the Project be officially launched?	It will take one year for negotiation between Government of Japan and Government of Armenia for signing the loan agreement. After that, D/D and construction works will be started. The construction stage will last 4-5 years. (Khoren Tsarukyan / PIU)
7.	Resident	What do you mean by saying partial alienation of land?	After completion of the design, the land size to be alienated will be decided based on the inventory survey. For example, if you have a land with 50 m width and only 15 m width of that will be alienated by the Project, the amount of compensation will be calculated only for the part of 15 m width. (Suren Gyurjinyan / ATMS Solutions)
8.	Resident	What type of canal will be constructed?	It is going to be a pipe with 1,600 mm diameter, buried at 2-2.5 m depth (Khoren Tsarukyan / PIU)
9.	Resident	Will the compensation be provided equal to market price or cadastral price?	Higher price between them will be applied. However, usually market price is higher than the cadastral one. (Suren Gyurjinyan / ATMS Solutions)
10.	Resident	I expect that tourism around the Reservoir will be developed after construction.	-
11.	Resident	My private land will be affected by canal construction. However, I support the Project, since I know its importance.	-

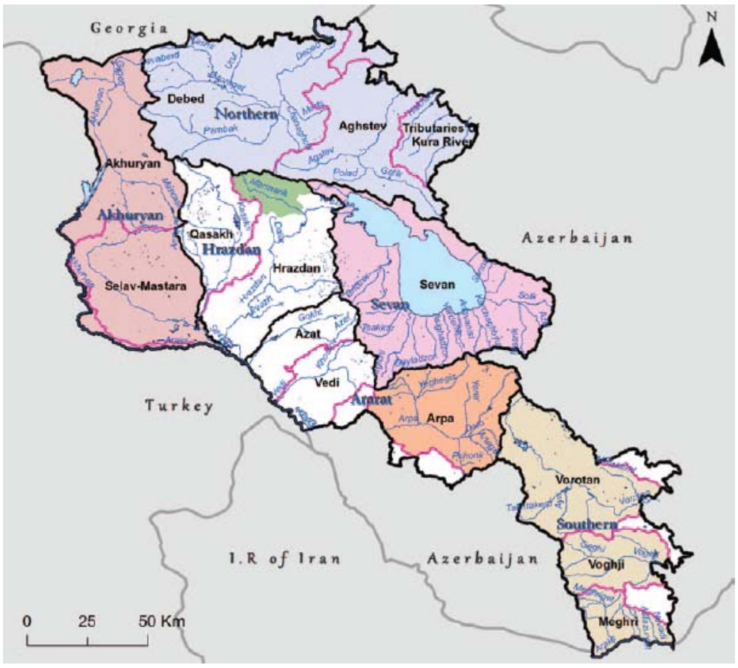
Table 5-2-10.13 Participant List of the Public Seminar in Yeghvard WUA (3rd June 2016)

No.	Name	Position	Organization
1.	-----	Resident	
2.	-----	Resident	
3.	-----	Resident	
4.	-----	Resident	
5.	-----	Resident	
6.	-----	Resident	
7.	-----	Resident	
8.	-----	Resident	
9.	-----	Resident	
10.	-----	Resident	
11.	-----	Resident	
12.	-----	Resident	
13.	-----	Resident	
14.	-----	Resident	
15.	-----	Resident	
16	Gayane Karapetyan	WUA officer	Yeghvard WUA
17.	Aida Hovhannissyan	WUA officer	Yeghvard WUA
18.	Gyurjinyan Suren	Resettlement expert	ATMS Solutions
19.	Ayumi Shiga	Social Consideration	JICA Survey Team
20.	Rie Kitao	Environmental Consideration	JICA Survey Team
21.	Gevorg Gevorgyan	Assistant	JICA Survey Team
22.	Tatevik Minasyan	Assistant	JICA Survey Team
23.	Luiza Ohanyan	Assistant	JICA Survey Team

5-3 Climate Changes

5-3-1 Review of Current Perspective on Climate Change

According to WB, Armenia is highly vulnerable country against climate change compared to other countries in the South Caucasus region (WB 2014)[1]. The impact of climate change will be in various sectors. The total future loss to the agricultural sector is estimated at around 75 billion to 170 billion Armenian Drams, which equivalent to a loss of 2-5 % of GDP in 2009. Moreover, it will be worse if indirect losses (e.g. food processing industries, input markets) are also included. Temperature increase and intensification of evaporation of moisture from the soil surface imply additional demands of irrigation water for agricultural land. On the other hand, in the water resource sector, future streamflow is assessed to decrease by 45-56 % in the Khami-Debed basin (Armenia/ Georgia) and by 59-72 % in the Agstev basin (Armenia/Azerbaijian) by the end of the century. Reduced river flows coupled with an increased demand for irrigation water may be future risks not only of agriculture but also of other sensitive sectors such as hydropower development.



Source World Bank (2014)

Figure 5-3-1.1 Map of Armenia by River Basin

The RA has cooperated with international climate change frameworks for a long time. The government ratified the United Nations Framework Convention on Climate Change (UNFCCC) in May 1993 as Non-Annex I party and the Kyoto Protocol in December 2002. MNP has been appointed as the Designated National Authority (DNA) for the Clean Development Mechanism (CDM) of the Kyoto Protocol by a decree of Government of Armenia. One of the main functions is to approve the compliance Kyoto Protocol, as well as to ensure effective participation of Armenia in international CDM processes. In 2010, the Republic of Armenia submitted a statement to the Convention Secretariat for association with the Copenhagen Accords. This statement presents the position of the Republic of Armenia on the continuation of the Kyoto Protocol and the limitation of greenhouse gas (GHG) emissions. In September 2015, the RA approved the Intended Nationally Determined Contribution (INDC) under the UNFCCC. According to this, the climate change mitigation actions should not reverse the social and economic trends, but contribute to the socioeconomic development of the RA. The adaptation activities, on the other hand, has not been yet submitted, but it is mentioned that the submission will be prioritized based on the most vulnerable sectors to climate change i.e. a. Natural ecosystems (aquatic and terrestrial, including forest ecosystems, biodiversity and land cover), b. Human health, c. Water resource management, d. Agriculture including fishery and forests, e. Energy, f. Human settlements and infrastructures, and e.g. Tourism.

All of climate change adaptation activities will have to be based on appropriate future forecasting with some GHG emission scenarios. Perhaps, the most comprehensive reports about climate change

[1] WB (2014) "*Towards Integrated Water Resource Management: Revised*"

forecasts in Armenia are the series of national communication papers prepared by MNP in accordance with Article 4.1 and 12.1 of the UNFCCC and the guidelines for national communication of non-Annex I parties to the Convention. The latest paper; "*the Third National Communication on Climate Change* (TNC)", was submitted in 2015 following "*the First National Communication on Climate Change* (FNC)" and " *the Second National Communication on Climate Change* (SNC)" submitted in 1998 and 2010, respectively. They have been widely utilized by major international donner organizations. Although some of them have recommended to commission additional studies, these reports are based on Global Climate Model and there is no reliable Regional Climate Model in Armenia so far. In this respect, the Survey Team has employed results from TNC for climate change adaptation strategies in spite of the data limitation of Global Climate Model. It is noted that TNC made corrections from SNC in climate change scenarios. Although it shows very similar tendency as the previous two reports, some of forecasts dramatically are changed due to some modifications. For example, annual precipitation in the territory of Armenia has forecasted an increase by 2.9% in TNC, according to the RCP8.5 (equivalent to A2, See Table 5-3-1.1) scenario by 2100, while it was estimated 8-24% decrease in SNC. One of the reasons for this is to uniform with the other climate change scenarios provided by neighboring countries and international organizations. Therefore, it is noted that the future forecasts discussed in the following sub-chapters might have certain limitations.

Table 5-3-1.1 IPCC Recommended Scenarios and Their Explanations

Scenario	Explanation
SRES A2 (Equivalent to RCP 8.5 scenario)	The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.
SRES B2 (Equivalent to RCP 6.0 scenario)	The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

Source: IPCC (2007)[2]

5-3-2 Trends in Annual Temperature and Precipitation in Armenia

According to the TNC, there has been a significant temperature increase in recent decades. When baseline period is set 1961-1990, temperature and precipitation in following years have been changed drastically. Table 5-3-2.1 shows the changes in temperature and precipitation in 1929-2012 and 1935-2012, respectively, compared with those of baseline. The annual mean temperature increased by 0.4 ºC in 1929-1996, 0.85 ºC in 1929-2007, and 1.03 ºC in 1929-2012. Annual precipitation was 6% decrease in 1935-1996, and it was close to 10% decrease in 1935-2012. Over the last 80 years, the climate in the northeastern and central (Ararat Valley) region of the country has turned arid, while precipitation has increased in the southern and northwestern region, as well as in the western part of the Lake Sevan basin.

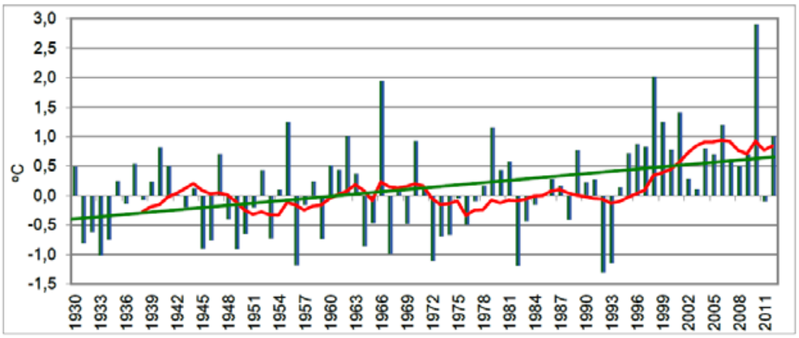
Table 5-3-2.1. Annual Mean Temperature and Precipitation Changes in 1929-2012 Compared with the Baseline

Time Period	Air Temperature (℃) and Changes Compared with the Baseline	Time Period	Precipitation, mm (%) and Changes compared with the Baseline
1961-1990 (Baseline)	5.5	1961-1990 (Baseline)	592
1929-1996	+0.40	1935-1996	-35(-6%)
1929-2007	+0.85	1935-2007	-41(-7%)
1929-2012	+1.03	1935-2012	-59(-10)

Source) MNP (2015)

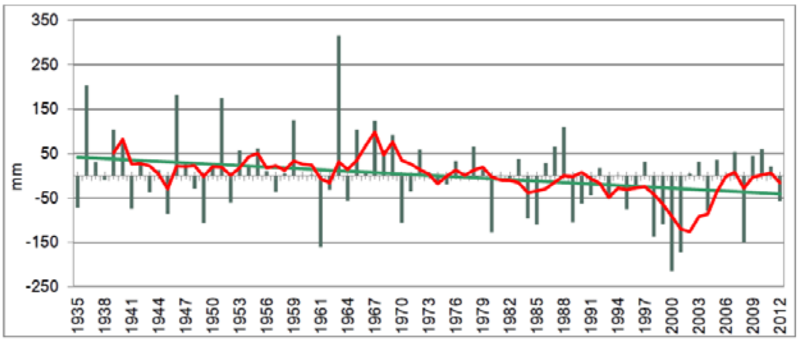
[2] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Figure 5-3-2.1 and Figure 5-3-2.2 show the trend of air temperature and precipitation, respectively provided that those in 1961-1990 are baseline (=0).



Source) MNP (2015)

Figure 5-3-2.1. Deviation of Annual Average Air Temperature in Armenia from the Baseline



Source) MNP (2015)

Figure 5-3-2.2. Deviation of Annual Average Precipitation in the Territory of Armenia from the Baseline

5-3-3 Climate Change Projection in Armenia

In order to forecast the future climate change and its ecological impacts in Armenia, the Third National Communication on Climate Change (TNC) has adopted CCSM4 model in accordance with IPCC recommended RCP 6.0 (equivalent to the SRES B2 scenario) and RCP 8.5 (equivalent to the SRES A2 scenario) scenarios for CO_2 emission. As per the RCP 6.0 scenario, CO_2 concentration will be 670 ppm by 2100, while it will be 936 ppm according to the RCP 8.5 scenarios. Future changes are forecasted in the period of 2011-2040, 2041-2070, and 2071-2100.

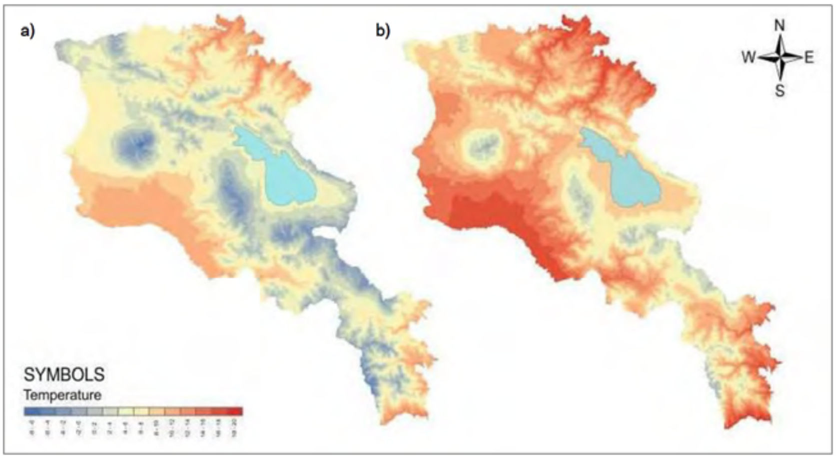
Table 5-3-3.1 indicates that the temperature will be continuously increased in all seasons of the year. It will be accelerated since 2041 under RCP 8.5 scenario. Given that the baseline through the year is 5.5 ºC, and it is simulated that 4.7 ºC will be increased under RCP 8.5 scenario in 2071-2100, the average annual temperature in Armenia could be 10.2 ºC in 2100 (=4.7+5.5). Figure 5-3-3.1 represents spatial distribution maps for annual mean temperature for the 1961-1990 baseline (a) and projections for 2071-2100 under RCP8.5 scenario (b). It is expected that temperature will be increased in most of the regions of Armenia by 2100. The annual average temperature in the beneficial area is expected to reach to around 16-20 ºC in 2100 under RCP 8.5 scenario.

Table 5-3-3.1 Projected Changes in Annual and Seasonal Average Temperatures in Armenia

Seasons	Baseline (1961-1990 average)	Scenarios	2011-2040	2041-2070	2071-2100
Winter	-5.3	RCP, 6.0	1.4	2.6	3.6
		RCP, 8.5	1.7	2.8	4.4
Spring	4.3	RCP, 6.0	1.3	2.4	2.7
		RCP, 8.5	1.4	2.7	3.9
Summer	15.7	RCP, 6.0	1.9	3.0	3.8
		RCP, 8.5	2.1	4.0	6.0

Seasons	Baseline (1961-1990 average)	Scenarios	2011-2040	2041-2070	2071-2100
Autumn	7.2	RCP, 6.0	0.8	2.3	3.0
		RCP, 8.5	1.4	3.2	4.4
Year	**5.5**	RCP, 6.0	1.3	2.6	3.3
		RCP, 8.5	1.7	3.2	**4.7**

Source) MNP (2015)



Source) MNP (2015)

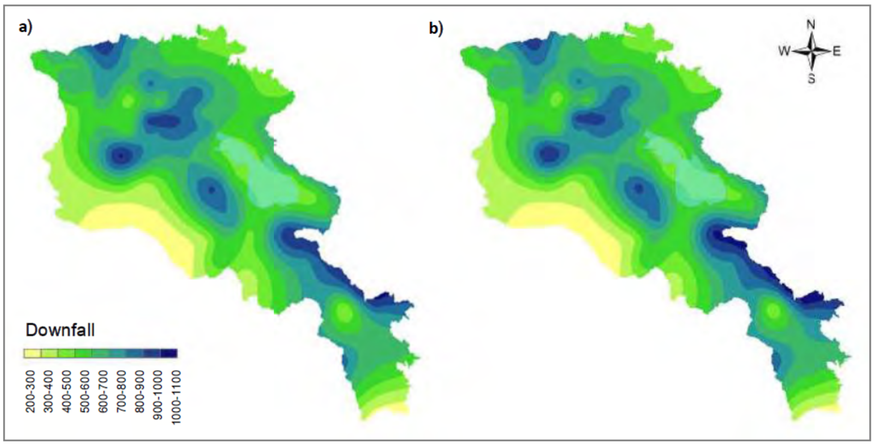
Figure 5-3-3.1. Distribution of Annual Average Temperature in Armenia in (a) 1961-1990 and (b) in 2071-2100, RCP 8.5

Table 5-3-3.2 shows that annual precipitation might be 2.9% increase in the long run (in 2071- 2100) under the RCP8.5 scenario, while there might be also 6.2% increase under the RCP6.0 scenario. However, it should be noted that there are much more uncertainties in future precipitation than that of temperature. The distribution of annual precipitation is expected to insignificant change. The amount of annual average precipitation in the beneficial area was around 200-400 mm in 1961-1990 and it has almost unchanged in 2071 – 2100 (see Figure 5-3-3.2).

Table 5-3-3.2 Projected Changes in Annual and Seasonal Precipitation in Armenia, %

Seasons	1961-1990 average	Scenarios	2011-2040	2041-2070	2071-2100
Winter	114	RCP, 6.0	5.3	5.8	6.2
		RCP, 8.5	-5.7	16.3	2.9
Spring	211	RCP, 6.0	1.2	4.2	2.6
		RCP, 8.5	4.2	-8.0	2.4
Summer	148	RCP, 6.0	-10.1	-10.8	12.8
		RCP, 8.5	-23.0	-3.4	-13.0
Autumn	119	RCP, 6.0	5.0	3.2	1.2
		RCP, 8.5	2.5	8.6	13.6
Year	592	RCP, 6.0	5.3	5.8	**6.2**
		RCP, 8.5	-5.7	16.3	**2.9**

Source) MNP (2015)



Source) MNP (2015)

Figure 5-3-3.2 Distribution of Annual Average Precipitation in Armenia in (a) 1961-1990 and (b) in 2071-2100, RCP 8.5

5-3-4 Expected Climate Change Impacts by Sensitive Sectors

a) Agriculture

Agriculture sector is one of the most climate sensitive sectors in the economy. Even in the current conditions, the sector is affected by adverse weather phenomena such as drought, hail, early frost, spring floods, and landslides. In recent decades, extreme weather events have been becoming more frequent and lasting longer. Agriculture accounts for about 20% of the country's total GDP, and the sector has a role of ensuring food security, targeting 75-80% of self-produced basic foods. Therefore, the TNC notes that the strategy for this sector should be aimed at enhancing competitiveness and sustainable development, and at implementing preventive adaptation measures.

The impact of climate change in agriculture is not uniform by agro-climatic zone, crops, and land types. However, there are some major negative consequences such as;

- Shift of agro-climatic zones 100 m upward by mountain slopes by 2030, and 200-400m by 2100;
- Reduced crop yields as a result of temperature increases, reduced rainfall, and increasing evaporation from soil surface;
- Reduction of fertility and deterioration of agricultural land;
- Increased negative impact of extreme weather events due to expected increases in their frequency and intensity;
- Expansion of irrigated lands and the need for additional irrigation water; and
- More intensive degradation of land, including natural grazing land.

b) Water Resources

Needless to say, water resources are important for the social and economic development of the country. According to WB (2014), Armenia has sufficient water to supply approximately 3,100 cubic meters per capita per year well above the typically cited Falkenmark water stress indicator of 1,700 cubic meters per capita per year, which is one of the most commonly used indicators when one is describing water availability in a country. It means that Armenia has sufficient water resource "on average". However, the spatial and seasonal distribution of water resources in Armenia is extremely uneven. In particular, the Hrazdan River has significant seasonal fluctuations. In a normal year, about 55% of the total river flow is fed by melting snow in spring and rainfall; the maximum and minimum flow ratio can be in the range of 10:1 (MNP, 2015).

As it is mentioned above, even if climate change will not be realized as forecasted, the needs for stabilizing the uneven seasonal water supply is still high. On the other hand, if the climate change will be realized as forecasted, the water instability becomes a critical issue as water scarcity would become worse. For example, in upper stream of the Hrazdan River, there are estimated to be a reduction of 2-3 % of river flows by 2040; of 6-7% by 2014-2070; and of 15-20% by 2100 under the scenario of A2 according to the TNC.

c) Lake Sevan

During 1933-1981, the water level of Lake Sevan dropped by 18.5 m due to excessive discharge of water for irrigation and power generation purposes. Thanks to diversion of water from River Arpa through a newly built tunnel designed to supply annually around 250 MCM water to the lake, the water level recovered by 0.9 m in 1981-1990. However, in 1991-2005, during the energy crisis, the level turned to a decreasing trend by 1.60 m for the sake of power generation. In 2004, the second tunnel Vorotan-Sevan was built to replenish water resources of the river and in 2006, the water level increased by 1.93m.

The historical experiences indicate how the water level of Lake Sevan has fluctuated reflecting the socio-economic circumstances at the time. So far, the water level shows an increasing trend since 2003, but if climate change will be realized as forecasted, Lake Sevan's inflow might decrease again by 53.0 million m^3 against baseline (787 million m^3) in 2030; by 114.0 million m^3 in 2070; and by 192.0 million m^3 in 2,100, according to TNC (Table 5-3-4.1). It means that the water level might have been going down by about 16cm per year. By the way, it is expected that after the project implementation, irrigation water conveyance from Lake Sevan, with the amount of 50 MCM, will not be needed any more. It could partially offset the impact of climate change.

Table 5-3-4.1 Projection of Inflows in Lake Sevan, A2 Scenario, million m^3

variables	1961-1990	2030	2070	2100
Inflow	787.0	734.0	673.0	595.0
difference from 1961-1990	-	-53.0	-114.0	-192.0

Source) MNP (2015)

5-3-5 Mitigation Strategy

In this chapter, the project benefit for climate change mitigation will be estimated. In the Protocol Decision No.41, 10 September 2015, "*On approving the Intended Nationally Determined Contribution of the Republic of Armenia under the UN Framework Convention on Climate Change*", it is mentioned that the total aggregate quantitative contributions of the Republic of Armenia under INDC equal to 633 million tons carbon dioxide equivalent (189 tons per capita × 3.35 million people) in the period of 2015-2050 or an annual average of 5.4 ton per capita. Currently, the total GHG emission in Armenia in 2010 made up 7,463.6 Giga grams (Gg) $CO_{2eq.}$ Most of CO_2 emissions are generated by the energy sector that account for 5,008.6 Gg CO_{2eq} or 67.1% of total emission in 2010.

In the project, it is expected that existing deep wells and pump stations will be converted to gravity irrigation systems. The abolishment of them may reduce GHG emission through saving in energy use. Although the impact may not be large, the project possibly contributes to climate change mitigation to some extent. The contribution of the project is quantitatively evaluated using a tool "*JICA climate-FIT version2.0*".

For the calculation of the net reduction of CO_2 emission, following formula has been applied;

$$ER_y = (BE_y - PE_y)$$

ER_y : Emission reduction in year "y" comparing with-without project (unit: tCO_2/year)

BE_y : Baseline emission in year "y" without the project implementation (unit: tCO_2/year)

PE_y : Project emission in year "y" with the project implementation (unit: tCO2/year)

Current total amount of energy use for the operation of deep wells and pump stations in our beneficial areas was collected from related WSA and WUA, is estimated at 31,856.9 MWh/year. The impact calculation is standardized in year "y", then, baseline emission should be evaluated under the water demand in year "y" by multiplying the ratio P_{PJ} / P_{BL}. It should be noted that there is no diesel pump station in the beneficial area so that baseline and project consumption of fuels are regarded as "zero".

$$BE_y = BE_{elec} \times P_{PJ} / P_{BL} = (EC_{BL} \times EF_{elec}) \times P_{PJ} / P_{BL}$$

BE_{elec}: Baseline (current) emission due to energy consumption (unit: t-CO_2/year)
P_{BL}: Production Capacity (Water demands for irrigation) in the baseline (unit: MCM)
P_{PJ}: Production Capacity (Water demands for irrigation) in the project (unit: MCM)
EC_{BL}: Electricity consumption in the baseline in year "y" (MWh/year)
EF_{elec}: CO_2 emission factor of the grid electricity (t-CO_2/MWh)

Project emission in year "y" (PE_y) is expected to be "zero" because all of deep wells and pump stations will be abolished after the project implementation, namely; PE_y =0 is assumed. The estimated GHG emission reduction of the project is 16,575.02 t-CO_2/year as shown in Table 5-3-5.1.

Table 5-3-5.1 Calculation of Energy Saving in Industrial Facilities (Pump Stations)

	Value	Unit
Emission reduction	**16,575.02**	**tCO_2/year**
Baseline emission	16,575.02	tCO_2/year
Production capacity (or other appropriate factors) in the baseline	104.0	MCM
Production capacity (or other appropriate factors) in the project	154.2	MCM
Electricity consumption in the baseline in year y	27,772.8	MWh/year
Consumption of the fuel in the baseline in year y	0.0	t/year
CO_2 emission factor of the grid electricity	0.40250	t-CO_2/MWh
Net calorific value of fuel	0.0	TJ/t
CO_2 emission factor of fuel	0.0	t-CO_2/TJ
Project emission	0.0	tCO_2/year
Electricity consumption in the project in year y	0.0	MWh/year
Consumption of the fuel in the project in year y	0.0	t/year
CO_2 emission factor of the grid electricity	0.40250	t-CO_2/MWh
Net calorific value of fuel	0.0	TJ/t
CO_2 emission factor of fuel	0.0	t-CO_2/TJ

Source) Output from JICA Climate-FIT ver.2.0.

5-3-6 Adaptation Strategy

The Project aims at the production increase through irrigation system improvement, and it is not a project focusing on the adaptation of climate change. On the other hand, there is possibility that existing water resources for farming will be decreased according to the simulation results mentioned above. Therefore, the Project is categorized into the "general development +adaptation option" based on the JICA Climate FIT Version 1.0 (June, 2010).

In Armenia, it is discussed to introduce a weather index insurance system to minimize damages by natural disasters to farmers. MNP and UNDP have prepared some reports altogether, however, it will take time for introduction of the system. Regarding international donors, WB has not implemented large-scale projects, which require considering the climate change, and the WB has not taken adaptation measures. Out of donors in Armenia, KfW is the most advanced in terms of examination of impacts by the climate change. However, according to the staff of KfW, the Regional Climate Model covering Caucasus countries i.e. Armenia, Georgia, and Azerbaijan has not been established, and the existing Global Climate Model cannot cover data for small spatial resolution. Therefore, KfW has not implemented any projects which focus on climate change specifically in Armenia.

KfW involved the climate change specialist at F/S stage of the Kaps project, and it was estimated that impacts on the Kaps project by the climate change will be minor. However, warming, precipitation decrease, increase of disaster frequency could be caused in the future, therefore, following measures are proposed by the Kaps project:

- Prevention of water losses by improving water supply system;
- Introduction of drip irrigation system: training of WUA and provision of financial incentive to the farmers; and
- Organization of a forum with other water users, e.g. WSA, WUA, hydropower plants, national parks and so on.

It can be said that the Kaps project proposes to take adaptation measure against the climate change through technical training, awareness and introduction of water-saving irrigation system. Given that other donors have not taken countermeasures against the climate change in Armenia, it seems reasonable to follow the methodology taken by the KfW.

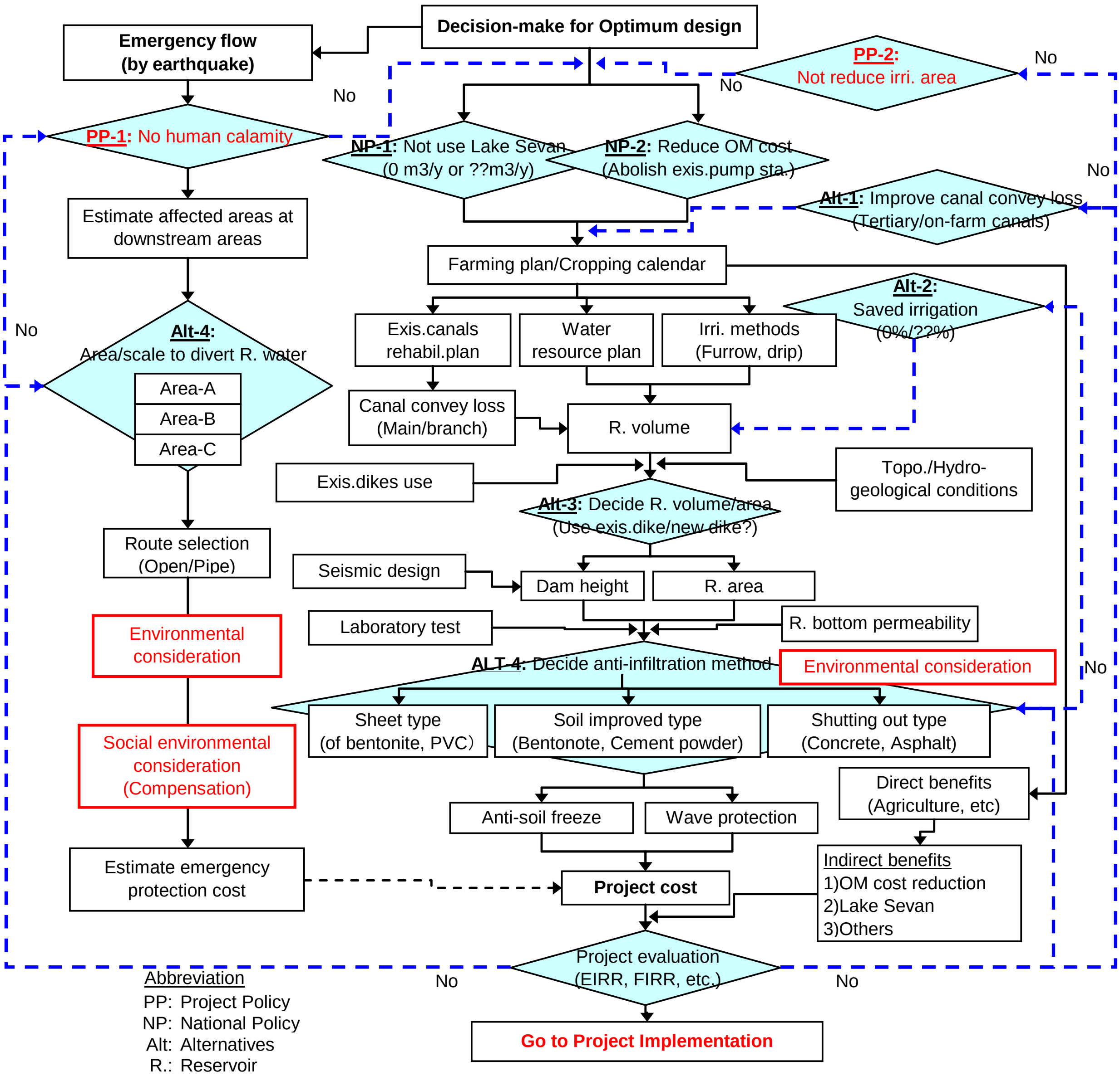
Water loss due to wasting of water resource has not been observed in the Project area so far, however, deterioration of the existing irrigation facilities cause water loss, e.g. water leaking from the canals. It is necessary to rehabilitate those facilities and the proposed project components include the rehabilitation works. In the future, it is possible to introduce water saving irrigation system such as drip irrigation and sprinkler irrigation. During the Project implementation, a pilot project to verify the water saving irrigation system can be implemented in collaboration with the MOA.

Concerning evaluation indicator for climate change adaptation, four (4) indicators; namely, 1) irrigable planted area, 2) agricultural production for main crops, 3) use of electricity for irrigation purpose, and 4) volume of water conveyance from the Lake Sevan to the beneficiary area, are proposed. The indicators are consistent with ones of project evaluation.

CHAPTER 6 PLANS OF YEGHVARD IRRIGATION SYSTEM IMPROVEMENT PROJECT

6-1 Considerations of the Optimum Plan

Figure 6-1.1 shows a flow of optimum design for the Project.



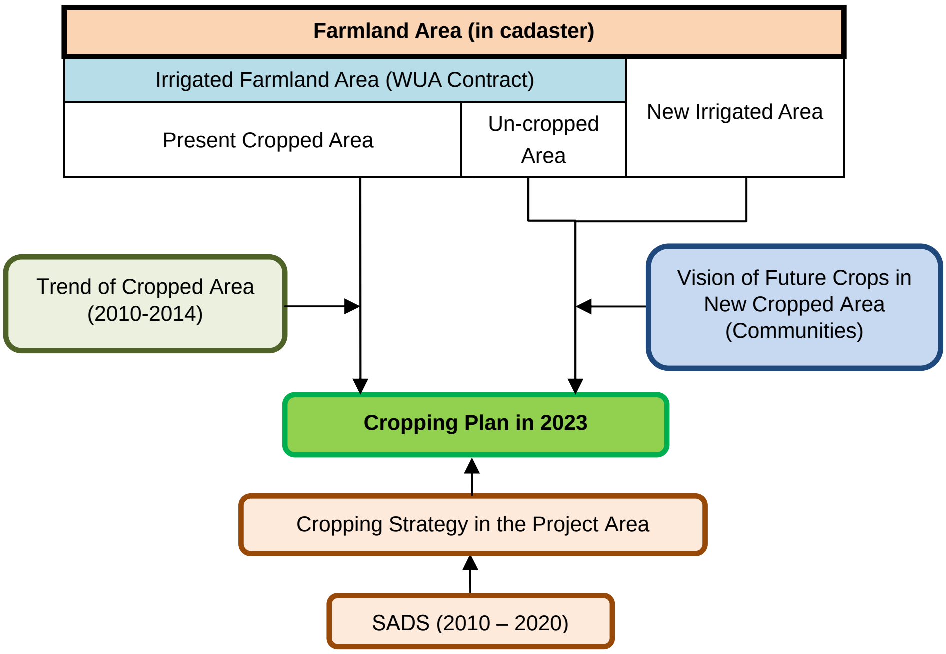
Abbreviation
PP: Project Policy
NP: National Policy
Alt: Alternatives
R.: Reservoir
Exis. Existing
Irri. irrigation
Rehabil. Rehabilitation
OM: Operation & Maintenance
Topo. Topographical
Sta. Station

Figure 6-1.1 Flow of Optimum Deign for the Project

6-2 Agricultural Plan

6-2-1 Cropping Area

A cropping plan of the Project area after construction of Yeghvard reservoir is drawn up in order to make a feasibility evaluation of the Project, while it is needless to say that actual cropping plan of each individual farmer shall be decided by his/her own interest under the present free economy system. The planning procedure is shown in Figure 6-2-1.1.



Source) The Survey Team

Figure 6-2-1.1 Cropping Planning Procedure

(1) Cropping strategy in the Project area

While SADS states agricultural development strategy by Marzes, the following Table 6-2-1.1 shows a suggested cropping strategy for the Project area in accordance with SADS and considering the present agricultural situation. The strategy provides a base of the cropping planning.

Table 6-2-1.1 Suggested Cropping Strategy in the Beneficiary Area

Sub-sector	Suggested Strategy
Wheat	• To increase productivity
Alfalfa and Forage Crops	• To increase cropped area • To promote forage cereals (barley, maize, etc.), especially in Yeghvard WUA area
Vegetables/Melons and Potatoes	• To increase productivity • To promote production by greenhouses or tunnels (forcing/suppression cultivation for continuous harvesting throughout the year) • To diversify crops (new crops including new varieties and ornamental plants)
Fruits/Grapes	• To increase planted area, especially grapes • To increase productivity

Source) The Survey Team

(2) Trend of planted area in present cropped area

During 2010-2014, 8,391 ha of farmland were cropped annually on average. The planted area by crops in 2023 in the present cropped area by WUAs is forecasted by the calculation based on actual changes of the planted area in 27 concerned communities during the 5 years. The following steps were taken for the calculation (see Appendix B-11 for details).

a. Planted area % of 7 crop groups, i.e. wheat, alfalfa, other food & forage, potatoes, vegetables/melons, fruits and grapes in 2010 – 2014 were calculated by WUAs.
b. A log approximation formula is derived from the change of the planted area % for the each crop category.
c. Forecasted cropping area % in 2023 for the each crop group is respectively calculated by the formula.

Table 6-2-1.2 Forecasted Cropping Area in the Present Cropped Area in 2023

WUA	Crop Groups (unit: %)							
	Wheat	Alfalfa	Other food & forage	Potatoes	Vegetables /Melons	Fruits	Grapes	Total
Yeghvard	8	31	3	1	8	43	6	100
Ashtarak	5	9	7	1	17	16	45	100
Vagharshapat	24	8	6	3	53	1	5	100
Khoy	19	10	6	14	30	9	12	100
WUA	Crop Groups (unit: ha)							
	Wheat	Alfalfa	Other food & forage	Potatoes	Vegetables /Melons	Fruits	Grapes	Total
Yeghvard	51	199	19	6	51	277	39	642
Ashtarak	40	72	56	8	136	128	361	801
Vagharshapat	597	199	149	75	1,319	25	124	2,488
Khoy	847	446	268	624	1,338	401	536	4,460

(3) Vision of future crops in new cropped area

It is planned that 3,956 ha of farmland shall be newly cropped after construction of Yeghvard reservoir. The Survey team carried out a series of interviews with 27 community offices for collecting information about the present agriculture in the communities, as well as their visons of promising crops after construction of the reservoir. The Survey team has taken into account results of the interviews for making a cropping plan in new cropped area. As many communities mentioned farming system and crops during Soviet era for discussing the promising crops, the Survey team has also paid attention to that farming system and crops during the planning. The interview results are summarized in Table 6-2-1.3 and the cropping plan by the communities is attached in Appendix B-12.

Table 6-2-1.3 Farming System and Major Crops in Soviet Era, and Promising Crops after the Project in Concerned Communities

No	WUA	Community	New Cropped Area (ha)	Soviet time crops			Priority crops after the Project (in new cropped area)	
				Type of Farm	Major	2nd Major	1st	after 2nd
1	Yeghvard	Zovuni	241	Sovkhoz	Grape and Apricot	Forage crops+ milk cow	Apricot, apple and other fruits	Cereals and Alfalfa
2		Kasakh	333	Sovkhoz	Apple and grape	Apricot	Apple and Apricot	Forage crop
3		Proshyan	803	Sovkhoz	Grape	Fruits	Grape	Apple and Apricot+peach
4	Ashtarak	Sasunik	291	Sovkhoz	Grape	-	Grape	Fruits (Apricot+peach) and Tomato
5		Norakert	98	Sovkhoz	Grape	Apricot and other Fruits	Grape	Apricot and other Fruits
6		Baghramyan	172	Sovkhoz	Grape	Apricot and Alfalfa	Grape	Apricot and Alfalfa
7		Merdzavan	263	Research Farms	Grape research farm, Soil research farm and Plant protection research farm		Grape	Apricot and Peach
8	Vagharshapat	Mrgastan	14	Kolkhoz	Vegetables and Potato	Grape, Wheat and Maize	Vegetables and potato	Apricot
9		Tsakhkunk	18	Kolkhoz	Vegetables	Maize	Wheat	Fruits
10		Artimet	2	Kolkhoz	Alfalfa and Maize	Grape and Apricot	Vegetables	Grape
11		Taroniq	119	Sovkhoz	Vegetables (seed production)	Wheat and Grape	Vegetables (hot pepper)	-
12		Aratashen	73	Kolkhoz	Vegetables	Grape, Fruits and Wheat	Vegetables (tomato)	Grape
13		Khoronk	160	Kolkhoz	Vegetables	-	Vegetables and potato	Wheat
14		Griboyedov	250	Kolkhoz	Grape	Vegetables, Wheat and Maize	Vegetables	-
15	Khoy	Lernamerdz	36	Kolkhoz	Grape	Vegetables and Flowers	Vegetables and Herb	Grape
16		Amberd	24	Kolkhoz	Grape	Vegetables and Potato	Vegetables	Maize, Herb and Grape
17		Aghavnatun	53	Kolkhoz	Grape	Vegetables and Fodder crops	Fruits	Alfalfa
18		Doghs	14	Kolkhoz	Vegetables	Grape and Fruits	Tarragon, other herbs and potato	Fruits
19		Aragats	133	Kolkhoz	Vegetables	Wheat and Alfalfa	Tarragon, vegetables and potato	Fruits and Alfalfa
20		Tsaghkalanj	166	Kolkhoz	Vegetables	Grape	Grape and Fruits	Alfalfa and Maize
21		Hovtamej	4	Kolkhoz	Vegetables	Grape and Fodder crops	Strawberry	Vegetables
22		Tsiatsan	1	Kolkhoz	Grape and Fruits	Vegetables and Fodder crops	Vegetables	Grape
23		Geghakert	64	Kolkhoz	Grape	Wheat, Potato and Tomato	Strawberry	Vegetables
24		Haytagh	223	Kolkhoz	Grape	Forage crops	Grape and Fruits	Vegetables
25		Ferik	49	Kolkhoz	Vegetables	Fruits (Apricot) and Grape	Fruits (Apricot, Peach, Apple)	Alfalfa and Forage Crops
26		Arshaluys	164	Kolkhoz	Potato and Tomato	Grape	Potato and Vegetables	Grape
27		Aknalich	186	Sovkhoz	Grape	Fruits (Apricot, Apple, Pear)	Vegetables (Tomato)	Grape

Source) The Survey Team

(4) Cropping plan in 2023

Cropping plans in 2023 both for the present cropped area and for the new cropped area are made considering the above mentioned factors, and the plans are integrated into a cropping plan in the Project area in 2023. Table 6-2-1.4 shows the integrated cropping plan by concerned WUAs.

Table 6-2-1.4 Cropping Plan in the Project Area in 2023

WUA	Cropped Area	Crop Groups (unit: ha)							
		Wheat	Alfalfa	Other food & forage	Potatoes	Vegetables /Melons	Fruits	Grapes	Total
Yeghvard	Present area	51	199	19	6	51	277	39	642
	New area	105	292	45	12	0	481	442	1,377
	S-total	156	491	64	18	51	758	481	2,019
Ashtarak	Present area	40	72	56	8	136	128	361	801
	New area	37	65	29	0	29	174	490	824
	S-total	77	137	85	8	165	302	851	1,625
Vagharshapat	Present area	597	199	149	75	1,319	25	124	2,488
	New area	127	75	11	13	382	7	24	639
	S-total	724	274	160	88	1,701	32	148	3,127
Khoy	Present area	847	446	268	624	1,338	401	536	4,460
	New area	97	104	24	113	387	126	265	1,116
	S-total	944	550	292	737	1,725	527	801	5,576
Project Area	**Present area**	**1,535**	**916**	**492**	**713**	**2,844**	**831**	**1,060**	**8,391**
	New area	**366**	**536**	**109**	**138**	**798**	**788**	**1,221**	**3,956**
	Total	**1,901**	**1,452**	**601**	**851**	**3,642**	**1,619**	**2,281**	**12,347**

WUA	Cropped Area	Crop Groups (unit: area %)							
		Wheat	Alfalfa	Other food & forage	Potatoes	Vegetables /Melons	Fruits	Grapes	Total
Yeghvard	Present area	7.9	31.0	3.0	0.9	7.9	43.1	6.1	100.0
	New area	7.6	21.2	3.3	0.9	0.0	34.9	32.1	100.0
	S-total	7.7	24.3	3.2	0.9	2.5	37.5	23.8	100.0
Ashtarak	Present area	5.0	9.0	7.0	1.0	17.0	16.0	45.1	100.0
	New area	4.5	7.9	3.5	0.0	3.5	21.1	59.5	100.0
	S-total	4.7	8.4	5.2	0.5	10.2	18.6	52.4	100.0
Vagharshapat	Present area	24.0	8.0	6.0	3.0	53.0	1.0	5.0	100.0
	New area	19.9	11.7	1.7	2.0	59.8	1.1	3.8	100.0
	S-total	23.2	8.8	5.1	2.8	54.4	1.0	4.7	100.0
Khoy	Present area	19.0	10.0	6.0	14.0	30.0	9.0	12.0	100.0
	New area	8.7	9.3	2.2	10.1	34.7	11.3	23.7	100.0
	S-total	16.9	9.9	5.2	13.2	30.9	9.5	14.4	100.0
Project Area	**Present area**	**18.3**	**10.9**	**5.9**	**8.5**	**33.9**	**9.9**	**12.6**	**100.0**
	New area	**9.3**	**13.5**	**2.8**	**3.5**	**20.2**	**19.9**	**30.9**	**100.0**
	Total	**15.4**	**11.8**	**4.9**	**6.9**	**29.5**	**13.1**	**18.5**	**100.0**

Source) The Survey Team

(5) Crop productivity

It is assumed that crop productivity base will not increase even after completion of Yeghvard reservoir, as the productivity of many crops in the Project area has already reached at a certain reasonable level, and the Project does not include practical components to change crop management of individual farmers. As shown in Table 6-2-1.5, the productivity will slightly increase due to more stabilized supply of irrigation water after construction of Yeghvard reservoir. The productivity of each crop was derived from the following calculations.

- Without project: Average yield/ha during 2010-2014 in the Project area after exclusion of the maximum and the minimum figures
- With project: The highest yield/ha during 2010-2014 in the Project area after exclusion of the maximum and the minimum figures

Table 6-2-1.5 Crop Productivity

No.	Crop	Yield (ton/ha)		
		Without project	With project	Difference (increase)
1	Wheat	3.6	3.8	0.2
2	Barley	2.7	3.0	0.3
3	Maize (grain)	2.4	2.4	0.0
4	Alfalfa	11.3	11.3	0.0
5	Potato	36.3	40.0	3.7
6	Tomato, open	47.7	48.3	0.6
7	Tomato, green-house	100.0	100.0	0.0
8	Cucumber, open	38.4	40.0	1.6
9	Cucumber, green-house	80.0	80.0	0.0
10	Eggplant	49.8	53.1	3.3
11	Sweet pepper	38.9	40.1	1.2
12	Cabbage	29.7	30.6	0.9
13	Water melon	42.7	44.4	1.7
14	Grape	11.2	12.2	1.0
15	Apricot	7.1	7.5	0.4
16	Apple	7.7	8.9	1.2

Source) The Survey Team

It is important to note that the productivity in the new cropped area will gradually increase and reach to the expected yield as shown in Table 6-2-1.5 after several years. Table 6-2-1.6 and 6-2-1.7 show the assumed yield change both for annual crops and perennial crops under open-field condition. As for greenhouse farming, it is assumed that the expected yield can be obtained from the first year of planting, as crops can grow under well-controlled condition with rich inputs.

Table 6-2-1.6 Crop Yield in New Crop Area during the First 5 Years (Annual Crops)

No.	Crop	Year (ton/ha)				
		1st	2nd	3rd	4th	5th
1	Wheat	2.9	3.2	3.4	3.6	3.8
2	Barley	2.3	2.6	2.7	2.9	3.0
3	Maize (grain)	1.8	2.0	2.2	2.3	2.4
4	Potato	30.0	34.0	36.0	38.0	40.0
5	Tomato, open	36.2	41.1	43.5	45.9	48.3
6	Cucumber, open	30.0	34.0	36.0	38.0	40.0
7	Eggplant	39.8	45.1	47.8	50.4	53.1
8	Sweet pepper	30.1	34.1	36.1	38.1	40.1
9	Cabbage	23.0	26.0	27.5	29.1	30.6
10	Water melon	33.3	37.7	40.0	42.2	44.4

Source) The Survey Team

Table 6-2-1.7 Crop Yield in New Crop Area (Perennial Crops)

No	Crop	Yield (ton/ha)	Life (year)	Yield Change
1	Alfalfa	11.3	6	1st year: 7.80 ton/ha 2nd year: 9.60 ton/ha 3rd – 6th year: 12.60 ton/ha
2	Grape	12.2	50	1st – 2nd year: No production 3rd year: 5.20 ton/ha 4th year: 8.70 ton/ha 5th year: 10.30 ton/ha 6th year: 11.60 ton/ha 7th – 50th year: 13.05 ton/ha
3	Apricot	7.5	60	1st – 4th year: No production 5th year: 2.62 ton/ha 6th year: 3.50 ton/ha

No	Crop	Yield (ton/ha)	Life (year)	Yield Change
				7th – 60th year: 8.22 ton/ha
4	Apple	8.9	30	1st – 2nd year: No production 3rd year: 5.10 ton/ha 4th year: 7.10 ton/ha 5rd – 30th year: 9.80 ton/ha

Source) The Survey Team

6-2-2 Other Consideration in the Cropping Plan

(1) Planted area in new cropped area

It is assumed that only 70% of the total area of the new cropped area shall be planted in the 1st cropping year and the remained 30% shall be cropped within the following 2 years as shown in Table 6-2-2.1.

Table 6-2-2.1 % of Planted Area in the New Crop Area

Year	1st	2nd	3rd
Planted Area	70%	90%	100%

Source) The Survey Team

(2) Greenhouse farming

Greenhouse farming is well developed in the Project area, especially in command areas of Vagarshapat WUA and Khoy WUA. It is estimated that the area of greenhouse cultivation occupies about 3% of total cropped area of vegetables and melons in the Project area according to information from the Greenhouse Association, RA. Also, many communities have mentioned that greenhouse farming area, especially for vegetables, is going to expand due to its high profitability. Considering such condition, the cropping plan makes a provisional assumption that greenhouse farming area will reach 5 % of cropped area of vegetables and melons in 2023.

(3) Area % of crops in crop groups

Crops are categorized into 7 crop groups in the cropping plan. Cropping area % of major crops in each crop group, as shown in Table 6-2-2.2, is derived based on actual cropping area of the crops during 2010 - 2014 in the present cropped area.

Table 6-2-2.2 % of Planted Area of Crops in Crop Groups

Crop Group	Crop	Area (%)
Wheat	Wheat	100
Other food & forage	Barley	76
	Maize	24
	Total	100
Alfalfa	Alfalfa	100
Potatoes	Potatoes	100
Vegetables/Melons	Tomato (open)	29
	Tomato (greenhouse)	3
	Cucumber (open)	14
	Cucumber (greenhouse)	2
	Eggplant	7
	Sweet pepper	9
	Cabbage	16
	Water melon	20
	Total	100
Grapes	Grapes	100
Fruits	Apricot	64

Crop Group	Crop	Area (%)
	Apple	36
	Total	100

Source) The Survey Team

6-3 Recommended Agricultural Plans Supporting the Project

The Project aims at improving irrigation condition which is a highlighted concern to the farmers in the Project area. However, the farmers are facing many other difficulties in managing their farming as discussed in Sub-chapter 4-5-11. It is recommended that comprehensive supporting measures to address the difficulties be taken together with the Project in order to develop the regional agriculture and to improve the farmers' welfare in accordance with SADS.

6-3-1 Summary of Issues Confronting Farmers and Policy Direction

As described in the Chapter 4-5, the Survey team collected information about current situation of agriculture in the target area and difficulties confronting farmers through farm household survey, WUA workshops, data collection survey and interviews to concerned stakeholders. During the WUA workshops, participated farmers are asked to discuss several solutions for difficulties about farming. Detailed information about the workshops is described in Appendix C.

Table 6-3-1.1 shows suggested solutions from the participated farmers in the workshops. It implies that many farmers are still in a passive manner for tackling their difficulties and they haven't found out a good idea to materialize the solutions by themselves. It seems that farmers tend to aspire to external assistance for solving their difficulties about farming, while some suggested solutions are not realistic or less feasible considering current economic system.

Table 6-3-1.1 Suggested Solutions for Difficulties about Farming

Field	Suggested Solutions from Farmers	
Production	• Reduction of input cost • Improvement in transparency of information about subsidized inputs • Quality control of subsidized inputs • Provision of subsidized inputs (fertilizer, seeds, pesticides) • Reconsideration of payment timing for subsidized inputs (after harvesting)	• Introduction of quality testing equipment for fertilizers • Import of high quality fertilizers/pesticides • Review of subsidized inputs system • Establishment of seed/seedling company (farmer) • Soil melioration (increase fertility) • Further technical support by extension agency or agronomist
Irrigation	• Construction of reservoir • Reconstruction/repair of irrigation network • Installation of concrete gutter drains • Decrease of water losses • Financial support from the government	• Capacity building for WUA • Decrease irrigation fee • Control water pollution by community/WUA • Introduction of water saving technologies (drip irrigation, etc.)
Machinery	• Development of machinery stations • Government support for purchasing • Leasing scheme by the government • Grant from government/donor	• Import of second-hand machinery • Machinery service by community or private company
Marketing	• Establishment of cooperatives • Support for cooperative management • Creation of nearby market • Control of farm-gate price by the government • Establishment of processing companies	• Promotion of agricultural products' export • Financial support by the government (Long term agricultural credit scheme) • Government procurement for all harvested products with appropriate price • State guarantee for harvested products

Source) The Survey Team

Table 6-3-1.2 shows the farmers' issues confirmed by the Survey team and recommended policies to address them. While a part of the policies has already been taken by the government of Armenia or donor agencies, the remaining policies should also be taken effectively together with the Project in order to increase the Project's impact. Prioritization of the policies, materialization of concrete measures based on the policies and clear demarcation between the government's roles and the private sector's roles in the measures shall be vital to ensure the effective implementation.

Table 6-3-1.2 Policy Direction Against Farmers' Issues

	Farmers' Issues	Policy Direction
1	Difficulty in accessing reliable information on farming technology	To encourage research activity to address the technical issues at farmer level, i.e. fertilization, pest-control, farm-mechanization, water management & saving, etc.
		To enhance agricultural extension activity to be more friendly to individual farmers
2	Lack of promising crop-varieties to meet the market demand	To encourage research activity to develop or introduce new varieties
		To promote seed/seedling growing and importing business
3	High cost of agricultural inputs and farm machinery services & Shortage of farm machinery and spare-parts	To exempt or reduce import duties
		To ease regulations in order to accelerate the private sector entering the business
		To promote a competitive business environment by fostering private business operators and by phasing out of the government intervention from actual business transactions
		To promote a farm mechanization service managed by the private sector/cooperatives
		To introduce affordable credit-schemes to farmers and business operators including cooperatives
4	Low quality inputs are in the market & Banned agrochemicals are used	To educate business operators and farmers (regulations, good practice in handling & storage)
		To create a competitive business environment by increasing the number of business operators
		To practice periodical monitoring and inspection at market and field levels
5	Improper use (overuse or less use) of fertilizers and agrochemicals	To encourage research activity to define an appropriate dosage of fertilizers and agro-chemicals
		To educate farmers how to use fertilizers and agrochemicals properly
6	Shortage of irrigation water	To rehabilitate irrigation canals and networks
		To regulate grand water use
		To develop and introduce water saving technology acceptable to farmers
		To educate farmers the water saving technology
7	Low and unstable selling price of crops	To encourage research activity to develop or introduce new varieties with high market demand
		To develop and introduce forcing or inhibiting cultivation technology of crops
		To educate farmers how to adjust themselves to the present free-market economy system
		To disseminate updated market information to farmers including price information
		To promote a group marketing/processing among farmers by changing their negative mindset against cooperatives
		To interface farmers/cooperatives with private traders to develop a partnership in marketing and processing
		To encourage the development of agricultural marketing and processing industries in rural area
		To disseminate an international-competitive hygiene technology in marketing and processing industries
		To develop a cold chain system in the distribution of agricultural products

Source) The Survey Team

6-3-2 MOA Meeting

The Survey Team holds a roundtable discussion with related divisions of MOA in order to share collected information about difficulties confronting farmers, and to discuss about future direction of the agricultural policies to address the difficulties. Summary of the discussion is attached in Appendix B-13 and 14.

The participated MOA officials basically agreed that the government investment to support farmers is not enough because of the budgetary limitation, although there were some differences of recognition between farmers and the government officials about the difficulties as shown in Table 6-3-1.1. Farmers tend to claim that the government supports for their farming are not sufficient, instead of considering that some issues are caused by lack of farmers' knowledge and skills. The participated officials share a common view that MOA should actively use the assistance provided from external donor agencies to achieve the goals of SADS.

6-3-3 Recommended Projects

Armenian policy strategy, SADS sets three main goals of agricultural development, "Promotion of industrialization of agriculture", "Increase in the food security" and "Shaping favorable conditions for promoting export-oriented productions". Since vegetables and fruits, which are major exporting commodities in Armenia, are main agricultural products in the Project area, agriculture in the area should focus on promotion of export-oriented agriculture including processing industries of agricultural products to fulfill food demands from Yerevan city and foreign markets. Since the private sector plays a main role in the marketing and the processing sectors, and the government roles are relatively small compared to the farming support measures, it is recommended that the government remain in the background and support the private sector in order to maximize its potential.

Followings projects are drafted as priority agricultural projects supporting the Yeghvard Irrigation Project based on the discussion with MOA staffs. More information about the agricultural projects is attached in Appendix B-15.

(1) Pilot agricultural cooperatives development

a. Objective: to enhance productivity and market access of small-scale farmers in the Project area by organizing agricultural cooperatives

b. Main activities:

- To establish 2 (two) cooperatives (one in fruits area and another in vegetables area)
- To make a business plan of the cooperatives by participatory decision-making
- To introduce new technologies and facilities (new varieties, green-houses, water-saving system, farm-machinery, storage & processing facilities, etc.)
- To educate farmers a good practice in fertilizer application and pest-control, including recording the use of fertilizers and agrochemicals for ensuring traceability
- To educate farmers a good practice in group marketing
- To make a match between the cooperatives and business partners in marketing, processing and inputs procuring
- To promote a branding strategy of the products

(2) Enhancement of agricultural credit system

a. Objective: To establish or reconstruct affordable agricultural credit system for farmers in order to improve financial accessibility of them.

b. Main activities:

- To raise a special fund for agricultural credit system
- To regulate a credit system, e.g. target beneficiaries, target goods (inputs, livestock, farm-machinery, greenhouses and other agricultural facilities), implementation bodies, appraisal system, money flow and procedures, partner banks, etc.
- To set a credit terms, e.g. interest, payment term, grace period, etc.
- To educate farmers how to use the agricultural loan including a scheduled repayment, and
- To conduct capacity building of staff who will handle the credit system in the government sector.

(3) Establishment of monitoring and inspection system of pesticide residue

a. Objective: to establish monitoring and inspection system of pesticide residue for agricultural products in every food supply chain stage in order to secure food safety

b. Main activities:
- To conduct capacity building of the existing staff
- To recruit and train new staff for the monitoring and inspection
- To regulate a procedure of the monitoring and inspection
- To legalize responsibility and authority of inspectors

(4) Enhancement of agricultural research to promote a market oriented agriculture

a. Objective: To enhance and review agricultural research activities and system itself in order to correspond to demands from markets including foreign countries to promote market oriented agriculture

b. Main activities:
- To strengthen research capacity of the existing staff and to recruit new staff for vegetables and fruits promotion
- To concentrate every effort on the following priority subjects;
  - New promising varieties
  - Optimum use of fertilizers (balanced fertilizing)
  - Practical pest-control including IPM
  - Water saving technology
- To share research outcomes with agricultural extension agents

(5) Vitalization of agricultural extension

a. Objective: To strengthen and widespread agricultural extension activities based on demands from farmers in order to assist increase of agricultural productivity and their incomes

b. Main activities:
- To strengthen capacity of the existing extension staff and to recruit new staff working at field level
- To reinforce the existing extension system so that the extension agents will be closer to farmers
- To promote mutual exchanges with agricultural researchers about new agricultural technology desired from farmers and applicable to farmers
- To improve and enhance the ASMC/ASMCs websites and TV programs and newspaper articles about agricultural technologies

6-4 Irrigation Plan

6-4-1 Water Resources Utilization Plan

Hrazdan river is a major river in Armenia and there are hydro power generation systems along the river. Most of other countries in the world, Irrigation and Hydro power generation always have conflict because of mismatching period of demand needs between irrigation and hydro power generation respectively. However in Armenia, the hydro power generation is allowed its operation during irrigation period only, therefore it is no conflict between irrigation and hydro power generation. Furthermore, the water flow in Hrazdan river and operation of Lake Sevan has been operated well by Sevan-Hrazdanyan WSA.

Figure 6-4-1.1 shows the Lake Sevan, Hrazdan river, some other lakes and reservoirs and canals. The canals parallel to Hrazdan river is used for the Hydro Power Cascade System. The water is distributed from Lake Sevan for irrigation purposes prior to hydro power generation. During the water flow from Lake Sevan to Lake Yerevan, irrigation system take the water for irrigation and remaining water generate the hydro power at each power station.

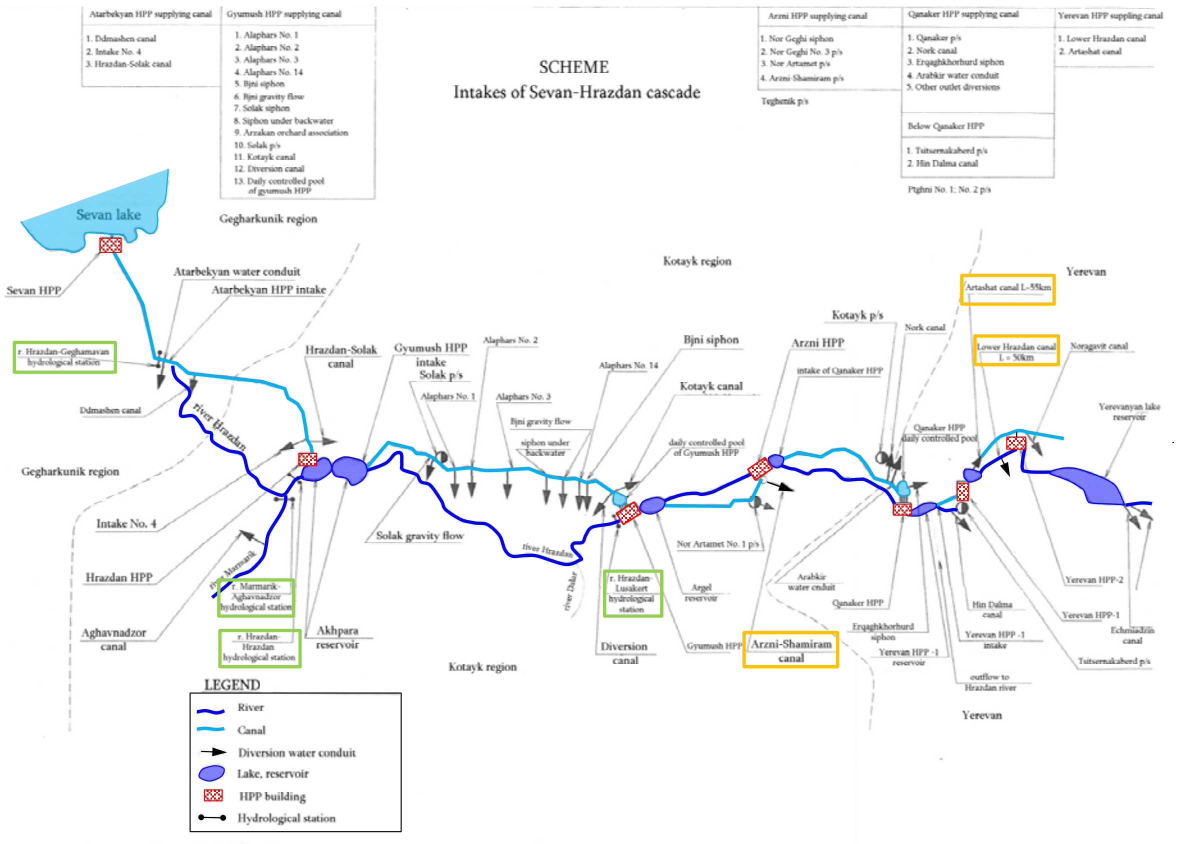


Figure 6-4-1.1 Schematic Diagram of Sevan-Hrazdan Cascade

6-4-2 Irrigation Area and Water Requirement

Target irrigation area is shown in Figure 6-4-2.1. The total area of the Project is 12,347 ha. The target area can be characterized into two (2) areas, one is higher altitude land located around 1,000-1,300m, and the other one is lower altitude land located around 800-1,300m. Figure 6-4-2.1 provides an altitude information and location of four WUA.

As shown in the Figure, altitude of 1,000m is the boundary of higher and lower altitude land.

Yeghvard and Ashtarak WUAs are located in higher altitude land belong to Kotayk and Aragatsotn Marzes. Vagharshapat and Khoy WUAs are located lower altitude land belong to Armavir Marz and this lower altitude land is well known as a major agricultural production area, Ararat plain.

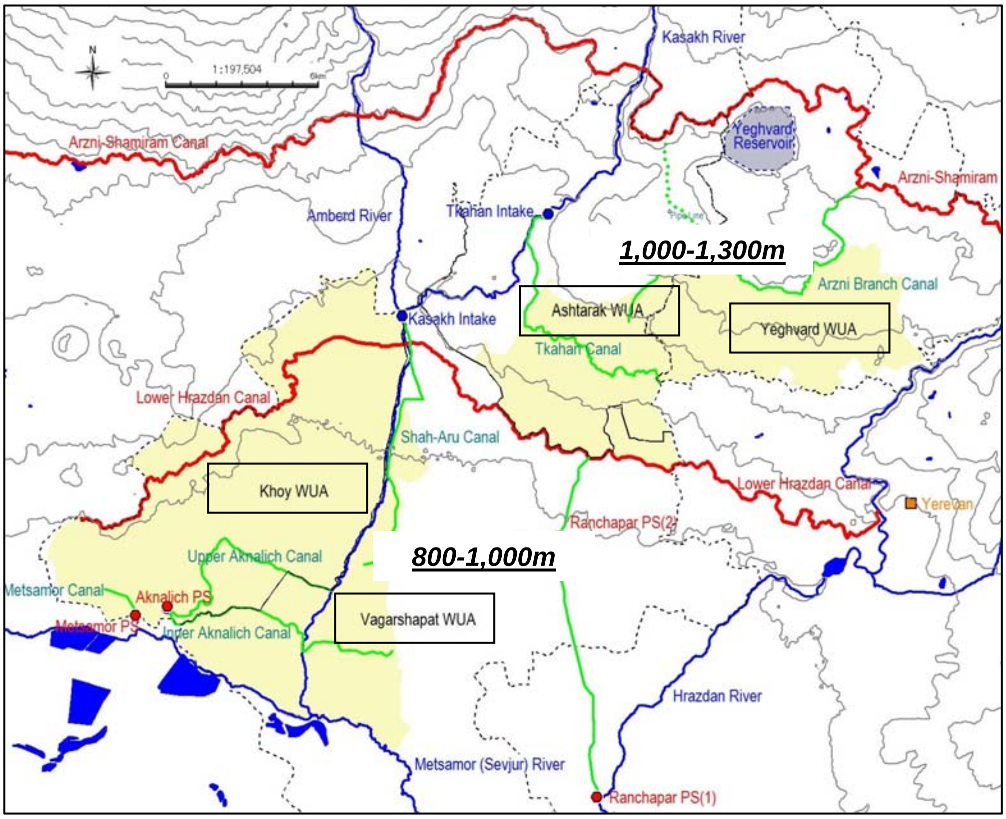


Figure 6-4-2.1 Location of WUA and Altitude

Table 6-4-2.1 shows the irrigation area and planned variety of crops. As it is evident from the Table, the major crop in Yeghvard and Ashtarak WUAs is Grape and Fruit production, and Wheat and Vegetable production in Vagharshapat WUA. This characteristic comes from the difference of meteorology, soil and topographical conditions and so on.

Table 6-4-2.1 Planned Irrigation Area and Crops

Crop	Yeghvard and Ashtarak WUA	Vagarshapat and Khoy WUA	Total
Wheat	233	1,693	1,926
Vegetable	216	3,401	3,617
Grape	1,338	993	2,331
Alfalfa	622	824	1,446
Fruit	1,060	559	1,619
Potato	26	781	807
Others	149	452	601
Total	3,644	8,703	12,347

Source: JICA Study Team

Crop water requirement is calculated by the Irrigation Norm in Armenia as reference. This norm was prepared and compiled by the Institute of Water Problems and Hydaulic Engineering, Yerevan, and published from Ministry of Agriculture in 2007. This irrigation norm's crop water requirement is estimated for each crops based on the Penman-Budagoyski method. The irrigation method defined as furrow irrigation which is most popular in ordinary Armenian farmers.

In the irrigation norm, crop water requirement is mentioned in consideration of rainfall probability for

50% and 75%. 50% probability represents a normal year, in other words, average value. 75% probability characterizes a dry year with rainfall in 3 out of 4 years exceeding, used as criteria for management of irrigation schedule as well as for designing of the irrigation system. It is not clearly mentioned in Armenia's norm that which probability is suitable for planning of irrigation system. However, according to discussion with PIU and referring to preceding projects, Kaps and Vedi project, water requirement of 75% probability is used as reference value for design criteria.

Irrigation norm is defined based on the location and soil types. Irrigation norms characterized as "Ararat, Aragatsotn, Kotayk Regions (1,000-1,300 m) with heavy loamy soil" and "Ararat and Armavir Regions (800-1,000m) with heavy loamy soil" could be applied to the target irrigation area. Example of major crops for the area of 1,000-1,300m and 800-1,000m are shown in Table 6-4-2.2 and Table 6-4-2.3 respectively. As it is mentioned in the Tables, water requirement for lower altitude area is higher than higher altitude area, and the irrigation starts earlier compare to that of higher altitude area.

Table 6-4-2.2 Water Requirement of Major Crop Examples for 1,000-1,300m area (in case of 75% Probability)

Wheat (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	900	(20-Sep)	(10-Oct)	21	0.496
2	900	(6-May)	(8-Jun)	34	0.306
3	900	(9-Jun)	(21-Jun)	13	0.801
4	900	(22-Jun)	(6-Jul)	15	0.694
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
	3,600				

Vegetable (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	600	(25-Apr)	(10-May)	16	0.434
2	600	(27-Apr)	(12-May)	16	0.434
3	600	(23-May)	(11-Jun)	20	0.347
4	600	(12-Jun)	(25-Jun)	14	0.496
5	600	(26-Jun)	(9-Jul)	14	0.496
6	600	(10-Jul)	(21-Jul)	12	0.579
7	600	(22-Jul)	(1-Aug)	11	0.631
8	600	(2-Aug)	(13-Aug)	12	0.579
9	600	(14-Aug)	(26-Aug)	13	0.534
10	600	(27-Aug)	(11-Sep)	16	0.434
11	600	(12-Sep)	(28-Sep)	17	0.408
12					
13					
14					
15					
	6,600				

Note: N.1 is ignored for demand calculation because N.1 and 2 dupulicated some period..

Grape (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	900	(25-Apr)	(20-May)	26	0.401
2	900	(15-Jun)	(5-Jul)	21	0.496
3	900	(6-Jul)	(21-Jul)	16	0.651
4	900	(22-Jul)	(7-Aug)	17	0.613
5	900	(8-Aug)	(24-Aug)	17	0.613
6	900	(25-Aug)	(10-Sep)	17	0.613
7	900	(10-Oct)	(25-Oct)	16	0.651
8					
9					
10					
11					
12					
13					
14					
15					
	6,300				

Table 6-4-2.3 Water Requirement of Major Crop Examples for 800-1,000m area (in case of 75% Probability)

Wheat (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	950	(28-Sep)	(20-Oct)	23	0.478
2	950	(20-Apr)	(20-May)	31	0.355
3	950	(21-May)	(11-Jun)	22	0.500
4	950	(12-Jun)	(28-Jun)	17	0.647
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
	3,800				

Vegetable (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	650	(10-Apr)	(30-Apr)	21	0.358
2	650	(12-Apr)	(1-May)	20	0.376
3	650	(7-May)	(23-May)	17	0.443
4	650	(24-May)	(6-Jun)	14	0.537
5	650	(7-Jun)	(20-Jun)	14	0.537
6	650	(21-Jun)	(3-Jul)	13	0.579
7	650	(4-Jul)	(16-Jul)	13	0.579
8	650	(17-Jul)	(28-Jul)	12	0.627
9	650	(29-Jul)	(11-Aug)	14	0.537
10	650	(12-Aug)	(25-Aug)	14	0.537
11	650	(26-Aug)	(9-Sep)	15	0.502
12	650	(10-Sep)	(24-Sep)	15	0.502
13	650	(25-Sep)	(7-Oct)	13	0.579
14					
15					
	8,450				

Note: N.1 is ignored for demand calculation because N.1 and 2 dupulicated some period..

Grape (Probability: 75%)

	Irrigation Norm				
N	(m3/ha)	From	To	(Days)	(l/s)
0					
1	900	(15-Apr)	(10-May)	26	0.401
2	900	(20-May)	(15-Jun)	27	0.386
3	900	(16-Jun)	(30-Jun)	15	0.694
4	900	(1-Jul)	(15-Jul)	15	0.694
5	900	(16-Jul)	(30-Jul)	15	0.694
6	900	(31-Jul)	(13-Aug)	14	0.744
7	900	(14-Aug)	(31-Aug)	18	0.579
8	900	(10-Oct)	(30-Oct)	21	0.496
9					
10					
11					
12					
13					
14					
15					
	7,200				

Prior to estimation of water demand for the Project, following conveyance efficiency is applied according to PIU's information. Table 6-4-2.4 and 6-4-2.5 are the water demand for 12,347ha. The water demand is calculated for higher and lower altitude area respectively, and combined both demand for the water balance calculation later. Figure 6-4-2.2 shows the bar-chart of water demand by 10-days decade interval.

Table 6-4-2.4 Conveyance Efficiency

Target irrigation facilities	Water conveyance ratio (present state)
Main canal	72%
Secondary ~ Tertiary ~ Parcels	65%
Comprehensive (main canal ~ parcels)	46.8%

Source) PIU

Table 6-4-2.5 Water Demand

Crop	Kotayk, Agaratsotn (1,000-1,300m)		Armavir (800-1,000m)		Total	
	Area (ha)	Demand (MCM)	Area (ha)	Demand (MCM)	Area (ha)	Demand (MCM)
Wheat	233	1.8	1,693	13.7	1,926	15.5
Vegetable	216	2.8	3,401	56.6	3,617	59.4
Grapes	1,338	18.0	993	15.2	2,331	33.2
Alfalfa	622	8.5	824	14.3	1,446	22.8
Fruits	1,060	7.9	559	4.7	1,619	12.7
Potato	26	0.2	781	5.4	807	5.6
Other food	149	1.2	452	3.8	601	5.0
Total	3,644	40.4	8,703	113.8	12,347	154.2

Source) JICA Survey team

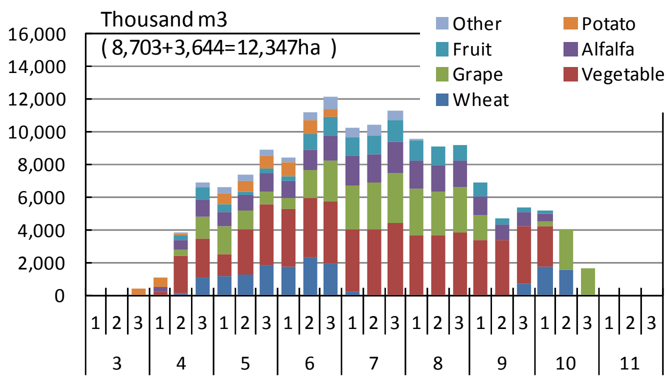


Figure 6-4-2.2 Water Demand for 12,347ha *)
***) 3rd decade of June: 12,158,000m^3 (= 14.071m^3/s)**

6-4-3 Water Balance Calculation

(1) Definition of reference year for calculation

As mentioned in Chapter 4, probability of rainfall and river flow at Hrazdan O.S. has been evaluated. Table 6-4-3.1 shows the return period for latest 10 years, 2004 to 2013. As prior to water balance calculation, year of 2013 is decided as a reference year for definition of the capacity of Yeghvard reservoir. 2013 is matched to the criteria of 75% probability (Return Period = 1/4) from the view point of rainfall and river flow.

Table 6-4-3.1 Return Period of Latest 10 Year's Rainfall and Discharge Data

No	Year	Return Period of Meteorology and Hydrological Data		
		Rainfall at Hrazdan		Hrazdan River's Discharge
		30 years 1)	10 years 2)	10 years 3)
1	2004	-	1/3	1/2
2	2005	-	-	
3	2006	-	-	
4	2007	-	-	
5	2008	1/16	1/5	1/16
6	2009	-	-	1/3
7	2010	-	-	
8	2011	-	1/2	
9	2012	1/3	1/16	1/6
10	2013	1/3	1/4	1/4

1)30 years: 1983 - 2013 (except no data period of 1995 - 2000)
2)10 years: 2004 - 2013 (Calculation Period is from March to October)
3)10 years: 2004 - 2013 (Calculation Period is from March to October)

(2) Pre-condition of water balance calculation

The water balance is calculated combining with hydro-meteorological data, water demand of the Project area and other irrigation systems along Hrazdan river. Table 6-4-3.2 gives the pre-conditions of water balance calculation, while Figure 6-4-3.1 shows a diagram of the irrigation network, including not only Yeghvard area but also others along Hrazdan river. Also, Table 6-4-3.3 shows the volume of water demand in another irrigation area which also utilizes water from the Hrazdan River and Lake Sevan.

Table 6-4-3.2 Premises of Water Balance Calculation

Item	Content
Target Area	12,347ha
Adopted Sites of Discharge Observation	Hrazdan (Hrazdan River) Lusakert (Hrazdan River) Ashtarak (Kasakh River)
Property of Discharged Data	10-days average data
Standard Documents of Irrigation	Norms and regimes of Irrigation of agricultural crops for the irrigable lands of the Republic of Armenia
Other Irrigation Beneficiaries	Arzni-shamiram 2nd part ,Lower Hrazdan 2nd part, Artashat canal, Other canals
Available Maximum Cross Section of Arzmi-Shamiram Canal	$22m^3/s$
Water Conveyance Efficiency	46.8% (Main Canal (72%), After Secondary Canal (65%))
Evaporation	50mm/month (The average value of the amount of evaporation from April to October in the Yeghvard observation point is adopted. It assumes that it evaporates from 3 km x 3 km as an amount of evaporation loss in 0.17 m^3/s)
Infiltration Loss from Reservoir	$0.24m^3/s$ ((90MCM x 5%) / (214 days x 86,400 second), Infiltration loss from reservoir from March to September (214days) is assumed to $0.24m^3/s$ by above equation. 214days is the precondition of reservoir utilization period. 5% is reference ratio of infiltration loss.)

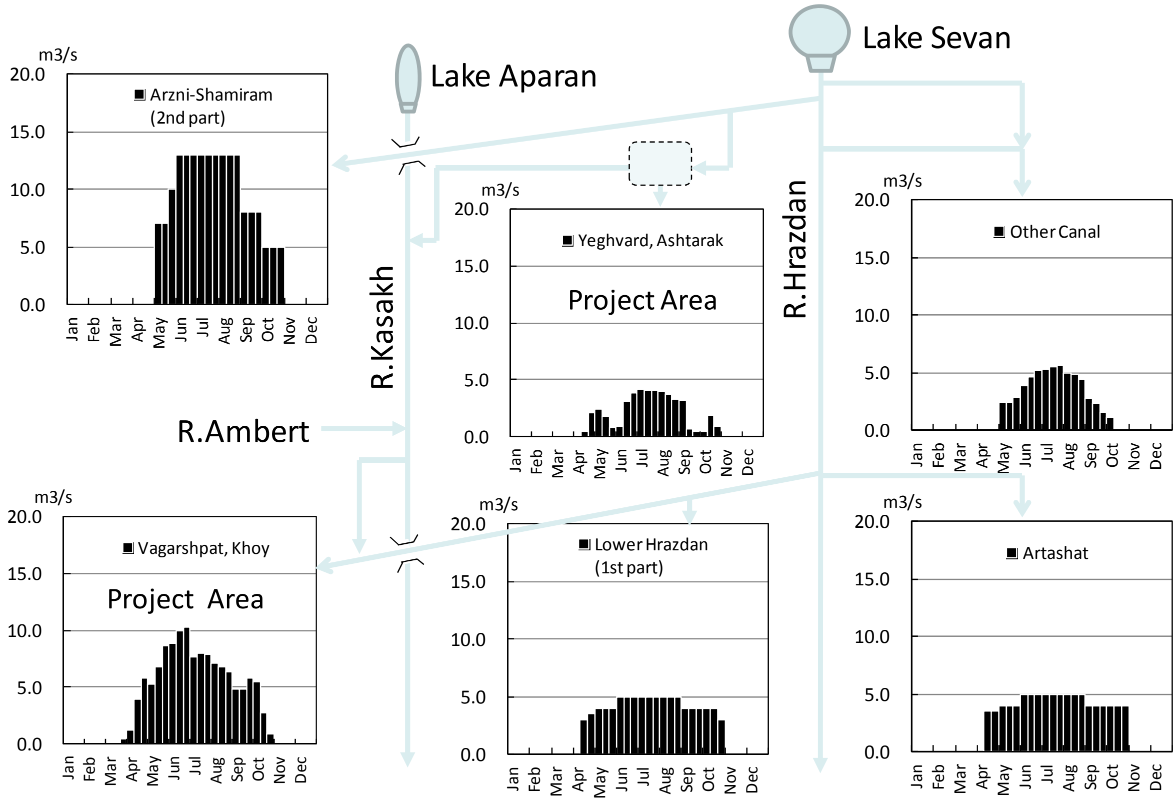


Figure 6-4-3.1 Diagram of Irrigation Network Used in Water Balance Calculation

Table 6-4-3.3 Water Demand of another Area along Hrazdan River

Irrigation Area	Demand
Arzni-shamiram 2nd part	159.1 MCM
Lower Hrazdan 2nd part,	76.2 MCM
Artashat canal	77.6 MCM
Other canals	52.6 MCM
Total	365.5 MCM

*) PIU, Water conveyance efficiency is already taken into account in this table.

(3) Water balance calculation (single year's analysis)

The water balance calculation is done for 2013 as reference year. Based on the result of calculation, the capacity of Yeghvard reservoir is defined as 94MCM. Table 6-4-3.4 and Figure 6-4-3.2 shows the result of water balance calculation with the pre-condition mentioned on Table 6-4-3.2. On the reference year, total area of 12,347ha could be irrigated by Yeghvard reservoir which has 94 MCM reservoir's capacity. Figure 6-4-3.2 is the change of reservoir's volume drawn by line graph. The distributed water from Arzni-Shamiram canal to Yeghvard reservoir is diverted start from 1st decade of March to 2nd decade of May.

Table 6-4-3.4 Result of Water Balance Calculation for the Yeghvard Reservoir

Unit: MCM

Demand	Supply			Deficit	Supply	Loss		Reservoir	Balance
	Kasakh River	Hrazdan River L.H.	Hrazdan River A.Br.		Hrazdan River	Evap.	Res.		
(1)	(2)	(3)	(4)	(5)=(1)-(2)-(3)-(4)	(6)	(7)	(8)	(9)=(6)-(7)-(8)	(10)=(5)-(9)
154	46	14	0	94	103	4	5	94	0 (OK)

Note: L.H.(Lower Hrazdan Canal), A.S.(Arzni Branch Canal), Evap.(Evaporation), Res.(Reservoir Loss)

Figure 6-4-3.3 shows the demand of 12,347ha which is drawn by bar chart, and available water at Arzni-Shamiram intake which is drawn by line. The concept of water distribution from Hrazdan river through Arzni-Shamiram canal is to store the snow melted river flow water to Yeghvard reservoir during March to May. The difference between available water and demand is the maximum water volume which can divert to Yeghvard Reservoir. However, the maximum discharge to Yeghvard reservoir is limited 22.0m^3/s according to the 80% of current canal cross section.

Figure 6-4-3.4 shows the amount of discharge to Yeghvard Reservoir through Azrni-Shamiram canal. Already mentioned above, Yeghvard reservoir is stored from March to May by utilizing of melted snow flow in Hrazdan river. Figure 6-4-3.5 shows the water distribution plan for four (4) targeted WUA from Yeghvard reservoir. As it is evident from Figure 6-4-3.5, Yeghvard reservoir starts to irrigate from 3rd decade of May and end to 2nd decade of October.

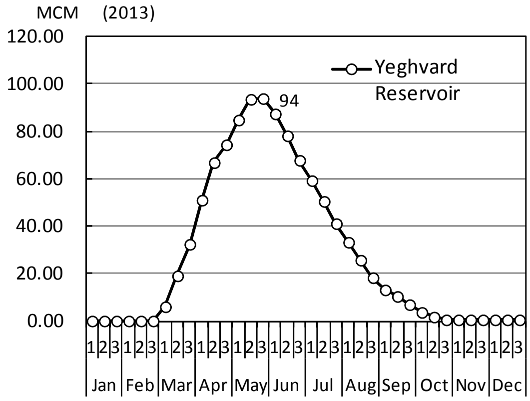


Figure 6-4-3.2 Change of Yeghvard Reservoir's Volume

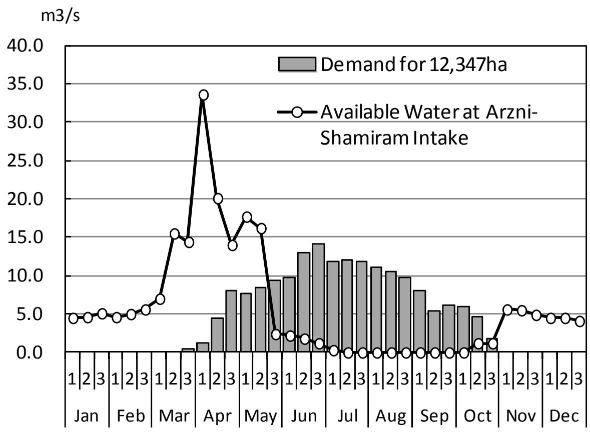


Figure 6-4-3.3 Comparison between Demand (12,347ha) and Available Water at Arzni-Shamiram Intake

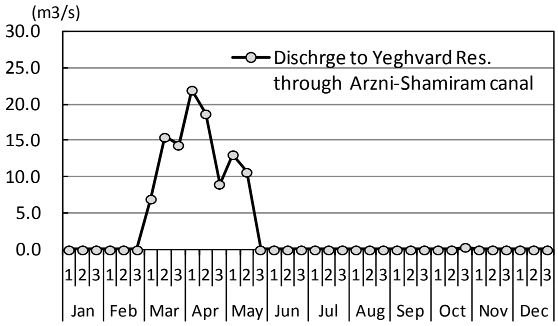


Figure 6-4-3.4 Discharge into Reservoir through Arzani-Shamiram Canal

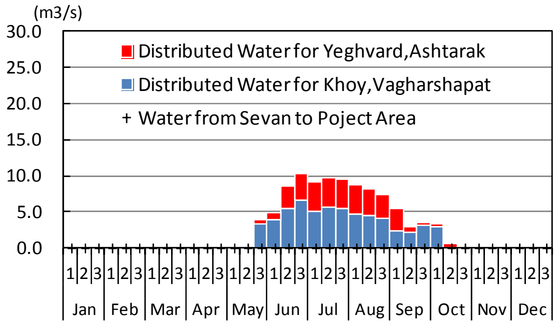


Figure 6-4-3.5 Distributed Water from Yeghvard Reservoir and Water from Lake Sevan

Following Figure 6-4-3.6 shows the plan of diagram of irrigation network after implementation of the Project, which mentions the irrigation area and maxim discharge requirement. Dotted red line in the Figure is the new areas and canals.

As a calculation of water balance, following result has come out.

- The Capacity of 94 MCM Yeghvard reservoir can irrigate 12,347ha without supplemental distribution from Lake Sevan and pumps stations.
- Around 50MCM can reduce the dependence on Lake Sevan. 50MCM is the dependence volume estimated data from latest 10 years.

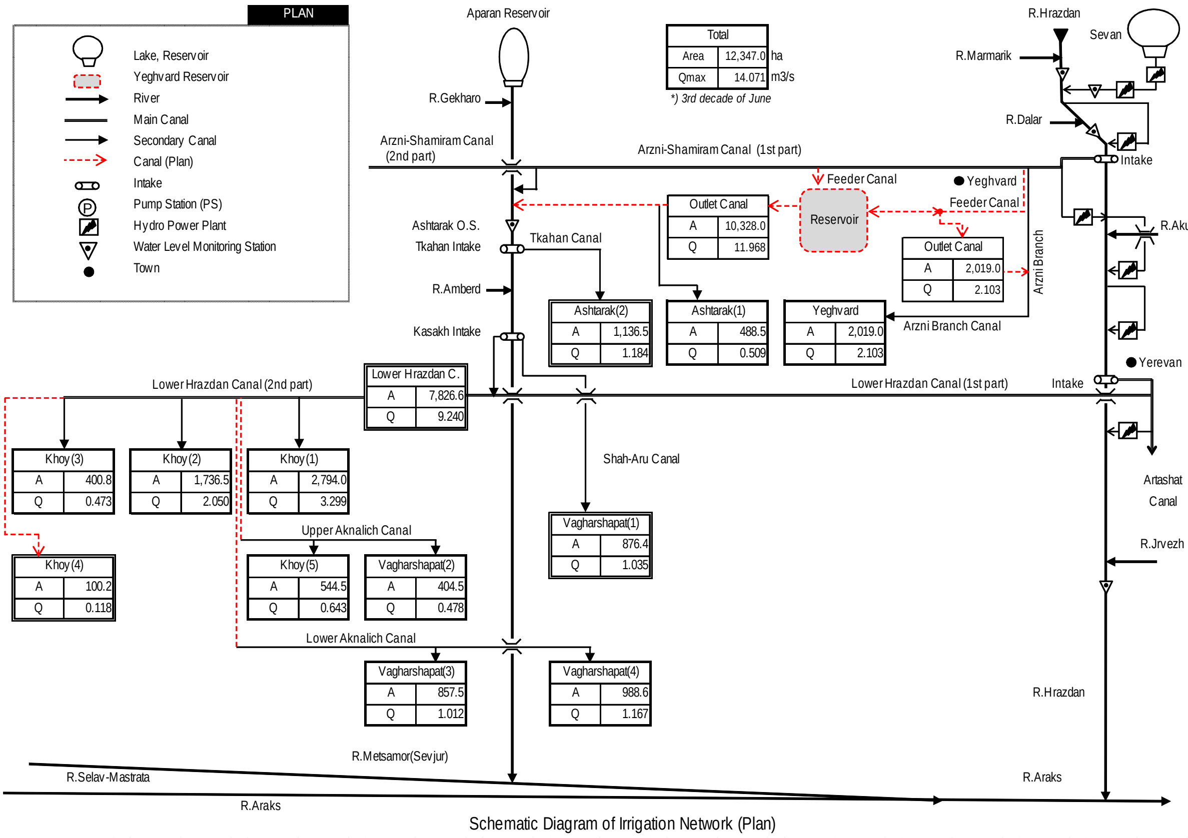


Figure 6-4-3.6 Schematic Diagram of Irrigation Network (Plan)

(4) Water balance calculation (10 consecutive years calculation)

To verify the effectiveness of reference year, water balance is calculated for 10 consecutive year period from 2004 to 2013. According to the 10 consecutive year calculation, in 4 cases out of 10 years, 95MCM is not enough to irrigate without supplemental water supply from other sources such as Lake Sevan and pump stations. And if the 2007's deficit volume (8MCM) regard as less shortage compares to 2008, 2009 and 2012 and neglect the 2007 as water deficit occurrence year, water shortage occurs in 3 cases out of 10 years. From the view point of evaluation of return period for 4 cases out of 10 years and 3 cases out of 10 years, each probability is around 60% to 70% respectively, and which almost matches to the pre-condition of reference year of 75% probability represented by 2013. Therefore, capacity of Yeghvard reservoir could be defined as 94MCM.

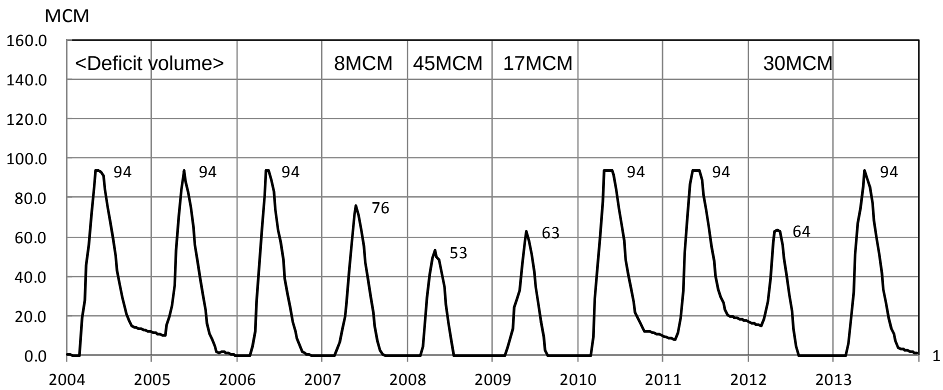


Figure 6-4-3.7 Changes in Yeghvard Reservoir's Operation for Latest 10 Years

(5) Case study for alternative Yeghvard Irrigation System Improvement Project

Lake Savan plays a very important role in Armenia. The dependence volume on the Lake Sevan and the planned capacity of Yeghvard reservoir is in the relationship of trade-off. In order to clarify the relationship between Lake Sevan and Yeghvard reservoir, some scenarios of the experimental trials were done for evaluating the Project purposes.

a) Dependant on the other water resources such as Lake Sevan and pump stations

Figures 6-4-3.8 shows the relationship between the dependant on other resources such as Lake Sevan or pumps stations and the capacity of Yeghvard reservoir. It describes that in case the dependant on the other water resources such as Lake Sevan is nil, the need for capacity of Yeghvard reservoir is 94MCM, which is already mentioned above calculation. However, for example, Lake Sevan releases 48MCM to the Project, the capacity of Yeghvard reservoir could be reduced to 40MCM, which contributes to reduction of reservoir construction cost.

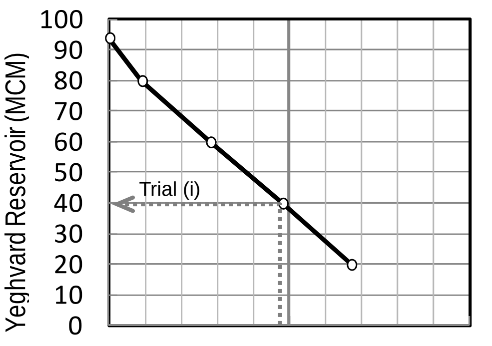


Figure 6-4-3.8 Relationship between Dependant on Other Resources and Reservoir

Table 6-4-3.5 Dependant on Other Resources and Reservoir

Trial	Dependant on other Resource (MCM)	Yeghvard Reservoir (MCM)	Water Resource
-	0	94	-
(i)	9	80	Sevan or Pump
(ii)	28	60	ditto
(iii)	48	40	ditto
(iv)	67	20	ditto

b) Irrigation area and irrigation method

Figures 6-4-3.9 shows the relationship between the irrigation area, irrigation method and the capacity of Yeghvard reservoir. According to this relationship, if irrigation area decreases to 3,644ha which only covers Yeghvard and Ashtarak WUAs, the capacity of Yeghvard reservoir could be reduced to 35MCM, which is mentioned as Trial (i).

If the irrigation method changes to drip irrigation from furrow irrigation, it is expected to reduce the capacity of reservoir. Trial (ii) and (iii) mention the result of changing the irrigation method from furrow irrigation to drip irrigation. However, it is not realistic plan to change the all area by drip irrigation method. Therefore the irrigation area of grape and fruit is the only trial area to change the drip irrigation. According to the calculation for trial (ii) and (iii), the Reservoir could be reduced to 84MCM or 79MCM respectively. Figure 6-4-3.10 and 6-4-3.11 shows the demand of trial (i) and (ii).

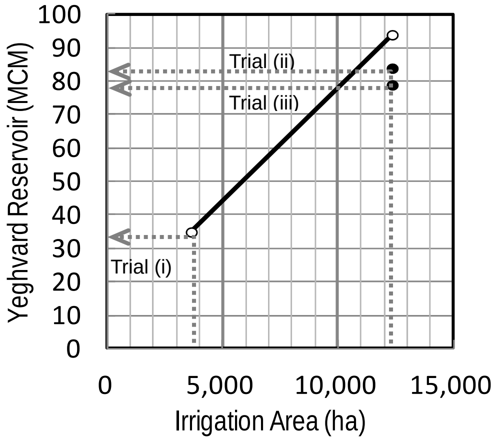


Figure 6-4-3.9 Relationship between Capacity of Reservoir and Irrigation Area, Irrigation Method

Table 6-4-3.6 Capacity of Reservoir by Irrigation Area and Irrigation Method

Trial	Area		Irrigation Type	Conveyance Efficiency	Demand (MCM)	Yeghvard (MCM)
-	12,347		Furrow	46.8%	154	94
(i)	3,644		Furrow	46.8%	40	35
(ii)	12,347	9,949	Furrow	46.8%	146	84
		2,398	Drip	71.3%		
(iii)	12,347	8,397	Furrow	46.8%	140	79
		3,950	Drip	71.3%		

Note: The conveyance efficiency by furrow irrigation defines 46.8% which is calculated as 72% times 65%, and that of drip irrigation defines 71.3% which is calculated as 75% times 95%.

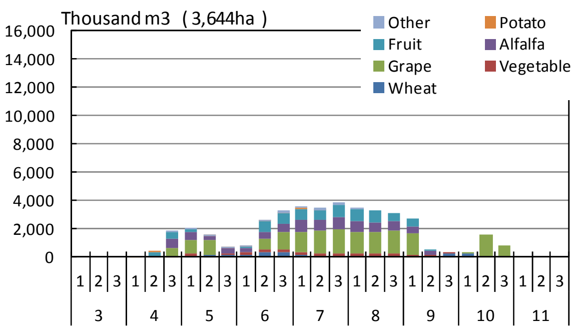


Figure 6-4-3.10 Water Demand for Trial (i) (3,644ha)

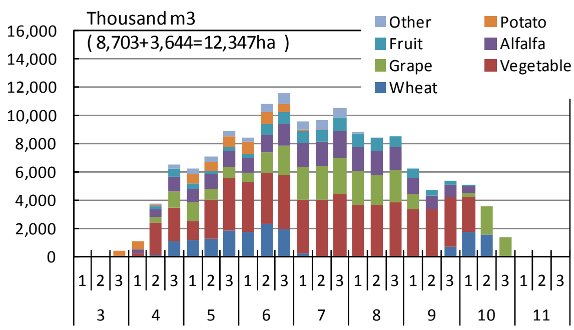


Figure 6-4-3.11 Water Demand for Trial (ii) (12,347ha (2,398ha is irrigated by drip system))

c) Canal conveyance efficiency and reservoir capacity

According to the PIU, the canal conveyance efficiency is around 50% in the Project area. The increasing of conveyance efficiency reduces the Yeghvard reservoir's capacity. Figure 6-4-3.12 mentions the relationship between conveyance efficiency and the capacity of Yeghvard reservoir. If the conveyance efficiency for main canal and distribution canal after secondary canal improve to 75% and 68% by upgrading of canal works respectively, the capacity of Yeghvard reservoir could be reduced to 81 MCM. Based on this result, it is evident that increasing 3 to 5% of conveyance efficiency can reduce around 10MCM of Yeghvard reservoir capacity. Figure 6-4-3.13 and 6-4-3.14 shows the demand of trial (i) and (ii) in Table 6-4-3.12.

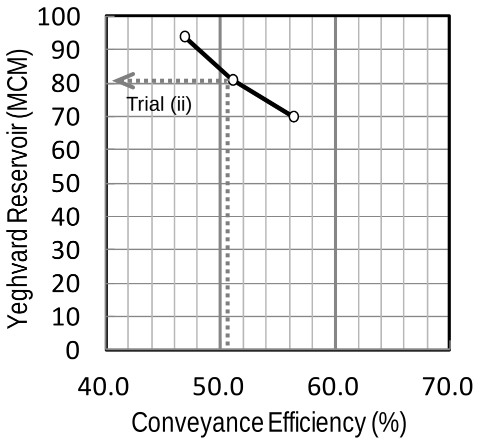


Figure 6-4-3.12 Relationship between Conveyance Efficiency and Reservoir

Table 6-4-3.7 Conveyance Efficiency and Reservoir

Trial	Conveyance Efficiency			Demand (MCM)	Yeghvard Reservoir (MCM)	Remarks
	Main Canal	After Secondary Canal	Total			
-	72%	65%	46.8%	154	94	Current condition
(i)	75%	68%	51.0%	141	81	
(ii)	75%	75%	56.3%	128	70	

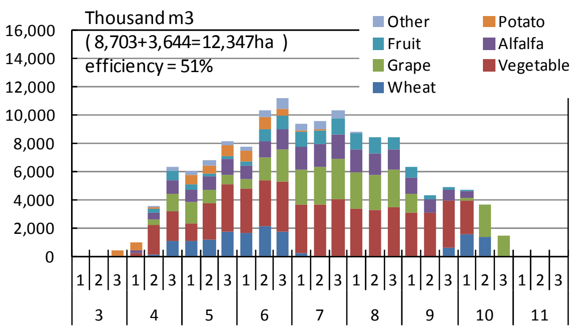


Figure 6-4-3.13 Water Demand for Trial (i) (12,347ha)
Conveyance Efficiency: 51.0%

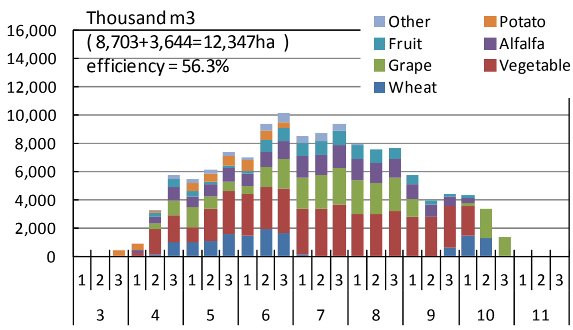


Figure 6-4-3.14 Water Demand for Trial (ii) (12,347ha)
Conveyance Efficiency: 56.3%

6-4-4 Improvement Plan of Irrigation Network System

The Project area is composed of two (2) areas largely. One area is construction area includes inflow and outflow facilities, the other one is irrigation filed which is managed by 4 WUAs. Herein after, the improvement plan is designed to following two areas respectively.

- **Target area 1 : Yeghvard reservoir and related facilities**
- **Target area 2 : Irrigation filed (composed by 4 WUAs)**

As for Target area 1, the reservoir condition shall deeply impact to design of related facilities. The basic conditions of Yeghvard reservoir are shown in Table 6-4-4.1.

Table 6-4-4.1 Basic Design Conditions of Reservoir

Full water level	EL 1,305.00m
Dam crest level	EL 1,307.55m
Dam Bottom level	EL 1,290.00m

6-4-4-1 Improvement Plan for Target Area 1

Stored water of 94MCM in Yeghvard reservoir is distributed to target irrigation area by the suitable conveyance facilities. Essential conveyance facilities are planned as shown in Figure 6-4-4.2 by following consideration and examination.

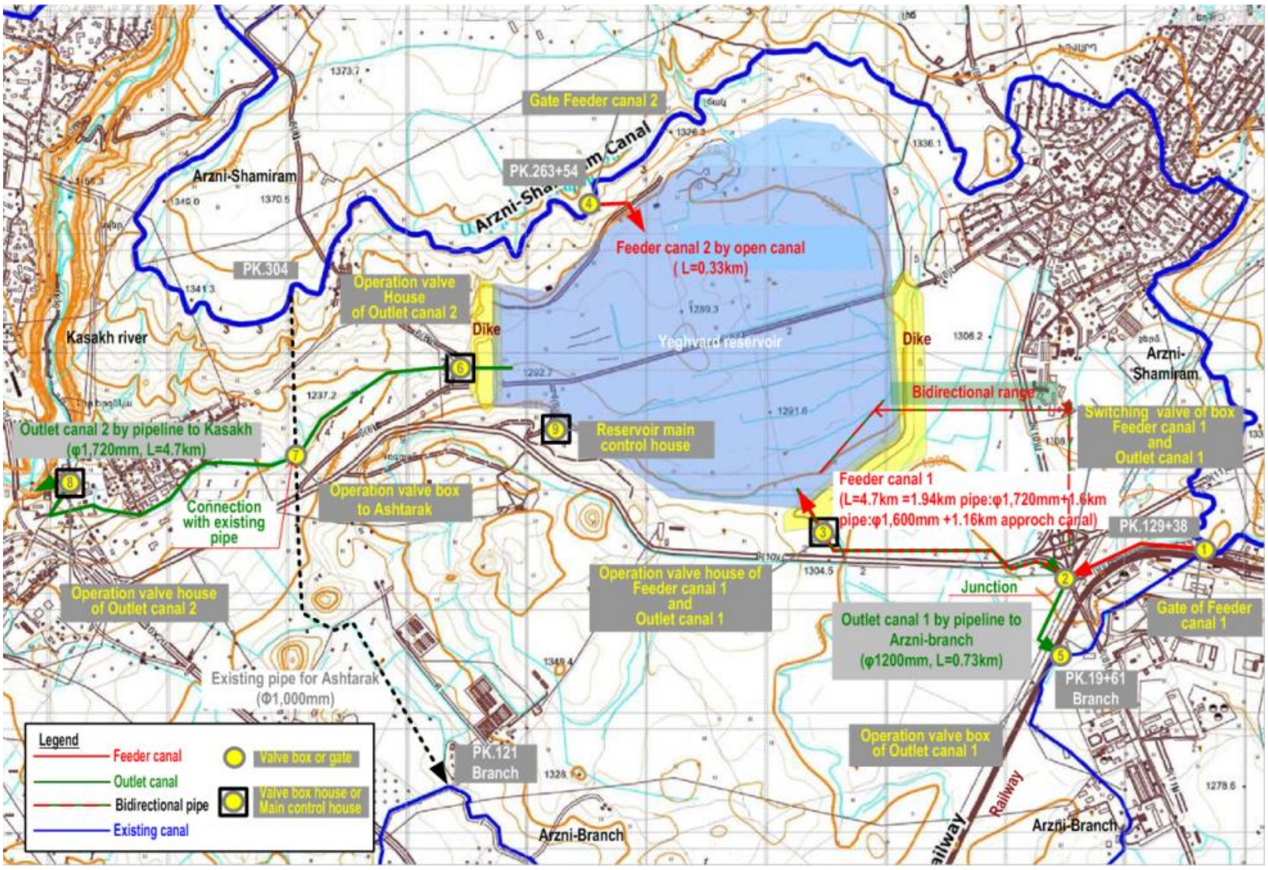


Figure 6-4-4.1 General Layout of Feeder and Outlet Canal for Targeted Area 1

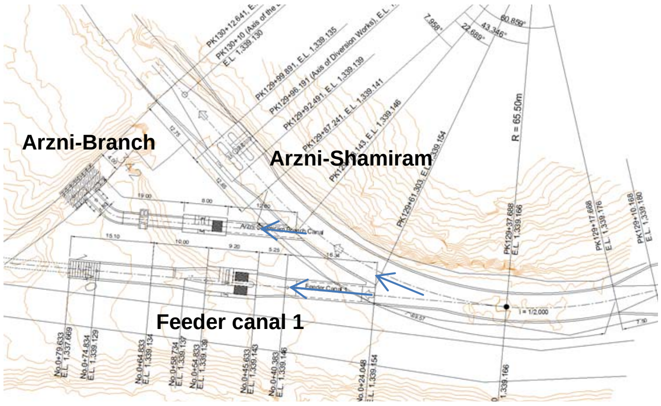
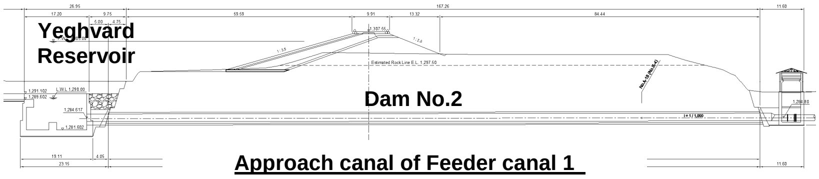
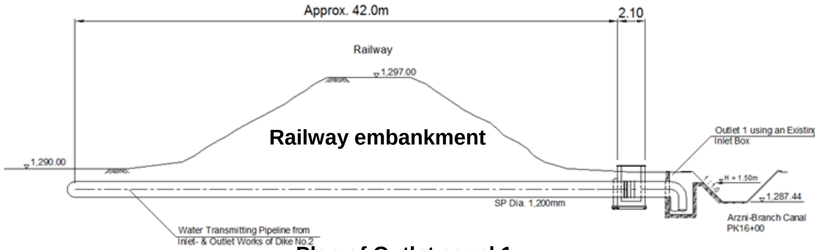
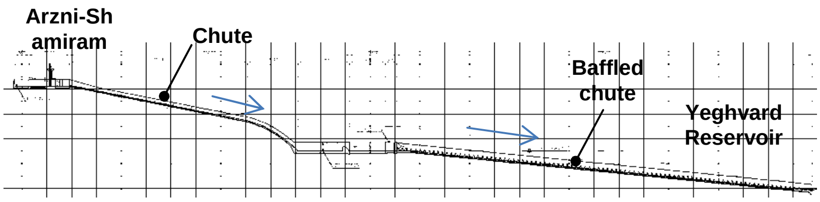
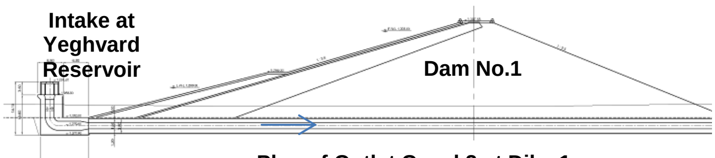
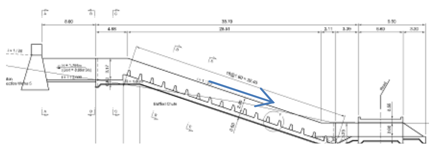
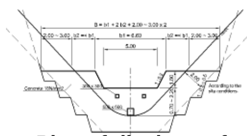
Canal	Typical section
Feeder canal 1 and Outlet canal 1	 Inlet plan of feeder canal1  Approach canal of Feeder canal 1  Plan of Outlet canal 1
Feeder canal 2	 Plan of Feeder canal 2
Outlet canal 2	 Plan of Outlet Canal 2 at Dike 1  Plan of dissipater for Kasakh river (1/2)  Plan of dissipater for Kasakh river (2/2)

Figure 6-4-4.2 Typical Section of Planned Feeder and Outlet Canal

(1) Arrangement of inflow aspects to Yeghvard reservoir

a) Actual condition of inflow in Arzni-Shamiram canal

The Yeghvard reservoir is planned to 94MCM as design entire water volume. The reservoir is filled by the melted snow water in the limited season, **1st March to end of May**, through existent Arzni-Shamiram canal.

According to water allocation in a year, Arzni-Shamiram canal have been allowed to the following water allocation from March to May. The reservoir shall be taken into account the existent allocation schedule and the necessary conveyance way of water so as not to miss available water in targeted season. To achieve full store of 94MCM for designated 3 month only, **inflow 22.0m^3/s as maximum shall be made the most of availability and Arzni-Shamiram canal shall be enable to convey 22.0m^3/s without the problem.**

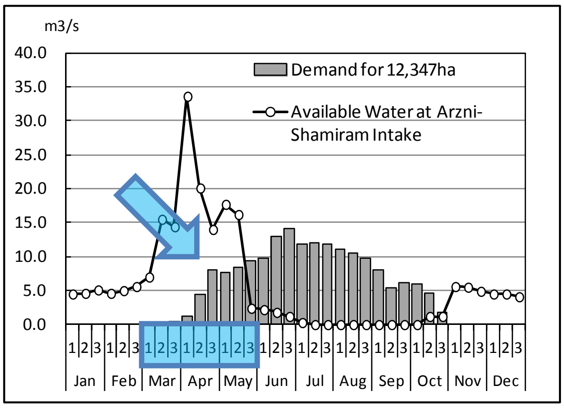


Figure 6-4-4.3 Available Water of Arzni-Shamiram in Year

Table 6-4-4.2 Water Allocation in Available Season in Arzni-Shamiram Canal

Month	March			April			May		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Vol. (m^3/s)	7.00	15.50	14.40	22.00	19.20	11.20	14.90	12.40	1.50

b) Hydraulic capacity of Arzni-Shamiram canal

In order to design the maximum utilization of Arzni-Shamiram canal, the hydraulic capacity should be verified. Given the designed reservoir location, the inflow canal (herein after "Feeder canal") to reservoir shall be planned at downstream of approx. PK130 where the beginning of Arzni- Branch is connected. PK130 is at distance of 13,000m from the beginning of Arzni-Shamiram canal.

Existent Arzni-Shmiram canal at downstream from PK130 is obtained and observed as following condition. The original design discharge is confirmed by "rehabilitation drawings by World Bank and Millennium Challenge Cooperation in Armenia (2011-2013). The actual discharge is assumed by visual observation of water trace on canal wall.

Table 6-4-4.3 Hydraulic Capacity Design and Actual

Location	Original design discharge (m^3/sec)	Expected discharge (m^3/s)	Remarks
PK 0+00 - PK 94+26	28.2	15.626	by OP. canal
PK 94+26 - PK 115+30	26.0	15.626	by OP. canal
PK 115+30 - PK 130+17	24.0	15.626	by OP. canal
PK 130+17 - PK 181+18	17.6	15.0	at east of planned reservoir / by OP. canal
PK 181+18 - PK 311+60	16.8	15.0	From PK181+18 to PK190+35 at Yeghvard city by box culvert
PK 311+60 - PK 350+95	15.0	15.0	at north and west of planned reservoir / by OP. canal

Note) Hatch show at range of D.S. of PK130

As a result of the careful consideration of hydraulic capacity, the expected maximum discharge is assumed to 15m^3/s. However, considering to safety pass of flow and to avoid overflow at narrow and shortage freeboard section, the maximum design discharge at downstream from PK130 shall be 13m^3/s. Because the enhancement of the canal capacity in Yeghvard city, where the box culvert has been applied as conveyance structure, is raised social difficulty and issue due to the residence area.

On the other hand, Arzni-Shamiram canal at upstream for PK130 which is constructed by open canal, is observed shortage capacity section such as short freeboard to convey 22m^3/s of maximum. Although Arzni-Shamiram canal was rehabilitated by World Bank project and by the program of Millennium Challenge Cooperation in Armenia, the rehabilitation could not be completed in the program because of lack of design. To satisfy the target maximum discharge of 22m^3/s, Arzni-Shamiram canal at upstream for PK130 shall be rehabilitated to secure the necessary freeboard by raising wall at distance of PK20 to PK45, PK70-PK90 and PK95 to PK105.

The available hydraulic capacity and necessary rehabilitation works in Arzni-Shamiram canal should be designed as Table 6-4-4.4;

Table 6-4-4.4 Hydraulic Condition for Allowable Capacity in Arzni-Shamiram Canal

Location	Max. discharge (m^3/s)	Remarks
PK0+00 ~ PK130+17	**22.0**	Leakage protection and other rehabilitation L=5.5km (PK20 to PK45, PK70 – PK90 and PK95-PK105)
Downstream of PK130+17	**13.0**	

Note) PK130+17 is at connected of Arzni-Branch

(2) Plan of feeder canals

a) Necessary feeder canals

As the result of the necessity of maximized use of discharge and consideration of hydraulic condition in Arzni-Shamiram canal, to reserve 94MCM for the designated 3 months, necessary feeder canals are planned by following options. As for the basic concept of alignment for canal, it is important that to avoid negative effect to land use and unnecessary long alignment. Therefore, structure shall be planned along road area and farrow area basically. With careful consideration of land-use and topographic condition, alignment of feeder canals and each option are outlined as followings;

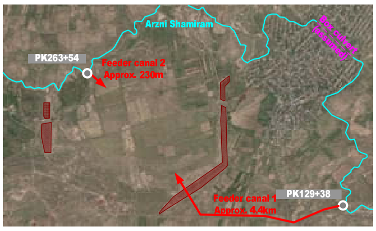
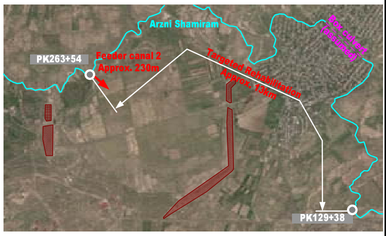
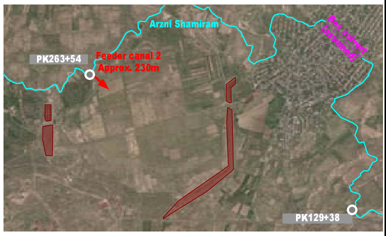
- ✓ **Option 1**: **Two feeder canals**, Feeder canal 1 and Feeder canal 2, convey water of max. 22m^3/s to reservoir.
  Feeder canal 1 should be from PK129+196 of Arzni-Shamiram canal to at south of reservoir along public road by pipeline and Feeder canal 2 should be at around PK263+20 of Arzni-Shamiram canal by open canal, which is at north of reservoir.
- ✓ **Option 2**: **One feeder canal** same as Feeder 2 of Option 1, convey water of max. 22m^3/s to reservoir. **The upgrading of Arzni-Shamiram canal** from PK129+196 to around PK263+20, L= approx. 13km, shall be essential to pass 22m^3/s because of short hydraulic capacity at that section.
- ✓ **Option 3**: **One feeder canal** same as Feeder 2 of Option 1 is planned, but conveyance water should be 13m^3/s so as not to be over allowable capacity in Arzni-Shamiram canal. To reserve 94MCM in reservoir, **periods of inflow from Arzni-Shamiram canal shall be extended to 4 - 5 months** with approval by related agency.

Considering of below comparison, **Option 1 is applied plan for feeder canal. Two feeder canals shall be planned.**

Table 6-4-4.5 Intake Allocation of Feeder Canal

Option	Facility	Rough location of facility	Max. design discharge (m3/s)	Intake vol. (m3/s)	Remarks
Option 1	Feeder canal 1	PK129+196 (near B.P of Arzni-branch)	**9.0**	22.0	Conveyance by pipeline to reservoir
	Feeder canal 2	PK263+20 (outside of Yeghvard city)	**13.0**		1) Conveyance by OP. canal to reservoir 2) Discharge is allowed to pass in Yeghvard city due to below capacity.
Option 2	Feeder canal 2	PK263+20 (outside of Yeghvard city)	22.0	22.0	1) Conveyance by OP. canal to reservoir 2) Upgrading of Arzni-Shamiram L=13km
Option 3	Feeder canal 2	PK263+20 (outside of Yeghvard city)	13.0	13.0	1) Conveyance by OP. canal to reservoir 2) Extension of available inflow periods

Table 6-4-4.6 Comparison of Feeder Canal Plan

Item	Option 1	Option 2	Option 3
Outline	 ■Plan is Two feeder canals ■Feeder canal 1 (max 9m^3/s) is at PK129+196 by pipeline, Feeder canal 2 (max 13m^3/s) is at north of reservoir by OP. canal. ■Max. intake volume is 22m^3/s	 ■Plan is one feeder canal with upgrading Arzni-shamiram canal ■Feeder canal is at north of reservoir by OP. canal. ■Max. intake volume is 22m^3/s	 ■Plan is one feeder canal without upgrading Arzni-shamiram canal ■Extension of available inflow periods to 4~5 months ■Feeder canal is at north of reservoir by OP. canal. ■Max. intake volume is 13m^3/s
Hydraulic feature	■Feeder canal 1(F.C.1) by pipeline has dully effective water head (Δhe) to convey water. Δhe =approx. 50m > 43m =Δhf ■Feeder canal 2(F.C.2) by OP. canal is dully applied, because B.P. of F.C.2 is far higher than F.W.L. of reservoir EL 1333.8m > F.W.L.1,305m ⇒**Hydraulic conditions are solved** **(+)**	■F.C.2 by OP. canal is dully applied, because B.P. of F.C.2 is far higher than F.W.L. of reservoir. EL 1331.1m > F.W.L.1,305m ■Upgrading of Arzni-Shamiram canal for 13km from PK129+196 is necessary of raising wall by approx. 1m to pass 22m^3/s include Yeghvard city. ⇒**Hydraulic conditions are solved** **(+)**	■F.C.2 by OP. canal is dully applied, because B.P. of F.C.2 is far higher than F.W.L. of reservoir. EL 1331.1m > F.W.L.1,305m ■Upgrading of Arzni-Shamiram canal for 2.7km is needless. ■But, longer inflow periods than other option is necessity. ⇒ **Hydraulic conditions are no obstruction** **(+)**
Construction feature	■Construction site of new facilities is two. ■F.C.1 works should be arranged road traffic and required to approval of road works. ⇒**Easy construction works** **(+)**	■Construction site of new facilities is one. ■Box culvert at Yeghvard city should be required to the upgrading, but land-use permission and consensus are essential. Construction works shall be avoided big negative effect to residents and case to costly works. ⇒**Difficult construction works and negative effect to Yeghvard city.** **(-)**	■Construction site of new facilities is one. ⇒**Easiest construction works** **(+ +)**
Social issue	■Arranged road traffic and permission of road works are required, but, those would be obtained by usual procedure. **(+, -)**	■Land-use permission and consensus are essential. Complexed social impact arise. **(- -)**	■Arrangement of permission on inflow for 4 - 5 months periods is essential, but it is negative prospection, due to difficulty of changing of water allocation on Hrazdan river. **(- -)**
Assess-ment	Total merit and demerit is 2+ (Applied)	Total merit and demerit is 2-	Total merit and demerit is 1+

b) Outline of Feeder canal 1 (at east of reservoir)

Feeder canal 1 is located from PK130+38 of Arzni- Shamiram canal to at south of reservoir along public road by pipeline. The reason of pipeline is as followings;

- ✓ To store the water up to F.W.L.1,305m, the water head shall not less than 15m of effective water head which is difference between EL.1,290m at B.P(Beginning Point) of Feeder canal 1 and F.W.L1,305m,
- ✓ OP. canal cannot keep within above effective water head on conveyance because water head are forced to affect by topographic level on its way which is descending toward reservoir. OP. canal

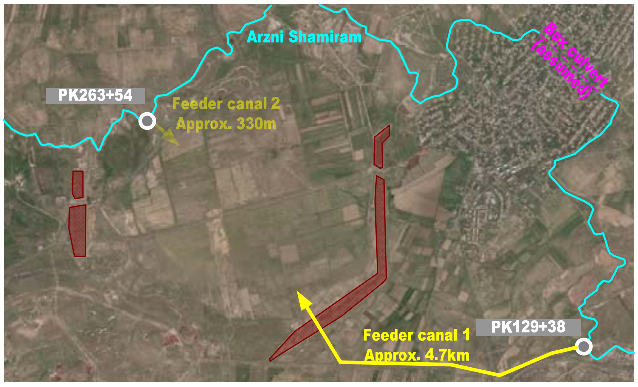
would be installed pump system to cross the reservoir dike, if applied,

- ✓ In the contrast to OP. canal, pipeline is only affected between topographic level at B.P. and E.P. of pipe, loss of pipe length and partial head-loss which means that the conveyance is enable to pass under the dike without pump,
- ✓ In addition, pipeline affect less negative impact on existent land-use along the alignment because of underground structure against OP. canal,
- ✓ OP. canal shall permanently need 3m width and 2m depth of section for same discharge of pipe and add approx. 4m maintenance road at side which means that the affected area by construction would be impacted on existent farm land,
- ✓ Pipeline, therefore, shall be applied by technical and social impact consideration

Basic layout and hydraulic conditions is shown on Table 6-4-4.7.

Table 6-4-4.7 Basic Layout and Maximum and Minimum Discharge of Feeder Canal 1

Discharge (m^3/s)		Month
Maximum	9.0	2nd period in Mar. to 2nd period in May
Minimum	1.11	3rd period in May
Length of canal	L=4.7km by pipeline	



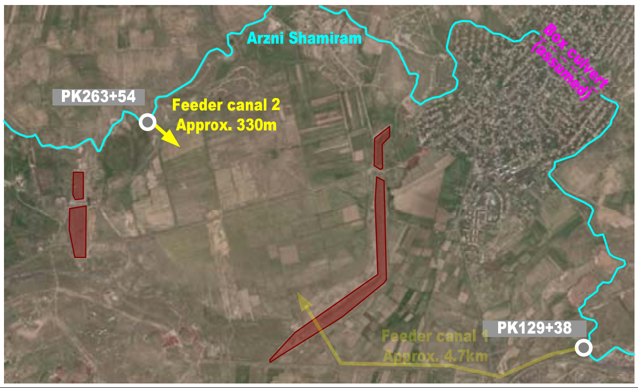
c) Outline of Feeder canal 2 (at north of reservoir)

Feeder canal 2 is located from PK263+54 of Arzni-Shamiram canal to at north of reservoir which is the closest to reservoir, no influence by roughness land-form and no negative impact on farm-land by construction. In addition, as the location is observed at considerable high place, canal alignment is designed by mountainous slope with OP. canal.

By approx. 26.5m of effective water head between approx. W.L.1,333.45m of Arzni-Shamiram canal of PK263+54 and F.W.L.1,305m, is available for OP canal, but the suitable dissipater shall be applied to take measure for high velocity.

Table 6-4-4.8 Basic Layout and Maximum and Minimum Discharge of Feeder Canal 2

Discharge (m^3/s)		Month
Maximum	13.0	2nd period in Mar. to 2nd period in May
Minimum	2.2	3rd period in May
Length of canal	L=0.33km by OP. canal	



Basic layout and hydraulic conditions is shown on Table 6-4-4.8.

(2) Plan of outlet canals

The outflow from reservoir (herein after "outlet canal") is toward three areas pursuant to expected water operation. The outlet canal should be planned to effective connect with existent canals. In addition, the alignment should be designed to avoid large impact and unnecessary long alignment.

Table 6-4-4.9 Target WUAs of Outlet Canals

Targeted area	Method of conveyance to area
Yeghvard WUA	Outlet canal 1 : From reservoir to Arzni-branch
Ashtarak WUA	Outlet canal 2 : From reservoir to existent pipe which convey water to Arzni-Branch at PK121 of Arzni-Branch
Khoy and Vagharshapat WUA	Outlet canal 2 : From reservoir to Kasakh river, which way convey water to targeted area through Kasakh river

a) Outline of Outlet canal 1 (From reservoir toward Yeghvard WUA)

Yeghvard WUA is irrigated from Arzni-Branch canal. The Outlet canal 1 should be connected to Arzni-branch canal from south of reservoir, which junction should be at upstream of Arzni-Branch before Yeghvard WUA's distributer. The situation of south area of reservoir is observed national road and wide farmland. The alignment should be planned along of road to avoid impact on farmland.

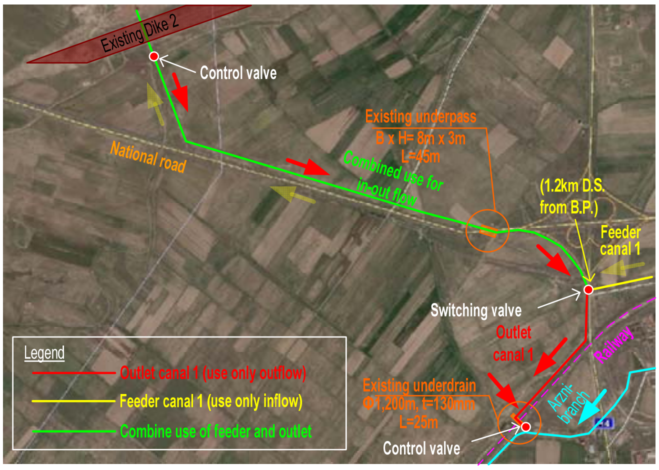


Figure 6-4-4-4 Alignment of Outlet Canal 1

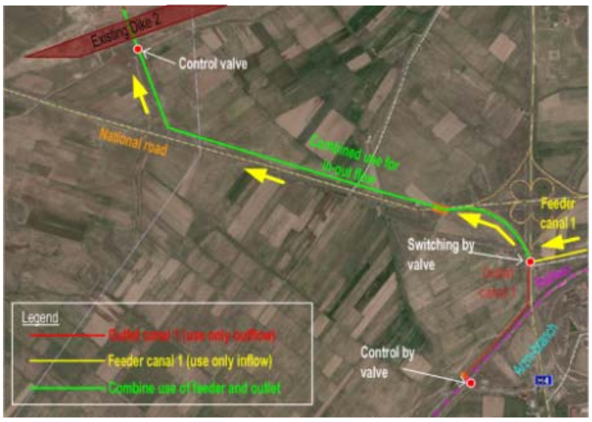
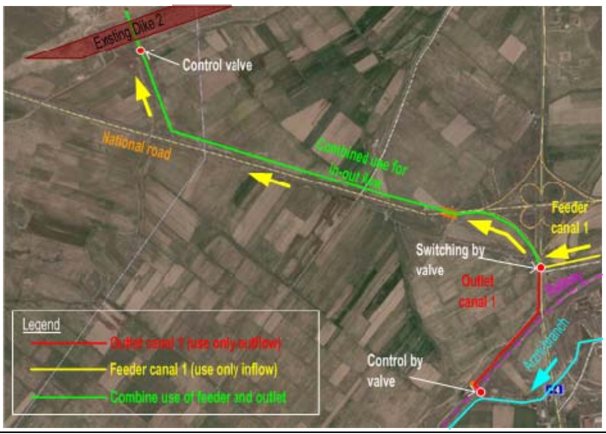
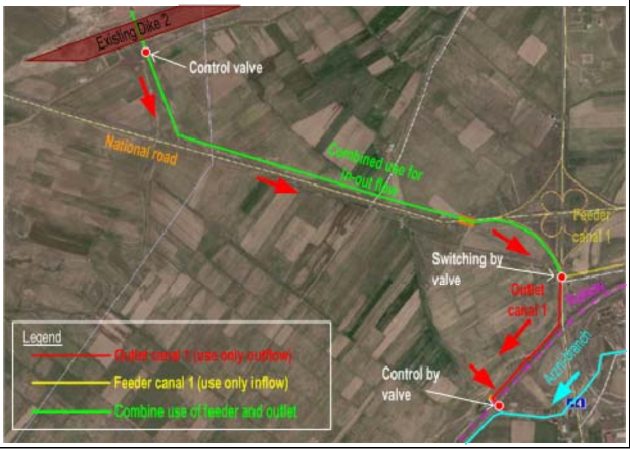
The alignment of Outlet canal 1 is almost same as Feeder canal 1 due to topographic condition. Although the alignment could be set in parallel of Outlet canal 1 and Feeder canal 1, which means that individual pipes are installed, the cost for two (2) pipes construction would be increased.

To save the cost, the Outlet canal 1 should be connected at Feeder canal 1 of approx. 1.2km from B.P. of Feeder canal 1 (refer to right figure). Hence, **from downstream 1.2km of Feeder canal 1, its function of pipes should be shared with Feeder canal 1 and Outlet canal 1 i.e. be combined with in-flow and out-flow.**

To operate these pipes, three valves are required at junction of two pipes as switching, at shortly downstream of the dike and at end of Outlet canal 1.

According to the water allocation of Feeder canal 1 and Outlet canal 1, operation should be done as Table 6-4-4.10. The opposite direction of water flow does not raise at junction of Feeder canal 1 and Outlet canal 1.

Table 6-4-4.10 Operation of Feeder Canal 1 and Outlet Canal 1 by Water Allocation

<table>
<tr><th rowspan="2">Month</th><th rowspan="2">Period</th><th colspan="3">Canal</th><th rowspan="2">Direction of water flow F.C.1 and O.C.1</th></tr>
<tr><th>F.C.1 note)</th><th>O.C.1 note)</th><th>Arz-Br.</th></tr>
<tr><td rowspan="3">March</td><td>1st</td><td>7.00</td><td rowspan="8">no-operation by End of May</td><td rowspan="4">no-operation by April 2nd term</td><td rowspan="4">
</td></tr>
<tr><td>2nd</td><td>9.00</td></tr>
<tr><td>3rd</td><td>9.00</td></tr>
<tr><td rowspan="3">April</td><td>1st</td><td>9.00</td></tr>
<tr><td>2nd</td><td>8.72</td><td>0.28</td><td rowspan="5">
</td></tr>
<tr><td>3rd</td><td>8.84</td><td>1.16</td></tr>
<tr><td rowspan="3">May</td><td>1st</td><td>7.67</td><td>1.33</td></tr>
<tr><td>2nd</td><td>8.00</td><td>1.00</td></tr>
<tr><td>3rd</td><td>1.11</td><td>0.39</td></tr>
<tr><td rowspan="3">June</td><td>1st</td><td rowspan="3">no-operation by next March</td><td>0.50</td><td rowspan="3">Irrigation water is covered by Outlet canal 1</td><td rowspan="3">
</td></tr>
<tr><td>2nd</td><td>1.66</td></tr>
<tr><td>3rd</td><td>2.11</td></tr>
</table>

Note) F.C. 1 is Feeder canal 1, O.C.1 is Outlet canal 1

According to the site survey, Outlet canal 1 should be located along existent road to avoid the farmland, then, can be reached to Arzni-Branch canal by crossing the railway embankment.

The crossed point at the railway embankment is observed an existent concrete pipe, ϕ 1,000mm, in the embankment. Since diameter of existing pipe is ϕ 1,000mm. It could be available to pass the planned pipe under the embankment, but the ground level around railway embankment is almost same as reservoir LWL 1,290m. This means that effective water head would be shortage to reach

Arzni-Branch canal. Therefore, in the plan in this Survey, the tunnel by pipe thrusting method should be applied. The location of junction with Arzni-Branch canal is around PK.19+61, 1.9km from B.P, of Arzni-Branch canal.

The maximum and minimum discharge by the existent water allocation of Yeghvard WUA from Arzni-Shamiram canal is shown in Table 6-4-4.11.

Table 6-4-4.11 Maximum and Minimum Discharge of Outlet Canal 1

Discharge (m^3/s)		Month
Maximum	2.33	1st period in July
Minimum	0.22	3rd period in September
Length of canal	L=0.73km by pipeline (partially combined with Feeder canal 1)	

In case of OP. canal, in order to detour the high land area which is almost EL.1,300m and to reach to Arzni-Banch canal, the seasonal water stream shall be used as canal alignment (refer to Figure 6-4-4.5). Since topographic situation at south of reservoir is higher than reservoir bottom level of EL.1,290m, according to the site survey. The alignment would be meandered and be longed to 6.5km which is considerably longer than the pipeline. OP. canal should not be applied to this condition.

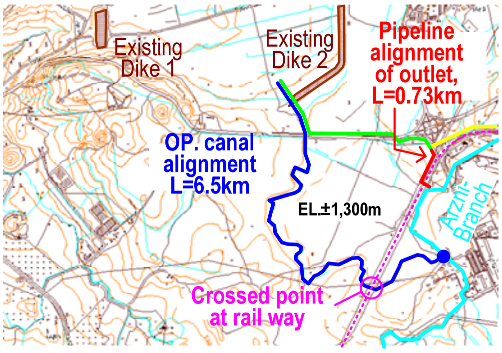


Figure 6-4-4.5 Alignment of OP. Canal

b) Outline of Outlet canal 2 (From reservoir to existent pipe and Kasakh river)

In water operation of Ashtarak WUA presently, the conveyance pipe line (ϕ 1,000mm) is connected directly to Arzni-Shamiram canal at around PK304 and reach to Arzni-Branch canal at around PK121 over the hill. In addition, Yeghvard reservoir need to convey the irrigation water to Khoy WUA and Vagharshapat WUA.

As for the conveyance to Ashtarak WUA, considering the present water operation, outlet canal should be divided around existing pipeline and connected to it. Since the existent pipeline is located at west of reservoir and crossed at valley topography with appearing on ground, the alignment of outlet canal should be used along valley without problem of land property.

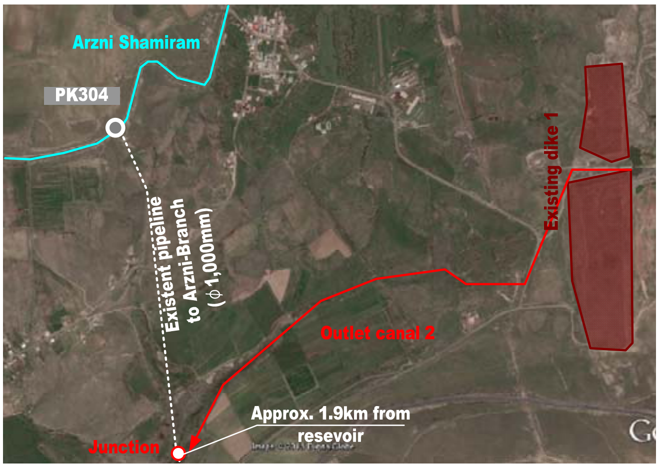


Figure 6-4-4.6 Alignment of Outlet Canal 2 till Existing Pipeline

According to the site survey, the existent pipe line to Arzni-Branch canal conveys the water over the hill which by using effective water head between Arzni-Shamiram canal (±WL.1,330m) and E.P. of pipeline at Arzni-Branch canal (±WL.1,276m). The level of hill on pipeline's way is EL1,270~1,280m.

On the other hand, the bottom level of reservoir is planned EL.1,290m, so effective water head is possible to approx.14m. Considering the loss water head for pipe length and some, 13.7 m in total loss include 10% extra loss for safety is calculated, which show to be allowable to apply above alignment of outlet canal. **In this situation, OP. canal cannot be applied naturally.**

The maximum and minimum discharge by the existent water allocation of Ashtarak WUA from Arzni-Shamiram is shown on Table 6-4-4.12.

Table 6-4-4.12 Maximum and Minimum Discharge of Outlet Canal 2 for Ashtarak WUA

Discharge (m^3/s)		Month
Maximum	0.56	1^{st} period in July
Minimum	0.05	3^{rd} period in September

As for the conveyance to Khoy WUA and Vagharshapat WUA, the original plan by USSR, which is to use Kasakh river as conveyance system, should be followed by new irrigation system. Presently, these WUAs are irrigated by Arzni-Shamiram canal, Lower Hrazdan canal, Kasakh Intake at Kasakh river and Pump stations of Aknalich and Metsamor.

Basically, the alignment of Outlet canal 2 should be extended from above connection with existing pipeline and reach to Kasakh River. According to the site survey, the valley topography is extended to Kasakh river through near the south area of village. Therefore, the alignment should be along the valley as well. At near Kasakh River of Outlet canal 2, however, the topographic condition is drastically changed, the suitable dissipater shall be planned to ease release to Kasakh river.

Figure 6-4-4.7 Outlet Canal 2 at near Kasakh River

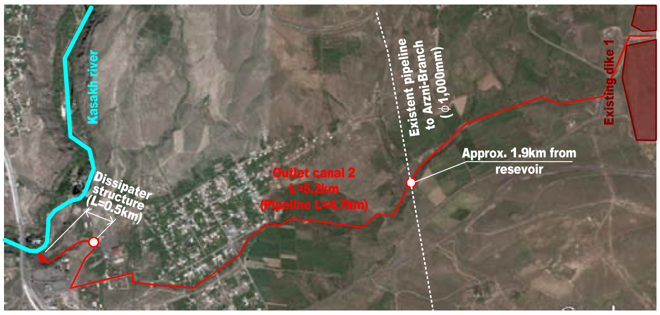


Figure 6-4-4.8 Alignment of Outlet Canal 2 till Kasakh River

As for the design from Outlet canal 2, since discharge is planned to release to Kasakh river, the influence for Kasakh river need to take it into account. Considering the hydraulic capacity of Kasakh river, the maximum discharge added Outlet canal 2 shall be within hydraulic capacity of Kasakh river. According to the record discharge for 30ys from 1983 to 2013 at Aparan dam observation, the average of every 10days discharge for each month are shown on table 6-4-4.13.

Table 6-4-4.13 Total Discharge in Usual between Outlet canal 2 and Kasakh River

Month	Jan. (m3/s)			Feb. (m3/s)			Mar. (m3/s)			Apr. (m3/s)			May (m3/s)			Jun. (m3/s)		
Kasakh	2.64	2.59	2.59	2.59	2.60	2.64	3.21	3.60	4.83	8.25	7.58	4.68	3.75	3.00	2.64	2.65	2.53	2.53
O.C. 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.16	0.66	0.75	0.56	0.22	6.48	8.24	8.99
Total	**2.64**	**2.59**	**2.59**	**2.59**	**2.60**	**2.64**	**3.21**	**3.60**	**4.83**	**8.25**	**7.74**	**5.34**	**4.50**	**3.56**	**2.86**	**9.13**	**10.77**	**11.52**
Month	Jul (m3/s)			Aug. (m3/s)			Sep. (m3/s)			Oct. (m3/s)			Nov. (m3/s)			Dec. (m3/s)		
Kasakh	2.39	2.38	2.38	2.42	2.43	2.41	2.48	2.38	2.33	2.45	2.60	2.65	2.80	3.01	2.79	2.72	2.66	2.66
O.C. 2	6.61	6.88	6.75	5.95	5.69	5.13	3.37	2.39	3.32	3.02	0.59	0.25	0.0	0.0	0.0	0.0	0.0	0.0
Total	**9.00**	**9.26**	**9.13**	**8.37**	**8.12**	**7.54**	**5.85**	**4,77**	**5.65**	**5.47**	**3.19**	**2.90**	**2.80**	**3.01**	**2.79**	**2.72**	**2.66**	**2.66**

Note) O.C.2 is Outlet canal 2

According to water relation between the discharge record of Kasakh river for every month and necessary discharge from Outlet 2 which shown on table 6-4-4.13, total **usual discharge** of Outlet canal 2 and Kasakh river, need to be less than 11.52m^3/s.

However, Outlet canal 2 is not only responsible to convey the water to the targeted area, but also to perform the emergency discharge in unusual situation. In the assessment of record for 30ys on **maximum discharge** and site survey along Kasakh river which are shown on "2) Discharge volume from Yeghvard reservoir in Chapter 6-5-7 Basic Design of Related Facilities (Emergency Discharge Structure)", 13.7m^3/s is assumed as the allowable hydraulic capacity of at downstream of Kasakh river**.**

Therefore, given of 13.7m^3/s as allowable hydraulic capacity of Kasakh river, maximum discharge in emergency conditions should be ranged from max. 12.00m^3/s to 12.82m^3/s which are calculated by comparison between varying effective water head at reservoir and the allowable discharge of Kasakh for 13.7m^3/s (refer to Chapter 6-5-7, 2)). The design conditions of maximum and minimum discharge are shown on Table 6-4-4.14.

Table 6-4-4.14 Maximum and Minimum Discharge of Outlet Canal 2 for Khoy WUA and Metsamor WUA

Discharge (m^3/s)		Month
Maximum [note)]	1) Not less than max. 12.10~12.82 m^3/s for varying reservoir water level, but not more than max. 13.7m^3/s (for pipe design) 2) 13.7 m^3/s (for dissipater)	emergency conditions
Minimum	0.16	2nd period in April
Length of canal	L=4.7km by pipeline (except for section dissipater of 0.5km)	

Note) Definition of max. discharge is referred to "6-5-7 Emergency Discharge Structure"

Accordingly, design condition of Outlet canal 2 should be taken into consideration value of Table 6-4-4.12 and Table 6-4-4.14.

(3) Structural design of Feeder canal and Outlet canal

a) Feeder canal 1 and Outlet canal 1

Feeder canal 1 and Outlet canal 1 are planned by pipeline. Pipeline of Feeder canal is ϕ 1,600mm and Outlet canal 1 is ϕ 800mmm, which are applied by hydraulic calculation. According to the previous consideration, Feeder canal 1 and Outlet canal 1 are needed to share with each of function. In addition, these conveyance structures are designed by pipeline. The following conditions should be considered.

- ✓ In order to distribute the irrigation water from Arzni-Shamiam canal, new intakes for Feeder canal 1 and Arzni-Branch canal should be constructed for the suitable regulation. In addition, the reconstruction of existing regulator which is located at shortly downstream of planned area, should be planned due to frost damage.
- ✓ The distributed water promptly flow into the pipe and pass the underground until inside of reservoir. To pass Dam No.2, the conveyed water should be passed by tunnel under Dam No.2. Because foundation of structure must be avoided to construct on embankment like dike.
- ✓ For the Feeder canal 1 and Outlet canal 1, inlet/outlet in reservoir should be equipped with dissipated block which is stationed at inlet/outlet in order to alleviate high velocity in inflow situation. In addition, collecting channel should be designed so as to easy collect water from reservoir at situation of low water level.

Accordingly, main structures of Feeder canal 1 and Outlet canal 1 are as shown in Figure 6-4-4.9;

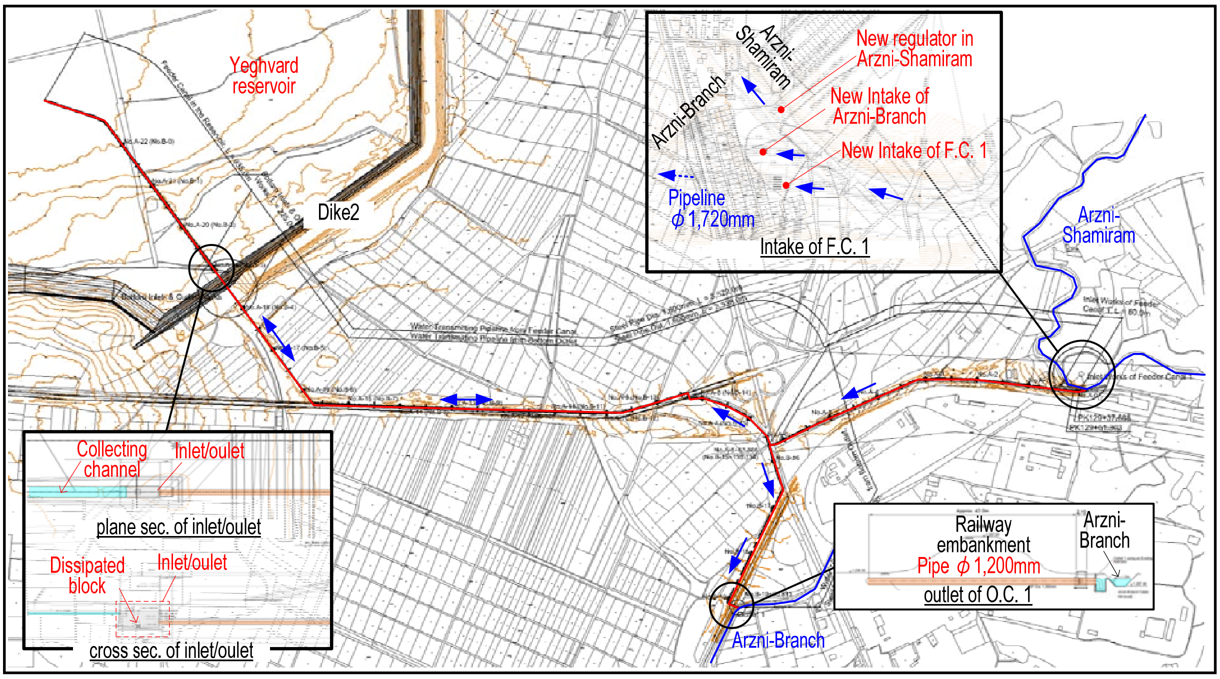


Figure 6-4-4.9 Plan of Feeder Canal 1 and Outlet Canal 1

b) Feeder canal 2

Feeder canal is planned by open canal. According to the topographic feature, inlet and outlet of feeder canal 2 has big difference of ground level which is almost 40m and its slope alignment is approx. 1/8. This means that flow velocity would be so high and it should be taken into consideration the effect of erosion to reservoir. Therefore the chute and baffled chute facilities are needed to secure the dissipated effect.

In addition, in order to regulate the inflow water to facility depend on seasonal demand, the regulator gate should be installed to Arzni-Shamiram canal and intake of Feeder canal 2.

Accordingly, main structures of Feeder canal 2 are as shown in Figure 6-4-4.10;

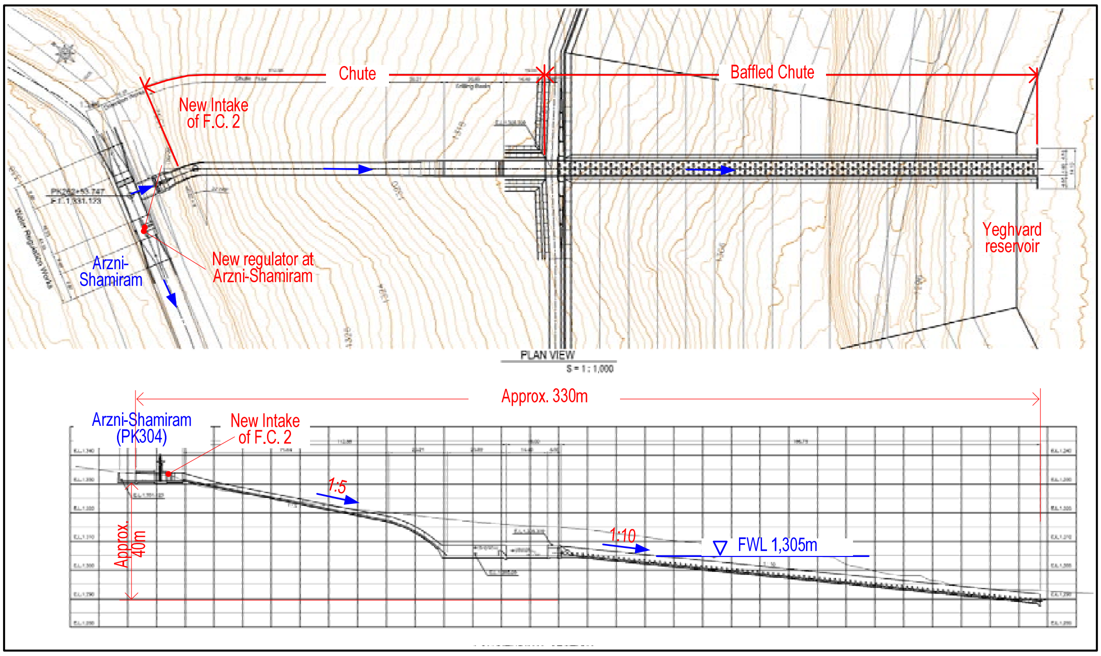


Figure 6-4-4.10 Plan of Feeder Canal 2

c) Outlet canal 2

Outlet 2 is planned by pipeline. Pipeline is ϕ 1,700mm, which are applied by hydraulic calculation. Outlet canal 2 needs to take into account as followings.

- ✓ In order to convey the irrigation water to Ashtarak WUA, Outlet canal 2 is needed to connect with existing pipe (ϕ 1,000mm) at distance of approx. 1.9km from reservoir.
- ✓ Function of Outlet canal 2 is to convey the usual irrigation water to farmland of Ashtarak WUA, Khoy WUA and Vagharshapat WUA, in addtion, to release the emergency discharge.
- ✓ Big water head difference between reservoir and outlet of pipeline which is almost 150 meter, would be affected to discharge control. Therefore the fixed corn valves should be installed at outlet to control the varying water demand depend on season. According to the yearly water demand, two type of valves, ϕ 1,200mm and ϕ 350mm should be installed to regulate ranged discharge.
- ✓ In addition, considering the topographic feature from outlet of pipeline to Kasakh river, suitable dissipated facility and structure should be constructed. According to careful consideration, five of protection walls like slit dam should be stationed at upstream and baffled chute should be stationed at downstream. Then finally the crossing box culvert to pass the existing road at near Kasakh river is constructed to approach Kasakh river.

Accordingly, main structures of Outlet canal 2 are as shown in Figure 6-4-4.11;

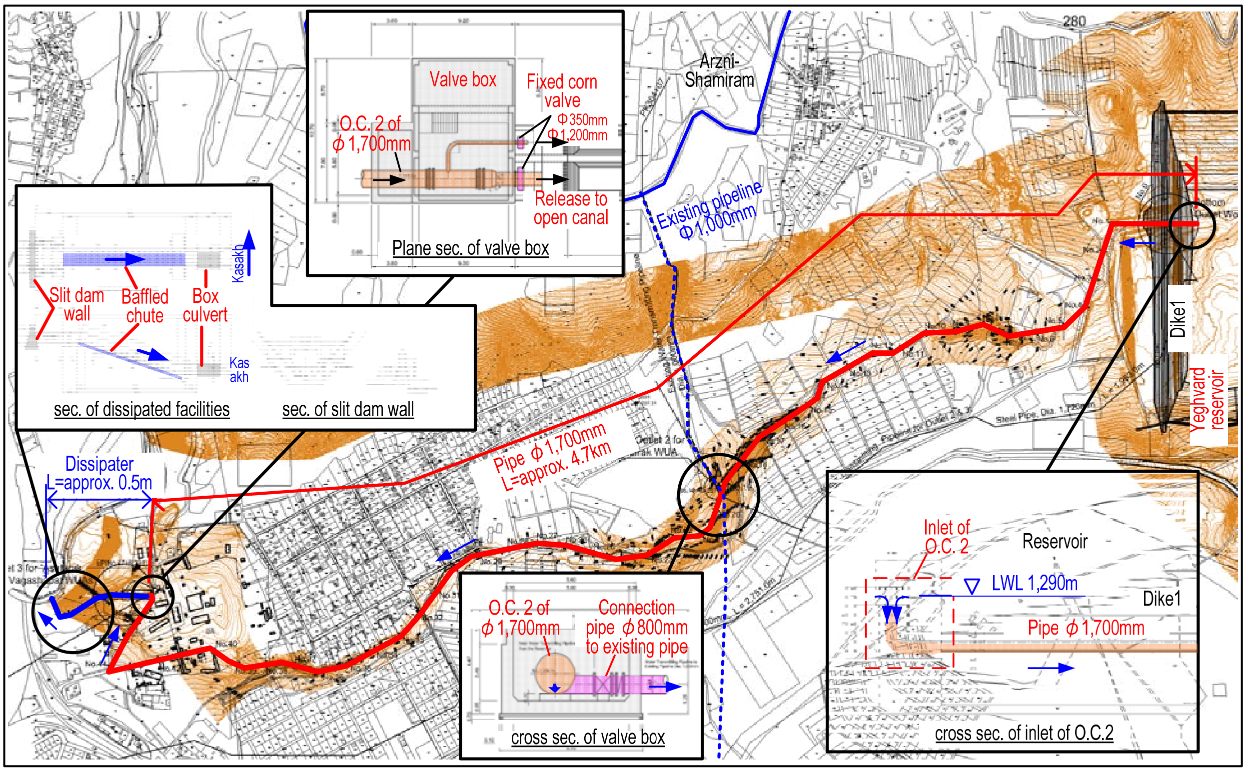


Figure 6-4-4.11 Plan of Outlet Canal 2

6-4-4-2 Improvement plan for Targeted area 2

(1) Outline of rehabilitation plan

The Target area 2 should be improved and rehabilitated as shown in Table 6-4-4.15.

Table 6-4-4.15 Outline of Rehabilitation Plan

Facility and structure	Rehabilitation outline	Responsibility
Arzni-Shmiram canal	・Section between approx. PK14 and PK17, PK28 and PK32, PK64 and PK69, PK85 and PK93, PK94 and PK96. PK96 and PK97, PK101 and PK105 (L=2.7km) ・Remove concrete panel and line with concrete	WSA
Lower Hrazdan canal part2, BP. to PK219	・Section between PK10 and PK188 (L=17.8km) ・Add the concrete for raising to the sidewall ・Installation of 2 pipes that connect Upper Aknalich canal (ϕ 400mm) at PK10 and Inner Aknalich canal (ϕ 1,000mm) at PK13 with Lower Hrazdan canal at PK188 .	
Aknalich PS.	・Abolished	
Metsamor PS	・Abolished	
Ranchaper PS. 1	・Abolished	
Ranchaper PS. 2	・Abolished	
Arzni-Branch canal, BP. to PK120	・Section between BP and PK23 (L=2.3km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 1 gate	Yeghvard WUA
Arzni-Branch canal, PK120 to EP.	・Section between PK123 and PK234. (L=12.1km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 22 gates, 1 water measurement facility and 2 aqueduct bridges	Ashtarak WUA
Takahan canal, BP. to PK130	・Section between PK69 and PK126 (L=5.4km(except pipeline 0.3km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 17 gate and 2 aqueduct bridges	
Shah-Aru canal, BP. to PK118	・Section between BP. and PK31 PK62 and PK70, PK82 and PK112 (L=6.9km) ・Remove the current canal and construct the lining concrete and/or install the precast concrete canal ・Replace 16 gates	Vagharshapat WUA
Inner Aknalich canal	・No rehabilitation in the Project	
Upper Aknalich canal BP to PK104	・Section between PK6 and PK104 (L=9.8km) ・Install the precast concrete canal in existing canals ・Replace 39 gates and 2 aqueduct bridges	Khoy WUA
Metsamor canal	・No rehabilitation in the Project ・Facilities and structures were rehabilitated under the assistance of the World Bank.	

(2) Location of rehabilitation plan

The target improvement and rehabilitation are as shown in Figure 6-4-4.12.

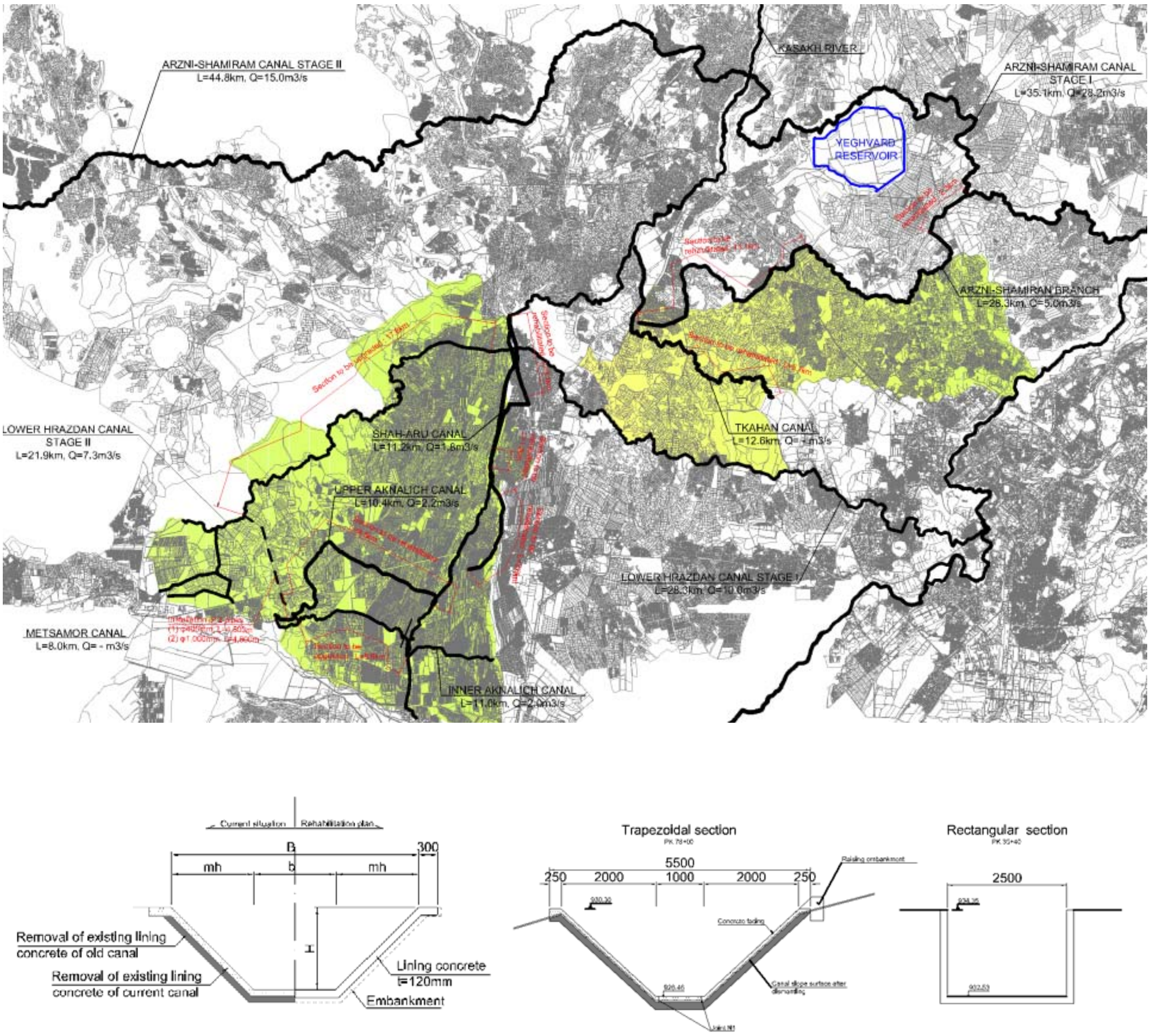


Figure 6-4-4.12 Canal Rehabilitation Plans

6-4-4-3 Plan of abolishment of pump station

As the result of completion of the Project, existing pump facilities are planned to be abolished because of replacement to gravity irrigation by Yeghvard reservoir. Presently, although the area by pump irrigation is mainly Khoy WUA and Vagharshapat WUA, these area are planned to be conveyed the irrigation water through Lower Hrazdan canal part 2 after the Project.

The profitability of the Project is expected to cost cutting of electricity for pumps. The priority of abolishment plan is assumed as followings;

- ✓ First priority : Four of major pump stations as followings and 13 of minor pump stations

  Ranchpar 1 and 2 P.S. for Vagharshapat WUA
  Aknalich P.S. for Khoy WUA and Vagharshapat WUA

Metsamor P.S. for Khoy WUA

- ✓ Second priority : 133 of deep wells scattered in Khoy WUA and Vagharshapat WUA

note) number of pump station and deep wells by survey

The pump irrigation, however, have been settled to present irrigation system so far. Especially, many deep wells could be essential water source as not only agriculture but also supplemental water. Therefore, before the abolishment of pump station, the instruction and explanatory conference should be taken place. In addition, the situation of deep wells should be carefully assessed and the phased abolishment plan could be appropriate to avoid the burden to the farmers.

6-5 Reservoir Plans

6-5-1 Comparative Study of the Reservoir Scale

(1) Facility layout around private orchard area

Northern slope of reservoir has high permeability and protection with anti-infiltration capacity on the slope is needed to reduce leakage volume.

There is an orchard area at the west edge of northern slope and a part of this area is target area to be covered by slope protection. Since this is a private area, some compensation to land owner is required.

On the other hand, it can be considered to extend Dam No.1 along the toe of slope as impervious structure instead of slope protection. In this case, orchard area is free from occupation by any facilities and no compensation is required. However additional cost to construct dam is required.

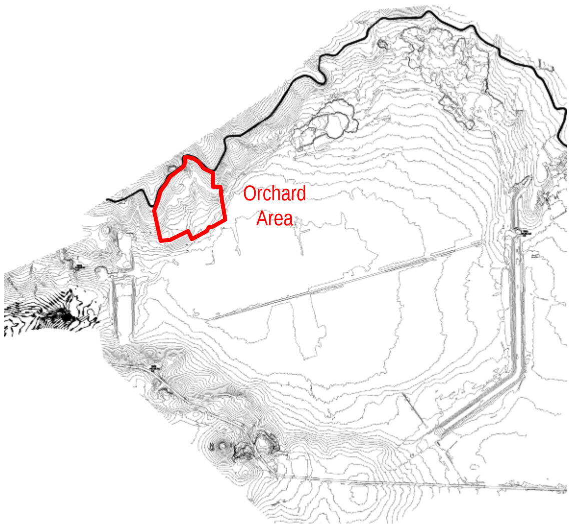
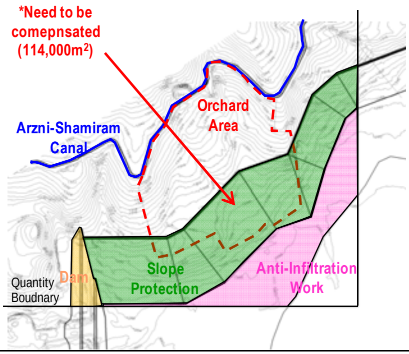
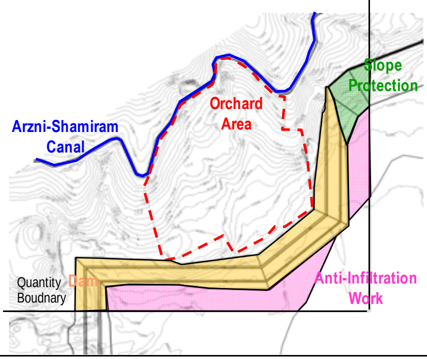


Figure 6-5-1.1 Location of Orchard Area

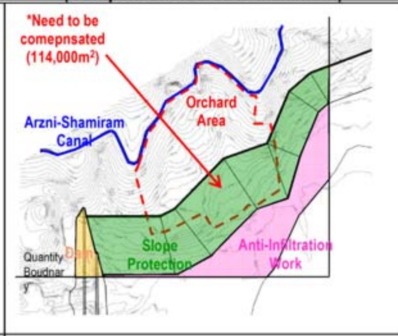
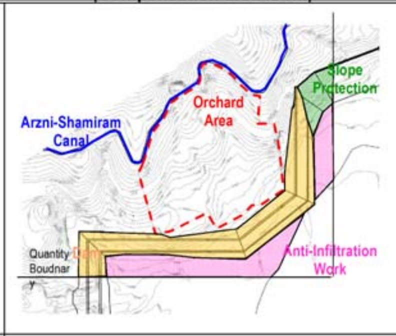
Therefore here conducts an economical comparative study targeting two (2) plans shown in Table 6-5-1.1.

Table 6-5-1.1 Outline of Comparative Plans for Orchard Area

		Plan A	Plan B
Outline			
Leakage Control Structure		Slope protection with anti-infiltration capacity	Dam constructed along the toe of slope
Compensation for Orchard Area		√	
Construction Cost	Slope Protection	√	
	Dam		√

The result of comparative study is shown in Table 6-5-1.2 and Plan A is selected due to economical advantage.

Table 6-5-1.2 Results of Comparison Study for Orchard Area

			Plan A (Compensation area is Maximum)						Plan B (Compensation area is Nil)					
Outline														
Compensation fee			Area/Volume (m^2/m^3)			Unit Cost (USD)		Sub Total (USD)	Area/Volume (m^2/m^3)			Unit Cost (USD)		Sub Total (USD)
		Tree loss	114,000	m^2	x	0.18	=	20,520	0	m^2	x	0.18	=	0
		Land loss	114,000	m^2	x	0.60	=	68,400	0	m^2	x	0.60	=	0
Construction Cost	Slope Protection	Small Dike	10,000	m^3	x	33.14	=	331,400	990	m^3	x	33.14	=	32,809
		Slope protection	314,000	m^2	x	14.31	=	4,493,340	27,000	m^2	x	14.31	=	386,370
	Anti Infiltration Work		154,000	m^2	x	14.31	=	2,203,740	170,000	m^2	x	14.31	=	2,432,700
	Dam	Core	59,000	m^3	x	4.56	=	269,040	375,000	m^3	x	4.56	=	1,710,000
		Filter	5,700	m^3	x	11.52	=	65,664	31,000	m^3	x	11.52	=	357,120
		Surface Protection	7,700	m^3	x	33.14	=	255,178	57,000	m^3	x	33.14	=	1,888,980
		Sand-and-Gravel	130,000	m^3	x	4.91	=	638,300	919,000	m^3	x	4.91	=	4,512,290
		Sand-and-Gravel (Dam Cres	1,500	m^3	x	4.91	=	7,365	7,900	m^3	x	4.91	=	38,789
		Scoria (Dam Crest)	240	m^3	x	4.91	=	1,178	1,300	m^3	x	4.91	=	6,383
		Counter Weight	7,100	m^3	x	3.83	=	27,193	49,095	m^3	x	3.83	=	188,032
		Stripping	14,000	m^3	x	3.98	=	55,720	87,000	m^3	x	3.98	=	346,260
	Direct Construction Cost							8,348,118						11,899,733
	InDirect Cost (111% of Direct Cost)							9,266,411						13,208,704
	Sub Total							17,614,529						25,108,437
Total	(USD)							17,703,449						25,108,437
	(Million USD)							**17.7**						**25.1**

(2) Facility layout to reduce total construction cost

A part of reservoir bottom, north slope and south slope has high permeability and anti-infiltration work is required on them. Total area of those are very huge and the cost of anti-infiltration works account high ratio of total construction cost.

Therefore in addition to examine economical anti-infiltration work structure, facility layout to reduce the area of anti-infiltration area shall be examined as well.

The most simple structure is to cover all the target area by anti-infiltration work.

On the other hand, it can be consider to construct dams along the toe of slope. In this case, anti-infiltration work on slope and a part of reservoir bottom is not required. However another construction cost, dam construction cost, is required. Additionally, since reservoir area becomes narrow, FWL (Full Water Level) shall be raised up to keep necessary capacity and the height of dam becomes higher.

Therefore here conducts an economical comparative study targeting two (2) plans shown in Table 6-5-1.3.

Table 6-5-1.3 Outline of Comparative Plans to Minimize Anti-Infiltration Area

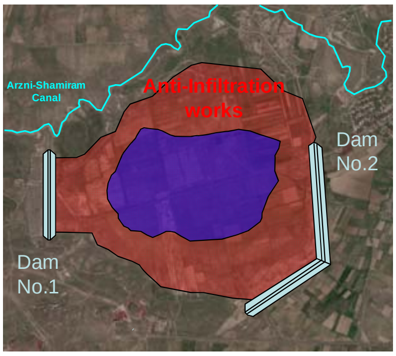
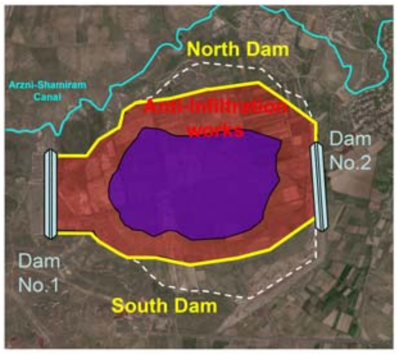
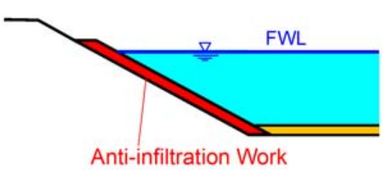
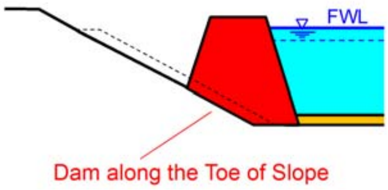
<table>
<tr><th colspan="2"></th><th>Plan A</th><th>Plan B</th></tr>
<tr><td rowspan="2">Outline</td><td>Plan</td><td>
</td><td>
</td></tr>
<tr><td>Leakage Control Structure for Slope Area</td><td>
</td><td>
</td></tr>
<tr><td colspan="2">FWL</td><td>Low</td><td>High</td></tr>
<tr><td colspan="2">Dam height</td><td>Low</td><td>High</td></tr>
<tr><td rowspan="3">Area of Anti-infitration works</td><td>North Slope</td><td>Huge</td><td>Nil</td></tr>
<tr><td>South Slope</td><td>Huge</td><td>Nil</td></tr>
<tr><td>Reservoir Bottom</td><td>Huge</td><td>Less than Plan A</td></tr>
<tr><td colspan="2">Cost to construct dams along the toe of slope</td><td>Nil</td><td>High</td></tr>
<tr><td colspan="2">Others</td><td>Material for dam body is collected from the area within reservoir area</td><td>Material for dam body is collected from area within and out of reservoir area.
*Amount of material within reservoir area is not enough</td></tr>
</table>

Figure 6-5-1.2 and 6-5-1.3 illustrate plan and typical cross section of each plan and result of comparative study is shown in Table 6-5-1.4.

Finally Plan A is selected due to economical advantage.

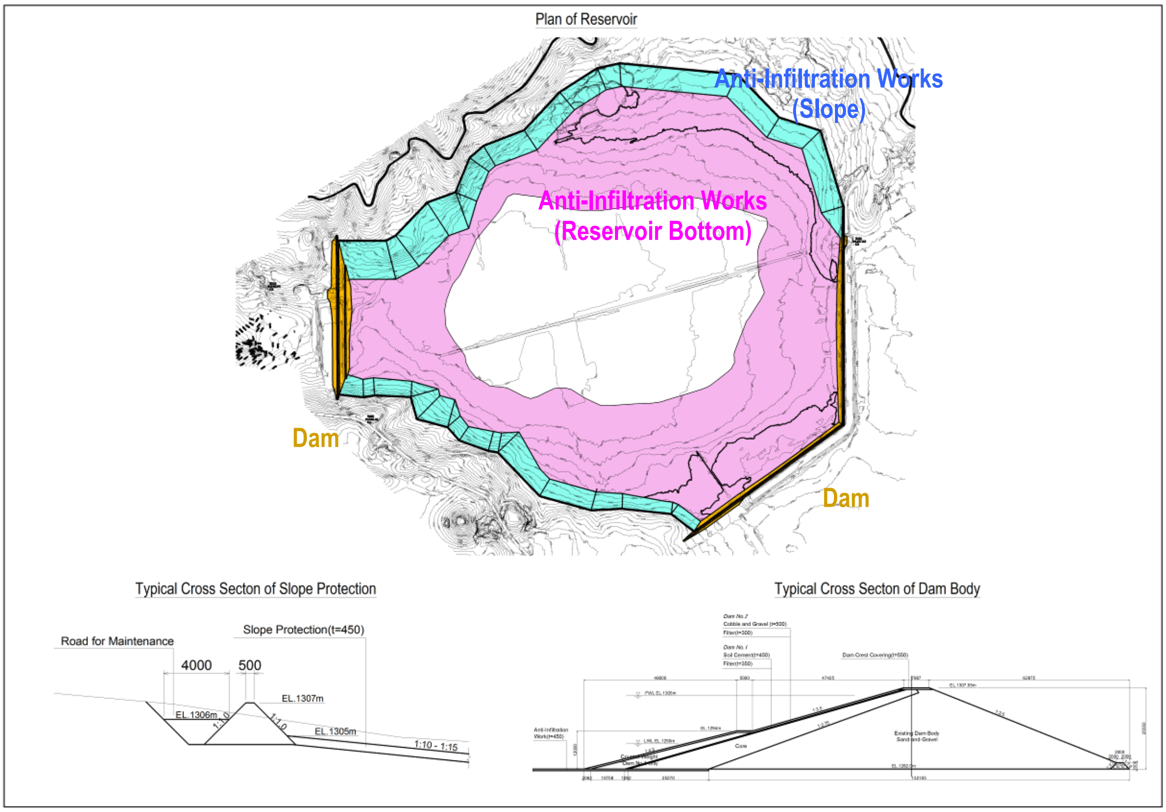


Figure 6-5-1.2 Plan and Typical Cross Section (Plan-A)

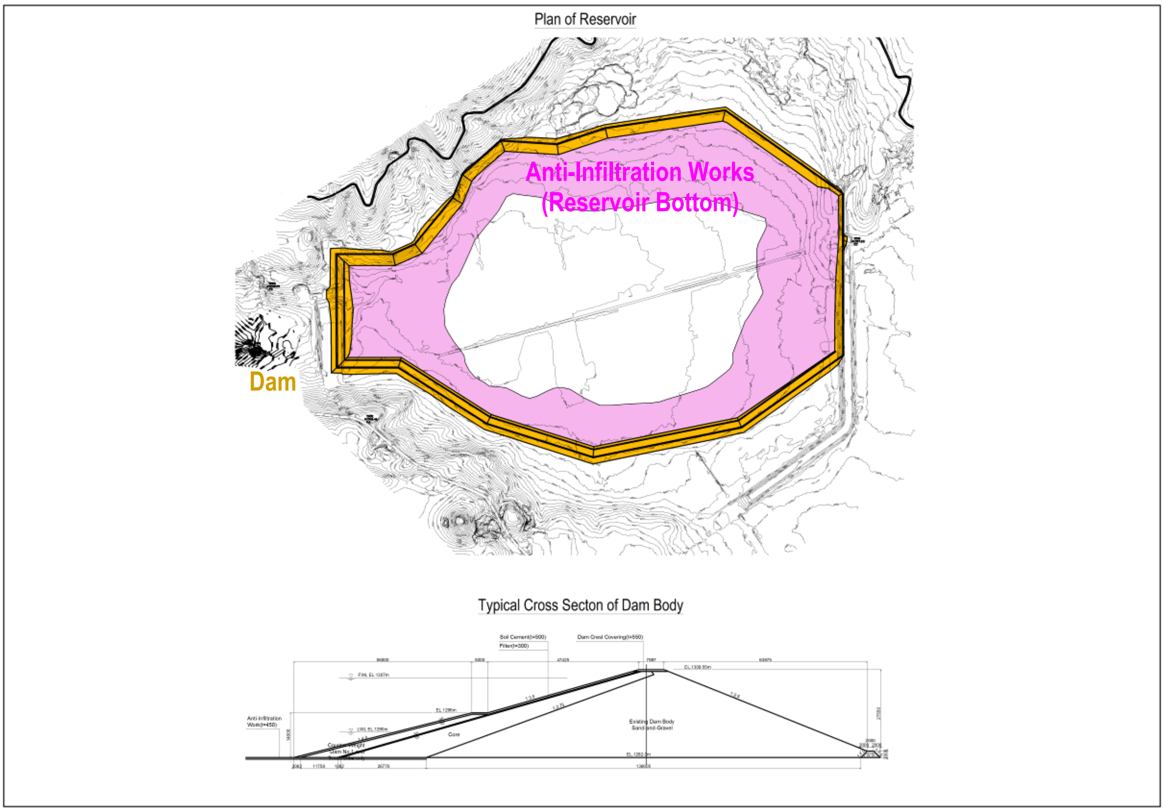
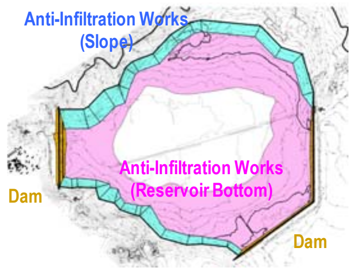
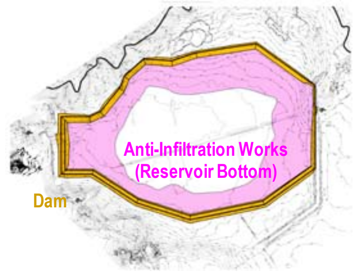


Figure 6-5-1.3 Plan and Typical Cross Section (Plan-B)

Table 6-5-1.4 Results of Comparison Study to Minimize Anti-Infiltration Area

					Plan A						Plan B					
					900ha						600ha					
Outline																
Reservoir Properties	Reservoir Capacity									94 MCM	Same as on the left					
	LWL									EL. 1290m	Same as on the left					
	FWL									EL. 1305m						EL. 1307m
	Dam Height									25.55m						27.55m
	Reservoir Area									7.96km^2						5.42km^2
Direct Construction Cost	Items				Quantity			Unit Cost (USD)		Amount (USD)	Quantity			Unit Cost (USD)		Amount (USD)
	Dam	No.1	Filling	Core	281,000	m^3	×	4.56	=	1,281,360	295,000	m^3	×	4.56	=	1,345,200
				Filter	25,000	m^3	×	11.52	=	288,000	24,000	m^3	×	12.12	=	290,880
				Slope protection (Soil Cement)	36,000	m^3	×	33.14	=	1,193,040	35,000	m^3	×	33.86	=	1,185,100
				Sand-and-Gravel	528,000	m^3	×	4.91	=	2,592,480	596,000	m^3	×	5.56	=	3,313,760
				Sand-and-Gravel (Dam Crest)	5,200	m^3	×	4.91	=	25,532	3,700	m^3	×	5.56	=	20,572
				Scoria (Dam Crest)	850	m^3	×	4.91	=	4,174	620	m^3	×	5.56	=	3,447
				Counter Weight	47,000	m^3	×	3.83	=	180,010	59,000	m^3	×	3.83	=	225,970
			Stripping		47,000	m^3	×	3.98	=	187,060	43,000	m^3	×	3.98	=	171,140
			Sub-Total							5,751,656						6,556,069
		No.2	Filling	Core	247,000	m^3	×	4.56	=	1,126,320	153,000	m^3	×	4.56	=	697,680
				Filter	26,000	m^3	×	11.52	=	299,520	14,000	m^3	×	12.12	=	169,680
				Slope protection (Cobble and Gravel)	43,000	m^3	×	4.74	=	203,820	24,000	m^3	×	5.39	=	129,360
				Sand-and-Gravel	62,000	m^3	×	4.91	=	304,420	50,000	m^3	×	5.56	=	278,000
				Sand-and-Gravel (Dam Crest)	14,000	m^3	×	4.91	=	68,740	5,000	m^3	×	5.56	=	27,800
				Scoria (Dam Crest)	2,000	m^3	×	4.91	=	9,820	830	m^3	×	5.56	=	4,615
			Stripping		40,000	m^3	×	3.98	=	159,200	23,000	m^3	×	3.98	=	91,540
			Sub-Total							2,171,840						1,398,675
		North	Filling	Core							561,000	m^3	×	4.56	=	2,558,160
				Filter							54,000	m^3	×	12.12	=	654,480
				Slope protection (Cobble and Gravel)							90,000	m^3	×	5.39	=	485,100
				Sand-and-Gravel							1,166,000	m^3	×	5.56	=	6,482,960
				Sand-and-Gravel (Dam Crest)							18,000	m^3	×	5.56	=	100,080
				Scoria (Dam Crest)							3,000	m^3	×	5.56	=	16,680
			Stripping								107,000	m^3	×	3.98	=	425,860
			Sub-Total													10,723,320
		South	Filling	Core							1,009,000	m^3	×	4.56	=	4,601,040
				Filter							91,000	m^3	×	12.12	=	1,102,920
				Slope protection (Soil Cement)							130,000	m^3	×	33.86	=	4,401,800
				Sand-and-Gravel							2,758,000	m^3	×	5.56	=	15,334,480
				Sand-and-Gravel (Dam Crest)							17,000	m^3	×	5.56	=	94,520
				Scoria (Dam Crest)							2,800	m^3	×	5.56	=	15,568
				Counter Weight							129,000	m^3	×	3.83	=	494,070
			Stripping								190,000	m^3	×	3.98	=	756,200
			Sub-Total													26,800,598
	Anti-infiltratio works	North Slope	Small dike (Soil Cement)		37,000	m^3	×	33.14	=	1,226,180						
			Slope Protection with anti-infiltration capacity		807,000	m^2	×	14.31	=	11,548,170						
			Sub-Total							12,774,350						
		South Slope	Small dike (Soil Cement)		22,000	m^3	×	33.14	=	729,080						
			Slope Protection with anti-infiltration capacity		354,000	m^2	×	14.31	=	5,065,740						
			Sub-Total							5,794,820						
		Reservoir Bottom			4,282,000	m^2	×	14.31	=	61,275,420	3,101,000	m^2	×	14.31	=	44,375,310
	Total			(USD)						87,768,086						89,853,972
				(Million USD)						87.8						89.9

6-5-2 Estimation of Leakage Rate from Reservoir

The Yeghvard reservoir is a wide-spread flat-basin type reservoir constructed on a foundation which mainly consists of volcanic rocks and sediments. Since the foundation is mostly pervious and the groundwater level is very low, it is obvious that an artificial anti-infiltration layer must be placed on the basin of the reservoir to reduce water leakage. Therefore, in order to grasp the efficiency of the layer, the leakage rate was estimated for alternative cases of reservoir layout and covering extent of the anti-infiltration layer.

(1) Method

Two (2) methods are applied, namely; the "2-D Simple Method" and the "3-D FEM Method". The calculation for all alternative cases was carried out with the 2-D method. The 3-D method was applied only for the main cases to infer the three-dimensional flow condition.

(a) 2-D simple method

Considering the hydrogeological conditions and the large extent of reservoir, it is hydraulically apparent that the reservoir water mainly infiltrates and flows down almost vertically to the groundwater body located deep. Therefore, there is no significant error if we consider only the vertical flow for the leakage rate estimation. The "2-D Simple Method" is one of such methods based on the Darcy's law which is basically the same as used in the detail design, 1985 in Soviet era.

First, the reservoir area was divided into triangles about 60m wide and tall as shown in Figure 6-5-2.1 **(**Such a set of area-covering triangles is called a "TIN - Triangulated Irregular Network"). Then the vertical infiltration rate is calculated at each triangle with the average thicknesses of geologic layers, their representative coefficients of vertical permeability, reservoir water depth and area of triangle. The total infiltration (leakage) from the reservoir is calculated by summing the rates for all triangles.

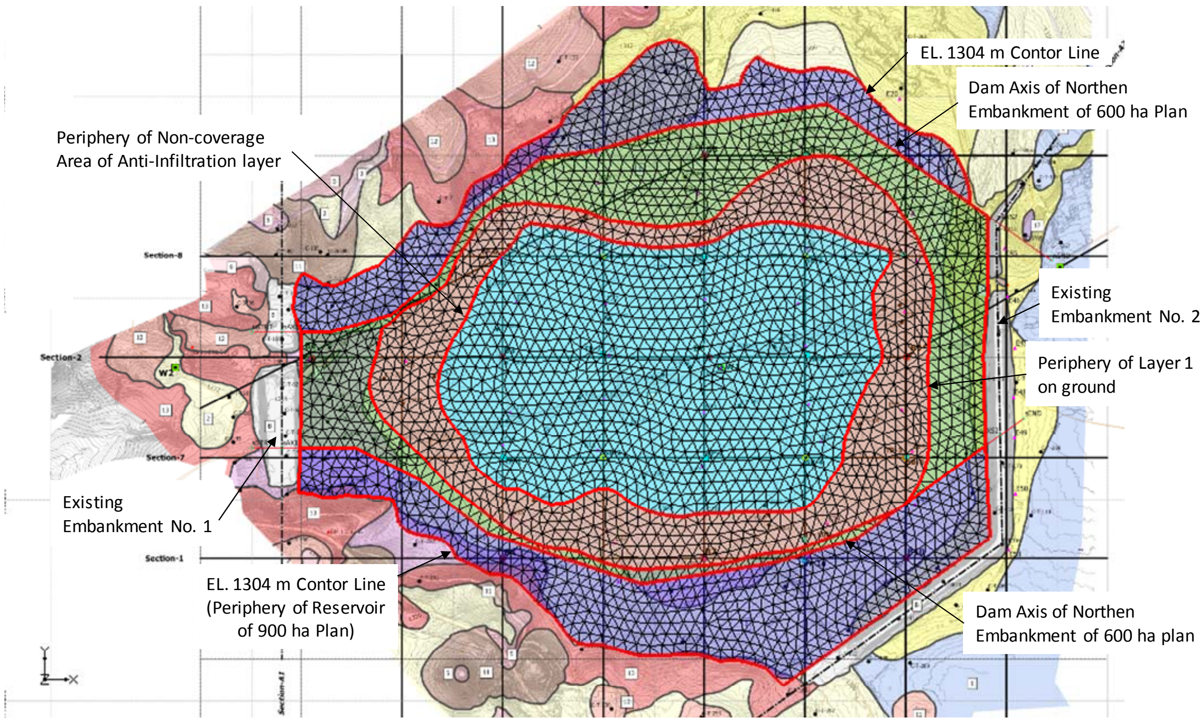


Figure 6-5-2.1 TIN for Calculation of Infiltration Rate from Reservoir

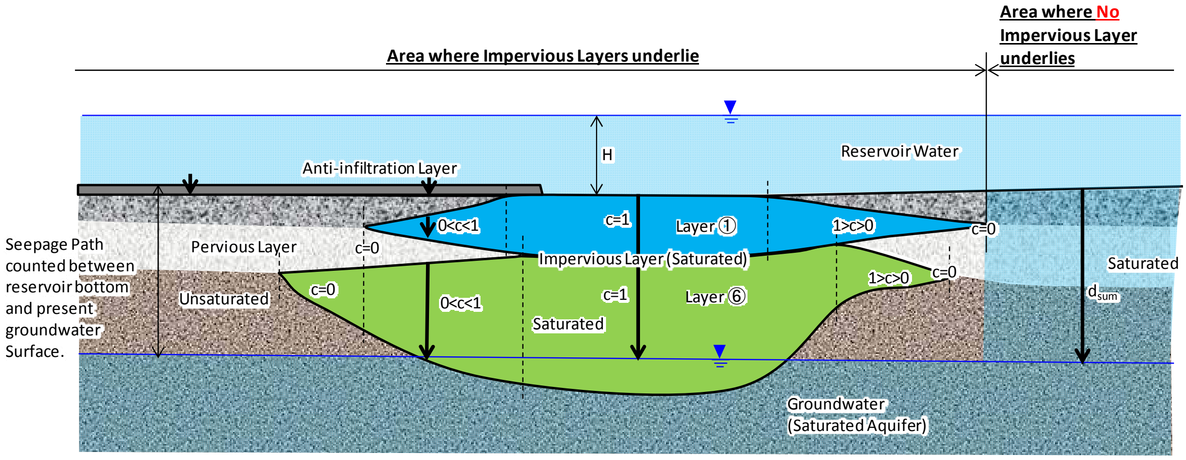


Figure 6-5-2.2 Schematic Figure to Explain Assumption of Infiltration-Rate Calculation Formula

The calculation formula is as follows:

$$Q_{total} = \sum_{i=1}^{n} Q_i$$
$$Q_i = q_i A_i$$

where Q_{total}: Total infiltration rate from reservoir
Q_i: Infiltration rate in an element
A_i: Area of an element
q_i: Specific infiltration rate at an element (rate in a unit area)
n: Number of elements

$$q_i = k_{ave} \frac{H + d_{sum}}{d_{sum}}$$

where k_{ave}: Average coefficient of vertical permeability of layers under an element (Harmonic mean weighted with layer thickness)
d_{sum}: Total average thickness of layers under an element
H: Average water depth on an element

$$k_{ave} = \frac{\sum c_i d_i}{\sum \frac{c_i d_i}{k_i}} \qquad d_{sum} = \sum c_i d_i$$

where k_i: Coefficient of vertical permeability of layer in saturation
d_i: Thickness of layer
c_i: Reduction factor of thickness of layer (see the Figure 6-5-2.2)

The seepage path is counted between the reservoir bottom and the present groundwater surface. The target layers for the calculation were selected as follows:

Area where impervious layers underlie

- Seepage path through only impervious layers (the Layer 1, Layer 6 and the anti-filtration layer) were considered.
- Seepage path through pervious layers were ignored, assuming that lateral or unsaturated flow

occurs in them.

- In case, a pervious layer overlies on an impervious layer, a reduction factor ranging 0 to 1 as shown in Figure 6-5-2.2 is applied to the thickness of the impervious layer assuming that the water partially flows out laterally.

Area where no impervious layer underlies

- Seepage path through all layers considered, assuming that saturated flow occurs.

In an area where an impervious layer is thin, the infiltration rate considering only the impervious layer might exceed that considering all layers. In that case, the latter value is adopted, because it means saturated flow occurs through the layers.

(b) 3-D FEM method

The 3-D FEM Method is the three-dimensional saturated and unsaturated seepage flow analysis with the finite element method. It formulates the groundwater flow with the calculus formula based on the Darcy's Law for the saturated zone and the so-called Richards's formula for the unsaturated zone. For the steady state, the formula is written as follows:

$$\nabla \cdot (K \cdot \nabla h) = 0$$

where: h = total head (elevation head plus pressure head)

K = hydraulic conductivity (coefficient of permeability)

$$K = K_{sat} \cdot k_r$$

K_{sat} = hydraulic conductivity in saturation

k_r = relative permeability (=1 in saturated zone; >0 and <1 in unsaturated zone)

In the unsaturated zone, the Darcy's Law is also applied, but the coefficient of permeability is multiplied by a relative permeability ranging greater than 0 to 1 which relates to the moisture content or suction head in a layer. The program code used for the calculation is the "DTRANS-3D" which is developed by Prof. M. Nishigaki of Okayama University, Mitsubishi Material Co. Ltd. and Dia Consultant Co. Ltd.

Figure 6-5-2.3 shows the FEM mesh for the calculation. It consists of the prism elements which are extruded from the same TIN in the reservoir area as used for the 2-D simple method.

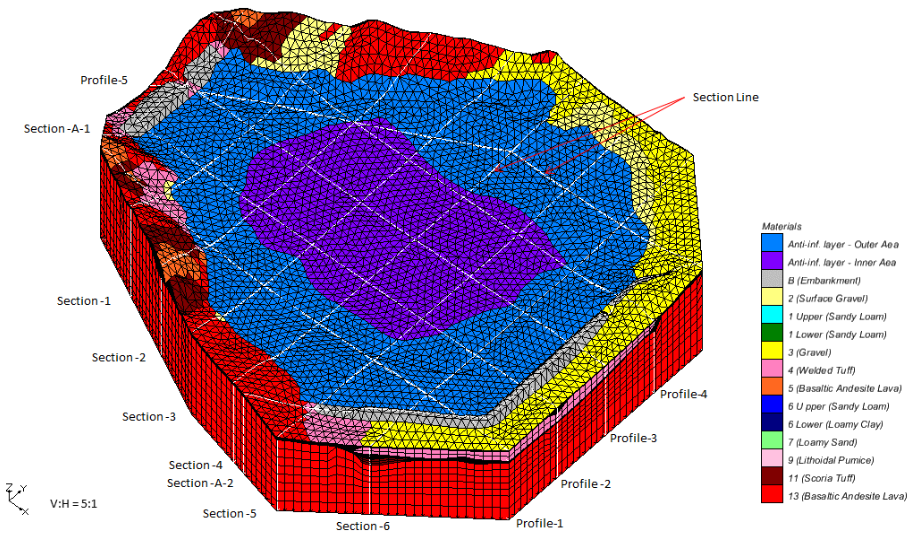


Figure 6-5-2.3 3-D Mesh used for Infiltration-Rate Calculation with 3-D FEM Method

(2) Basic conditions

Ground elevation

The ground elevation of the TIN is interpolated with the surveyed topographic map contours. .

Boundary elevation of geologic layers

The boundary elevation of the geology layers are interpolated from the geological map and sections made with the results of the present and past geological investigations. Figure 6-5-2.4 shows a 3-D geology model developed with the boundary elevation of layers used in the leakage calculation

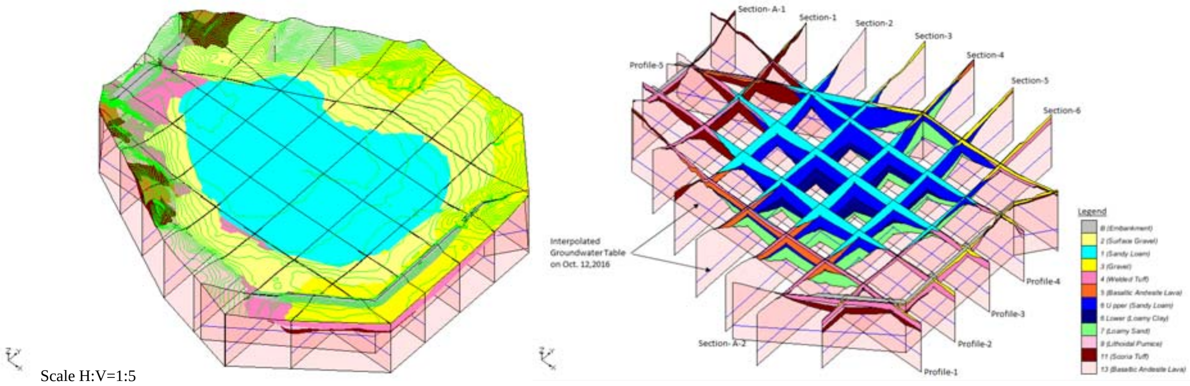


Figure 6-5-2.4 3-D Geology Model Developed with Boundary Elevations Used in Leakage Calculation

Permeability coefficient of geologic layers

The geometric mean of the values obtained by in-situ permeability tests is used for each layer as shown in Table 6-5-2.1. The used vertical permeability coefficient of the layer 1 is 4.3x10^{-4} cm/s for the upper 10m and 8.3x10^{-6} cm/s for the lower. That of the layer 6 upper is 7.5x10^{-6}cm/s, which is also used for the lower for the safety side.

Table 6-5-2.1 Average Coefficient of Permeability of Geologic Layers

Impervious Layers

Layer No.		Main Lithology	Test Place	Test by JICA, 2015						Test in the D/D, 1985					
				No. of Data	Vertical		No. of Data	Horizontal		No. of Data	Vertical		No. of Data	Horizontal	
D/D 1985	JICA 2015				Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean
①	①	Sandy Loam/Loam	Testpit	20	5.1E-04	4.3E-04	20	1.6E-03	1.2E-03	28	3.1E-04	2.1E-04	-	-	-
			Borehole	46	1.6E-05	8.3E-06	41	1.0E-04	4.9E-05	-	-	-	6	1.7E-05	9.7E-06
			All	-	-	-	-	-	-	-	-	-	34	2.0E-04	7.1E-05
⑥	⑥Upper	Loamy Sand/ Loam	Borehole	57	4.5E-05	7.5E-06	50	2.9E-04	3.2E-05	-	-	-	6	1.2E-05	1.1E-05
	⑥Lower	Loamy Clay	Borehole	6	3.1E-06	1.3E-06	5	1.3E-05	2.8E-06	-	-	-	-	-	-

Pervious Layer

Layer No.		Main Lithology	Test Place	Test by JICA, 2015						Test in the D/D, 1985					
				No. of Data	Vertical		No. of Data	Horizontal		No. of Data	Vertical		No. of Data	Horizontal	
D/D 1985	JICA 2015				Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean		Arithmetic Mean	Geometric Mean
②a	②	Gravel	Borehole	6	4.2E-05	1.7E-05	7	9.2E-04	6.9E-04	-	-	-	4	1.6E-03	1.3E-03
③	③	Gravel	Borehole							-	-	-	19	5.0E-03	1.5E-03
④	④	Welded Tuff	Borehole	13	1.2E-04	1.7E-05	12	5.4E-04	2.3E-04	-	-	-	60	4.7E-03	8.9E-04
⑤	⑤	Lava	Borehole	5	1.1E-05	4.2E-06	4	2.7E-04	2.2E-04	-	-	-	14	8.0E-03	5.4E-04
⑦	⑦	Sand, Sandy Loam	Borehole	12	2.6E-04	3.1E-05	7	5.4E-05	4.6E-05	-	-	-	23	3.1E-03	1.4E-03
⑧		Loamy Sand/Loam	Borehole							-	-	-	5	3.2E-04	-
⑨	⑨	Lithoidal Pumice	Borehole	-	-	-	-	-	-	-	-	-	5	4.4E-04	2.1E-04
⑩	⑩	Welded Tuff	Borehole	-	-	-	-	-	-	-	-	-	5	4.7E-03	-
⑪	⑪	Scoria Tuff	Borehole	-	-	-	-	-	-	-	-	-	64	1.6E-02	1.4E-03
⑬	⑬	Lava	Borehole	21	2.0E-05	6.9E-06	15	3.2E-04	2.0E-04	-	-	-	53	9.8E-03	3.9E-03
⑮		Lava	Borehole							-	-	-	21	2.8E-03	2.0E-03

注) Average is weighted with the test interval.
Gray-colored Layers are volcanic effusives. Generally jointed or pourous.
Yellowe-painted values are used in the present leakage calculation.
Green-colored values are used as the horizaontal permeability in 3-D FEM method..
Red-colored values were used in the leakage calculation in D/D, 1985.

Groundwater level

The groundwater level was interpolated from the observed data at the monitoring wells on Oct. 12, 2016. This was used as the lower limit of seepage path for the calculation by the 2-D simple method and as the fixed head boundary on the saturated part of side face for the 3-D FEM simulation.

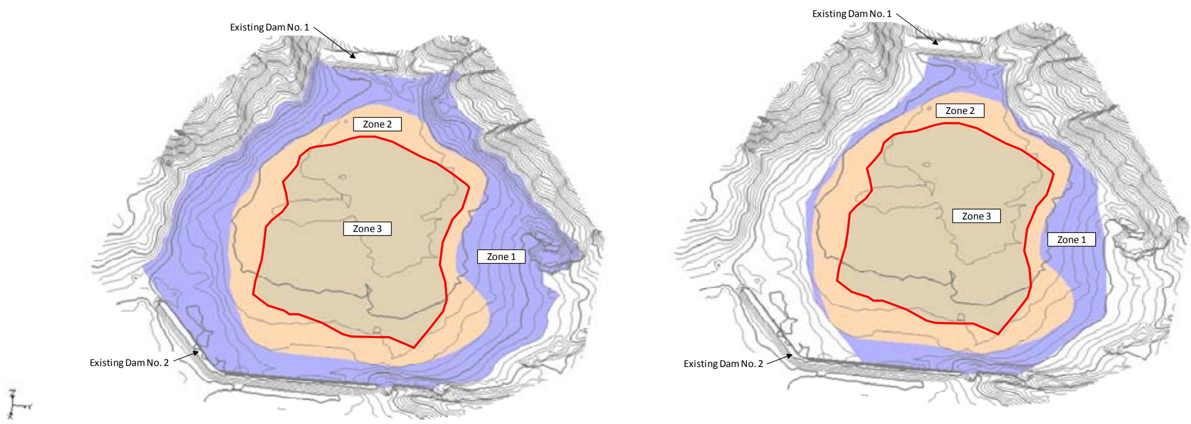
(3) Estimation cases

Figure 6-5-2.5 shows the areal extent of the estimation cases. For the reservoir layout, 900 ha and 600 ha plans were assumed. For the covering extent of the anti-infiltration layer, the whole and the partial coverage cases are assumed. The partial case doesn’t cover the central part of the reservoir shown in Figure 6-5-2.6, which is defined with the following conditions:

- Thickness of the layer 1 is greater than 15 m.
- Combined thickness of the layer 1 and 6 is greater than 30 m.
- Distance from the boundary of the layer 1 on the ground is greater than 100 m.

The imperviousness of the anti-infiltration layer is k=1.0 x 10^{-7} cm/s and t=0.2 m, or equivalent. As the full water level of the reservoir corresponding to the capacity 94 MCM, EL. 1304.51 is used for the 900 ha plan and EL. 1306.93 for the 600 ha plan which were calculated with the ground TIN.

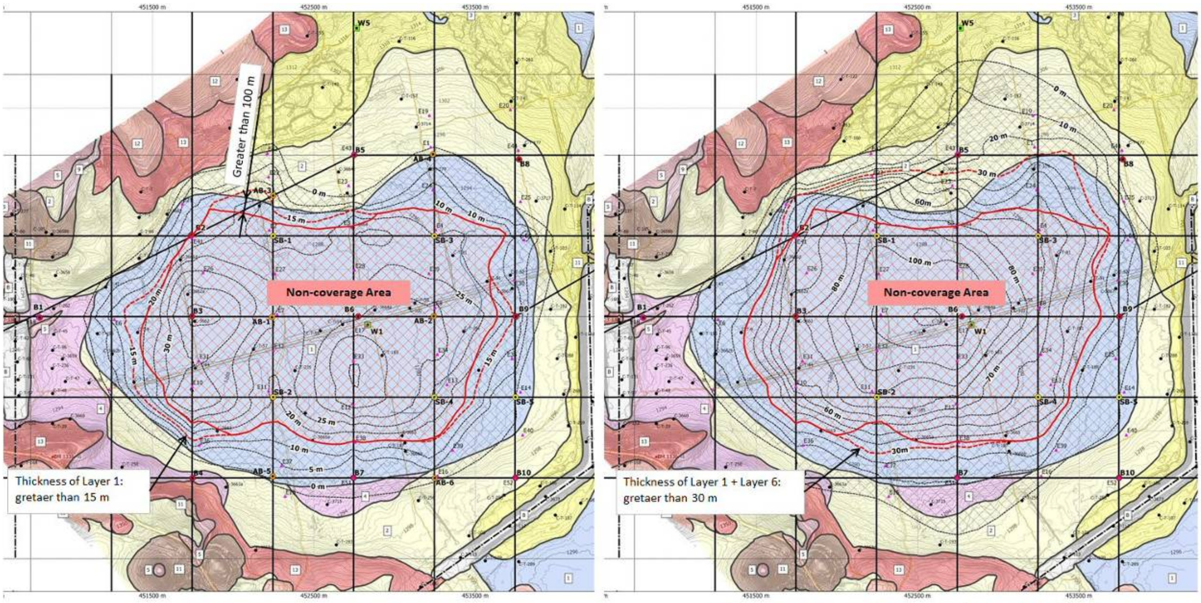
Note) The average permeability coefficient of the layer 1 and 6 is around k=1.0x10^{-5} or less. A layer with k=1.0 x 10^{-5} cm/s and t=20 m has the same imperviousness as the assumed anti-infiltration layer, if the hydraulic head of the layer base is the same. Because the upper about 10m of the layer 1 would have a larger permeability, at least 30 m of thickness would be required to obtain the ability.



900 ha Plan   600 ha Plan

Note) The Layer 1 (sandy loam) exposes on the ground in the zone 2 and 3. The partial coverage case of anti-infiltration layer doesn’t cover the zone 3 (263 ha).

Figure 6-5-2.5 Areal Extent of Estimation Cases



Thickness Contor Map of Layer 1 Thickness Contor Map of Layer 1 and Layer 6 Combined

Figure 6-5-2.6 Setting of Non-coverage Area of Anti-infiltration Layer

(4) Estimated leakage rate

Table 6-5-2.2 shows the estimated leakage rate from the reservoir for the alternative cases. The leakage rate is estimated around 43,000 to 53,000 m^3/day at the full water level and average 29,000 to 35,000 m^3/day in the irrigation period of the standard year. The value itself is a little large but probably does not affect the reservoir function significantly, because the ratio to the full reservoir capacity – 94 MCM is near or smaller than 0.05%/day which is the Japanese guideline for reservoir construction.

The reservoir water loss is larger in 900 ha plan than 600 ha plan, but the difference is small. Also the difference is not so large between the whole and partial coverage cases of anti-infiltration layer. Therefore the central part of the reservoir, where probably-impervious layers underlie, may not be covered with the anti-infiltration layer considering the cost efficiency.

Table 6-5-2.2 Estimated Leakage Rate from the Reservoir

Reservoir Layout Plan	Anti-infiltration Layer Coverage	Infiltration Rate at 94MCM			Average Infiltraion rate in Irrigation Period of Standard Year		
		Amount (m^3/day)	Ratio	Ratio to 94 MCM (%/day)	Amount (m^3/day)	Ratio	Ratio to 94 MCM (%/day)
900 ha	Whole	45,900	100%	0.049	29,599	100%	0.031
	Partial	52,196	114%	0.056	34,614	117%	0.037
600 ha	Whole	43,190	94%	0.046	28,809	97%	0.031
	Partial	49,712	108%	0.053	33,908	115%	0.036

(5) Flow pattern and movement of infiltrated water

Figure 6-5-2.7 shows the flow pattern and movement of the infiltrated water from the reservoir on the north-south and the east-west sections. The water flows down almost vertically and, after reaching the groundwater body, flows laterally.

Whatever the central part of the reservoir is covered with the anti-infiltration layer or not, the flow pattern in the foundation doesn't change much as understood from the figures. This means that the layer 1 and 6 will work well as natural impervious layers.

The infiltrated water is not useless, but would be a good groundwater recharge for the downstream area.

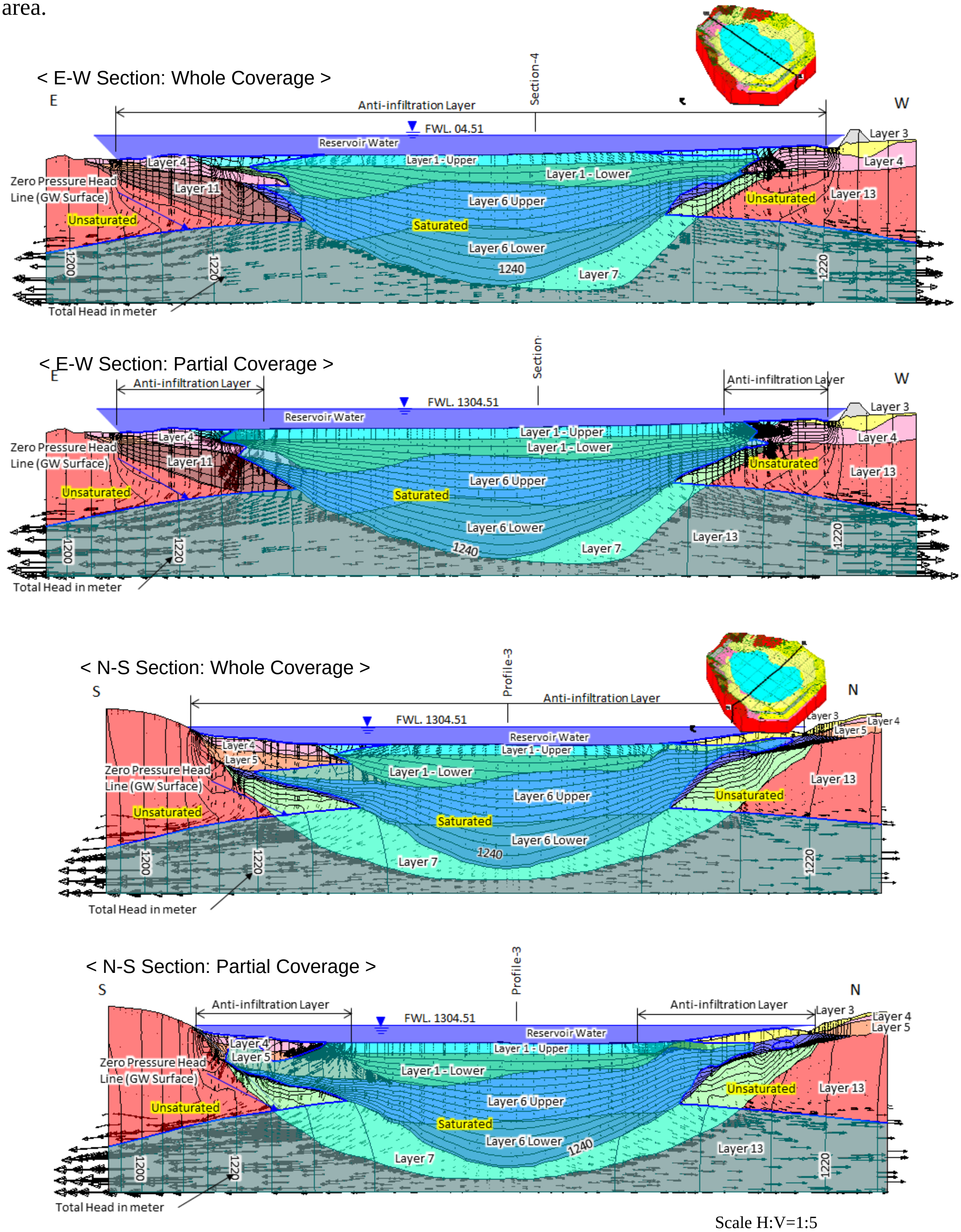


Figure 6-5-2.7 Flow Pattern of Infiltrated Reservoir Water

6-5-3 Outline of the Reservoir Plan

(1) Natural and structural conditions

(a) Meteorological conditions

1) Temperature

- 30 years (1983 - 2012) average of monthly mean temperature = - 4.8 - 23 ℃
- Months with minus (-) monthly mean temperature are December, January and February

2) Precipitation

- Average annual precipitation for 30 years (1983 - 2012) = 445 mm / year
- 30 years (1983 - 2012) average of monthly rainfall are 13mm (August) - 65mm (April)

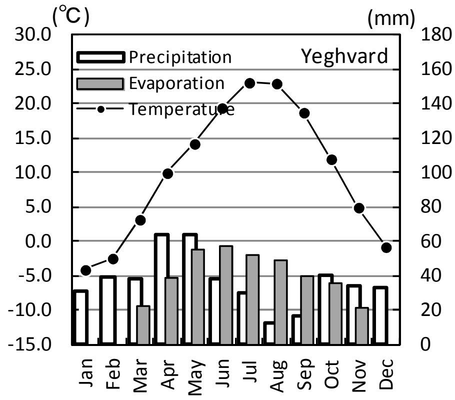


Figure 6-5-3.1 Temperature, Precipitation and Evaporation (1983~2012)

3) Wind

- Maximum mean wind velocity for ten minutes is 18 m/sec
- Predominant wind direction is north to south - north-east to south-west

It is impressive that strong wind keep blowing ceaselessly from north or north-east and the temperature becomes high to be 35℃ or so in summer day-time.

(b) Topographical condition

The reservoir area expanding 3 km long from north to south and 3 km wide from east to west is composed of the wide central plane and gentle slopes at both northern and southern side with the inclination of 1 to 100 or so in average. The reservoir area is pegged out by the existing dam bodies at both eastern and western sides.

(c) Geological condition

The north slopes are composed of Surface Gravel layer, Moraine Deposit, Basaltic Andesite lava stratum and Pyroclastic Flow deposit geologically, all of which are pervious fundamentally. The south slopes have a tri-laminar structure, the first of which is the thin Surface Gravel layer, the second Welded Tuff layer and the third Basaltic Andesite lava layer. The Welded Tuff layer tends to be impervious in case of the layer having no cracks. The basement of the central plane is composed of sediments of loamy soils with thickness more than 120 m approximately at its center. It is revealed by the investigations done in this time that these sediments layers have relatively low permeability coefficient and clear anisotropy between horizontal and vertical permeability.

(d) Structural condition

The expected reservoir capacity is about 94,000,000 m^3 on 9,400,000m^2 of the approximate reservoir area. It would be able to say that the reservoir is a shallow pond with tremendous expansion of 9,400,000 m^2 of water surface.

(2) Topic items to be considered in the reservoir planning

(a) Slope protection against wave actions

Strong wind and the long blow-over distance bring high waves to reservoir slopes so that they shall be protected against wave actions by the protection work.

(b) Protection against the freezing-thawing effect

Low temperature less than 0 ℃ in average from December to February shall bring the cycles of freezing and thawing that would loosen the compacted soil layer to be weak in strength and be more pervious in seepage. To avoid such circumstances brought to the compacted soil layers, suitable protection works shall be provided with on to the slope surface.

(c) Anti-infiltration works to the reservoir slopes

Anti-infiltration works on the reservoir slopes to prevent the leakage water from surpass the allowable limit shall be studied. The effectiveness and economy of the anti-infiltration works shall be considered together with the protection works against wave actions, freezing-thawing effect, the foundation treatment against the piping phenomenon and the back pressure caused by groundwater acting from behind the anti-infiltration works.

(d) Anti-infiltration works to the reservoir bottom

There exists a thick mass of sediments of loamy soils with relatively low permeability coefficient. How to evaluate its efficiency in preventing the reservoir water from infiltrating through and how to design the anti-infiltration works to the reservoir bottom shall be studied.

(e) Shape-arrangement to the existing dams and the anti-infiltration works to them

The existing dams shall be arranged in shape according to the full water surface of the Reservoir and be provided with the anti-filtration work, which shall function as the continuous structure connected with the anti-infiltration work to the reservoir basin, on the upstream slope against the seepage.

(f) Total shape-arrangement of the Reservoir considering plans of the bottom area and the embankment.

Finally, the shape-arrangement of the reservoir shall be done considering the borrow area plan.

6-5-4 Comparative Study on the Anti-infiltration Works to the Reservoir (Including Risk Assessment for Leakage and Technical Specification of Trial Construction)

(1) Candidates of the anti-infiltration works

Followings shall be nominated as the candidates of the anti-infiltration works.

(a) Earth blanket coverage method

The slopes/bottom shall be covered by the earth blanket made of impervious soil layer spread and compacted. The sandy loam lying in the reservoir basin is applicable as the impervious soil. The drainage-cum-filter layer shall be provided with under the earth blanket; and the blanket surface must be protected by the slope protection work.

(b) Watertight asphalt concrete coating method

The slopes/bottom shall be coated by the pavement of watertight asphalt concrete. This method is similar to the asphalt facing work on the upstream slope of the fill-type dam. The drainage-cum-filter layer shall be provided with under this pavement.

(c) Polyethylene sheet (rubber sheet) coating

The slopes/bottom shall be coated by the impervious film such as low density polyethylene sheet. The edges of each sheet must be connected together to the ones of adjacent sheets by manpower using chemical agent and devices so that it is important how to manage these works and conduct the quality control of these works to avoid the damage due to faulty workmanship. The drainage-cum-filter layer shall be provided with under this coating work. It is a difficult choice for the slope protection to be provided with or not to be; if to be, probability of damages by its construction would increase; if not to be, durability of the work would decrease due to the friction caused by ceaseless wave actions.

(d) Bentonite sheet coating

The slopes/bottom shall be coated by the impervious thin mat of bentonite sheet. The connection work is easy only to overlap together each edge of adjacent sheets; and so it is important to manage the laying works and conduct quality control of these works to avoid the damage due to faulty workmanship caused by the easiness of the work. The drainage-cum-filter layer shall be provided with under this coating work; and its surface must be protected by the slope protection work.

(e) Soil-cement coverage

The downward seepage shall be constrained by the impervious coverage of soil-cement constructed on the slopes/bottom. Soil cement has a long history of being used empirically for small-scale waterway constructions, ground improvement works and so on but has rare example of being used as an anti-infiltration work to wide area. The drainage layer shall be provided with under this coverage; but the slope protection work is not necessary.

(f) Blanket coverage by the compacted layer of soil and bentonite-powder mixture

The slopes shall be covered by the compacted blanket layer made of soil and bentonite-powder mixture. This coverage work is treated as the standard anti-infiltration method for the industrial waste disposal pond because of high reliability on its high level imperviousness. The drainage-cum-filter layer shall be provided with under this blanket; and the blanket surface must be protected by the slope protection work.

(2) Design/construction conditions and confinement of the candidates

(a) Design condition: allowable leakage quantity and the required permeability coefficient/thickness of the anti-infiltration work

In usual dams' case, foundation treatment works are done to reduce leakage quantity through their foundation; but it is impossible to shut out all the leakage so that the scale of treatment works is designed considering the allowable leakage quantity. This allowable quantity is decided empirically considering the efficiency as a reservoir and the capability or the limit of improvement of the treatment works. In Japan's case, the target of this allowable quantity is '0.05 % of the total reservoir capacity per day'. This target value shall be applied to this reservoir.

Then, Allowable quantity = total capacity of the reservoir 94,000,000 $m^3 \times 0.0005$

$= 47,000\ m^3/day$

When assuming the reservoir to have the area of 9,400,000 m^2 and the average depth of 10 m,

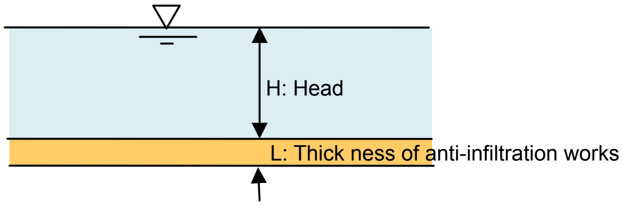
Allowable quantity per square meter = 0.005 $m^3/day/m^2$

When assuming the reservoir to have the area of 6,267,000 m^2 and the average depth of 15 m,

Allowable quantity per square meter = 0.0075 $m^3/day/m^2$

The quality of the anti-infiltration work means its permeability coefficient. The seepage direction through the reservoir bottom is vertical. In the vertical seepage problem, seepage quantity is almost decided by the layer with the lowest permeability coefficient, i.e. the anti-infiltration work. The seepage quantity through the anti-infiltration work shall be estimated by the following formula.

$$Q=k \cdot i \cdot A$$



Here, Q ; seepage quantity
k ; permeability coefficient
i ; hydraulic gradient・・・・i=H/L
A ; seepage area

The permeability coefficients and the thicknesses required for the anti-infiltration works to satisfy the allowable leakage quantity are estimated as shown in Table 6-5-4.1.

Table 6-5-4.1 Quality and Thickness Required for the Anti-infiltration Work

Reservoir model	Allowable Q (m3/day/m2)	H (m)	A (m2)	k (cm/sec)	k (m/day)	L (cm)
A=9,400,000 m2 Av. Depth=10m	0.005	10.0	1.0	5.E-05	4.E-02	8640.0
	0.005	10.0	1.0	5.E-06	4.E-03	864.0
	0.005	10.0	1.0	5.E-07	4.E-04	86.4
	0.005	10.0	1.0	5.E-08	4.E-05	8.6
	0.005	10.0	1.0	5.E-09	4.E-06	0.9
A=6,267,000 m2 Av. Depth=15m	0.0075	15.0	1.0	5.E-05	4.E-02	8640.0
	0.0075	15.0	1.0	5.E-06	4.E-03	864.0
	0.0075	15.0	1.0	5.E-07	4.E-04	86.4
	0.0075	15.0	1.0	5.E-08	4.E-05	8.6
	0.0075	15.0	1.0	5.E-09	4.E-06	0.9

(b) Construction condition: strong wind

According to the observation record of wind velocity at the Yeghvard Weather Station, strong wind blows down frequently in summer and not frequently but almost always all through a year (refer to Figure 4-3-6.13, 4-3-6.14 and 4-3.6.15). Wind pressure arises when flat surface receives wind and its degree of wind pressure is estimated according to wind velocity as follows;

The force that the body placed in fluid receives is called drag; that is calculated by the following formula.

$$D=Cd \cdot A \cdot y \cdot u^2/(2g)$$

Here, D; drag (kgf)
Cd; drag coefficient, Cd=2 in case of the flat plate
A; area of the body surface (m^2)
y; density of the fluid (kg/m^3), y=1.0 kg/m^3 corresponding to air
u; velocity of the fluid
g; gravity acceleration (m/s^2), g=9.8 m/s^2

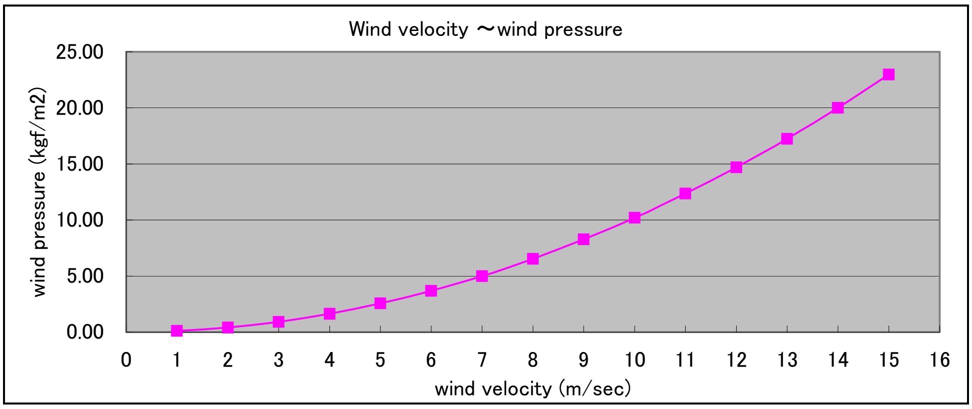


Figure 6-5-4.1 Wind Pressure Brought to a Flat Surface by Wind from in Front

The weight of sheet for anti-infiltration work is 4.9 kg in a production of polyethylene sheet 1.5 mm thick and 5.5 kg in a production of bentonite sheet 6 mm thick, so that both of them shall be blown off by 7 m/sec or 8 m/sec of wind velocity and the wind pressure brought by 10 m/sec wind to the 10 m2 (=2m x 5m) sheet reaches 100 kg which is beyond the range of manpower work.

(c) Permeability coefficient obtained/confirmed through information collection or laboratory tests

Table 6-5-4.2 shows permeability coefficient obtained in the Survey.

Table 6-5-4.2 Permeability Coefficient Obtained/Confirmed through Information Collection or Laboratory Tests

Candidate	Permeability coefficient (cm/sec)	Source
Earth blanket	5×10^{-7} (sandy loam)~3×10^{-6} (loamy sand)	Laboratory test
Asphalt concrete	1×10^{-8}	Empirically
Polyethylene sheet	1×10^{-12}	Producer's catalog
Bentonite sheet	5×10^{-9}	Producer's catalog
Soil-cement	7.7×10^{-7} ~ 3.9×10^{-8}, Sufficiency/insufficiency of curing influences the permeability.	Laboratory test
Bentonite-soil mixture	7.0×10^{-6} ~ 4.6×10^{-7}, Possibility to improve the imperviousness is left.	Laboratory test

(d) Confinement of the candidates

Table 6-5-4.3 shows confinement of the candidates for anti-infiltration works.

Table 6-5-4.3 Confinement of the Candidates for Anti-infiltration Works

Candidate	Remarks	Adopted/rejected
Earth blanket	Permeability coefficient shall be evaluated to be 5×10^{-6} cm/sec or so, then the required thickness shall be 8.64m (Table 6-5-4.1)	Too thick, rejected
Asphalt concrete	Very expensive empirically to be 150 US$/m2 or so	Too expensive, rejected
Polyethylene sheet	Very hard to execute connecting works by using chemical agents and devices under strong wind	rejected
Bentonite sheet	The required thickness shall be 9 mm (Table 6-5-4.1). Hard but possible to execute laying works due to simplicity of connecting works	Adopted as the candidate
Soil-cement	Criteria of 5×10^{-7} cm/sec shall be adequate considering the freezing/thawing effect and the differential of curing conditions between in the laboratory and in the field, and applicable to the sand-and-gravels with adjusted gradational conditions; then the required thickness shall be 86.4 cm (Table 6-5-4.1)	Adopted as the candidate
Bentonite-soil mixture	Criteria of 5×10^{-7} cm/sec shall be applicable provided farther pursuit shall be done in terms of the imperviousness improvement of bentonite sand-and-gravel mixture. The required thickness shall be 86.4 cm (Table 6-5-4.1)	Adopted as the candidate

(3) Comparative study of the anti-infiltration works

(a) Forth candidate of the anti-infiltration work

Besides the three kinds of anti-infiltration works using the materials shown above, the forth one by using the same materials shall be devised, that is the anti-infiltration work composed of two layers of soil-cement and a bentonite sheet sandwiched between them.

The bentonite sheet coverage method has disadvantages. Even if the laying works of sheets are hard but possible, it would be inevitable to meet difficulties in laying works of sheets due to strong wind.

And the appearance of faulty workmanship caused by the simplicity of the laying works shall become more frequent through the works done hastily under strong wind. These disadvantages shall be overcome by laying the sheet sandwiched between two soil-cement layers and by applying the work process as follows.

1) To prepare a foundation by soil cement to fix the sheet on it
2) To prepare a roll of sheet product
3) To prepare a heavy construction equipment not to be effected by the wind and be able to mount and spread sheet on the foundation
4) To fix the sheet quickly on to the foundation surface in such a manner as fixing it on to the soil-cement slab by driving concrete nails
5) Not to extend the sheet long but to extend the sheet short and start the fixing work from the edge toward the inner step by step.

The soil-cement coverage method has also a disadvantage; that is variation in permeability coefficient caused by non-uniformity in mixing between soil and cement and by the insufficient curing to the compacted soil-cement. This disadvantage shall be covered by the low permeability coefficient and uniformity/continuity of bentonite sheets.

This coverage method by soil-cement with a sandwiched bentonite sheet is a good measure technically in the meaning that each other’s advantage covers the other’s disadvantage.

(b) Thickness of the anti-infiltration work and its total structural formation

The thickness of the anti-infiltration work shall be as follows based on the evaluation in Table 6-5-4.4.

Table 6-5-4.4 Thickness of the Anti-infiltration Work

Candidate	Required thickness/ permeability coefficient (cm/sec)	Adopted
Bentonite sheet	9 mm / 5×10^{-9}	Two-ply application (6 mm×2)
Soil-cement	86.4 cm / 5×10^{-7}	90 cm
Bentonite soil mixture	86.4 cm / 5×10^{-7}	90 cm
Soil-cement with a sandwiched bentonite sheet	Soil-cement; 45 cm, bentonite sheet; one sheet Soil-cement; 5×10-7cm/sec, t=45cm⇒5×10-7cm/sec, t=45cm Bentonite sheet; 5×10-9cm/sec, t=0.6cm⇒5×10-7cm/sec, t=60cm Total; 105 cm>86.4 cm	

The anti-infiltration works must be treated together with the slope/surface protection works. The slope protection works are planned as follows according to the studies in Chapter 6-5-6.

Dam No.1, South slope ; soil-cement protection   Dam No.2, North slope ; cobble-gravel rip rap

The total structural formation of each anti-infiltration work shall be planned as shown in Figure 6-5-4.2.

(c) Comparison of anti-infiltration works

Table 6-5-4.5 shows comparison of anti-infiltration works and "Soil-cement with a sandwiched bentonite sheet is selected as anti-infiltration works.

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Table 6-5-4.5 Comparison of Anti-infiltration Works

Method \ Item	Design (k: cm/sec)	A. Construction cost: item	A. Construction cost: cost	B. Construction work	C. Reliability	Judgment	A	B	C	Total
Bentonite sheet	k=5×10-9 t=6 mm	Bottom	12.6 $/m2	Frequent interruptions by strong wind	Low because of easiness of connection works done hurriedly in the strong wind condition	Bottom	10	5	3	18
		North	22.4 $/m2			North	5	5	3	13
		South	24.1 $/m2			South	5	5	3	13
Bentonite-soil mixture	k=5×10-7 t=90 cm	Bottom	18.3 $/m2	No problem	Complete enclosure is needed; if not, compscted body of bentonite- soil mixture loses its component.	Bottom	5	10	7	22
		North	28.1 $/m2			North	3	10	7	20
		South	30.4 $/m2			South	3	10	7	20
Soil-cement	k=5×10-7 t=90 cm	Bottom	15.3 $/m2	No problem	Lack of curing brings the compacted body incomplete imperviousness.	Bottom	8	10	7	25
		North	15.3 $/m2			North	9	10	7	26
		South	15.3 $/m2			South	9	10	7	26
Soil-cement with a sandwiched bentonite sheet	k=5×10-7 t=45 cm Bentonite sheet 1	Bottom	14.5 $/m2	The additional work of fixing the sheet by driving concrete nails Fewer occurrence of wind interruptions	Mistake in connection works of bentonite sheets can be covered by the continuous layer of soil-cement. Incomplete imperviousness of soil-cement can be covered by the low permeability of bentonite sheet.	Bottom	9	8	10	27
		North	14.5 $/m2			North	10	8	10	28
		South	14.5 $/m2			South	10	8	10	28
						adopted due to economy and reliability				

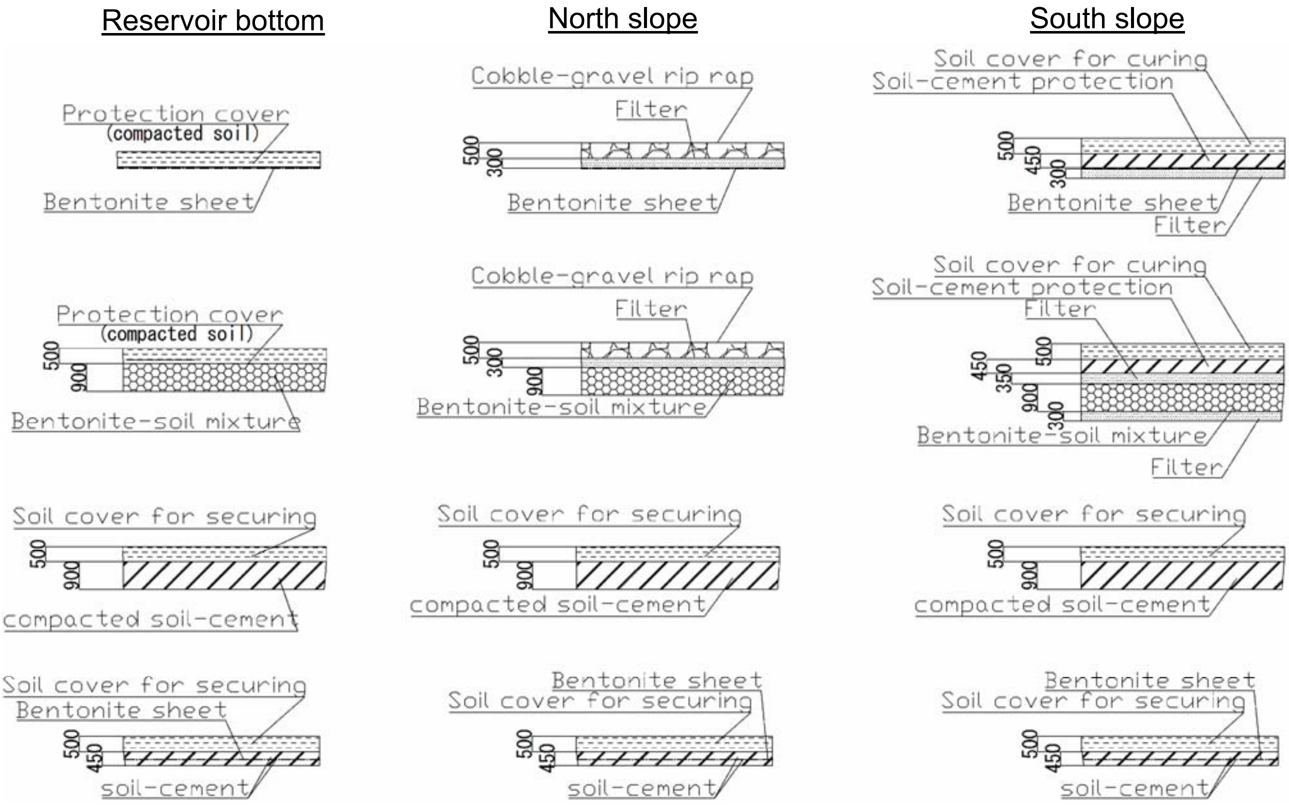


Figure 6-5-4.2 Total Structural Formation of Each Anti-infiltration Work to Each Location

(4) Risks and counter measures against leakage more than allowable volume

Although selected "Soil-cement with a sandwiched bentonite sheet" is to work as anti-infiltration works by covering disadvantage of each soil-cement and bentonite sheet by each advantage, there is a possibility that leakage volume more than allowable one will happen during operation. Therefore here examined the risks of leakage more than allowable one and countermeasures to mitigate risks.

(a) Risks

The following two (2) matters are considered as main risks for leakage more than allowable volume.

i) Higher permeability coefficient of soil cement and/or bentonite sheet than design value
ii) Cracks, gaps and spaces inside of soil-cement and/or beontonite sheet, or those boundary

(b) Hazards of risks and counter measures against those hazards

Hazards of risks above and counter measures against those hazards are summarized as Table 6-5-4.6. Many hazards will be cleared by counter measures conducted during design, construction and construction supervise stage. However some hazards summarized in from Table 6-5-4.7 to Table 6-5-4.8 requires some tests/examinations to examine countermeasure against those.

Table 6-5-4.6 Risks of Leakage more than Allowable Volume, its Hazards and Counter Measures to Mitigate Risks

Risks				Hazards	Counter Measure				
					Design Stage	Examined through Trial Constriction: Field	Examined through Trial Constriction: Laboratory	Construction Stage	Construction Supervise Stage
Higher permeability coefficient than design value	Soil-Cement		Insufficient Permeability Coefficient	- Insufficient compaction - Insufficient cement volume	-	Proper - Mixing time - Water adding measure - Specification of compaction - Curing method	- Physical test - Compaction test - Permeability test	-	- High frequency of permeability Test - Abbreviated initial pounding Test targeting a completion part (not one time after completion of all the construction)
			Deterioration by freeze-thawing	- Deterioration by freeze-thawing	-			-	-
	Bentonite Sheet		Insufficient Permeability Coefficient	- Insufficient quality	-	-	- Reproduction of inspection conducted by supplier	-	- Reproduction of inspection conducted by supplier
			Efflux of Bentonite	- Breaking of upside by gravels contained in the upper layer soil-cement during construction of upper layer soil-cement	-	-	-	-	- Removal of gravels during material collection
				- Breaking of downside by protrusion by gravels contained in lower layer soil-cement	-	-	-	-	- Removal of gravels during material collection - Protrusion observation after compaction of lower layer soil-cement
			Deterioration by freeze-thawing	- Deterioration by freeze-thawing	- (Bentonite is not affected by freeze-thawing)				
Cracks, gaps, spaces	Boundary with Concrete Structure	Normal	Gap/Space	- Insufficient treatment	- Sufficient Inserting of bentonite sheet to concrete structure	-	-	-	-
	Boundary of Soil-cement and Bentonite Sheet		Gap	- Insufficient adherence of soil-cement and bentonite sheet	- (Adherence is secured by compacting soil-cement by heavy equipment)				
	Soil-Cement	Normal	Crack	- Differential settlement	- Secure capacity against difference settlement by joints	-	-	-	-
				- Bending failure by water pressure	- Stress calculation based on the results of borehole dilation test	-	- Uniaxial compression test	-	-
				- Drying shrinkage	-	- Curing method	- Drying shrinkage test	-	-
		During Earthquake		- Tensile/Compressive failure	- Secure capacity against cracks by joints	-	-	-	-
	Bentonite Sheet	Normal	Breaking	- Differential settlement	- (Bentonite sheet has some capacity against differential settlement due to its tensile strength and tenacity capacity)				
			Gap at Sheet Joint	- Insufficient treatment	- Sufficient overlapping	-	-	-	- Construction with inspectors
		During Earthquake	Breaking	- Tensile failure	- (Bentonite sheet has some capacity against deformation by earthquake due to its tensile strength and tenacity capacity)				
			Gap at Sheet Joint	- Slippage of joint	-	-	-	- Fixing bentonite sheet on the lower layer soil-cement utilizing more fasting materials than the other part. - Avoidance of stress concentrating at joints during earthquake by the arrangement of joint location*	-
Others	Soil-Cement	Normal	Wearing/Exfoliation	- Erosion at inlet/outlet point	- Consolidation around inlet/outlet point by soil-cement or concrete - Confirmation of energy dissipater efficient by hydraulic-model test	-	-	-	-

*Arrangement of joint

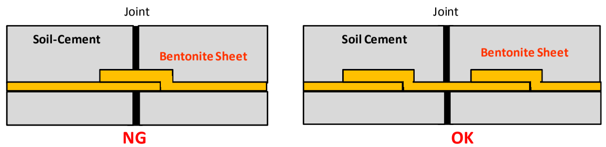


Table 6-5-4.7 Hazards to be Examined its Mitigation Measure (Design Stage)

Target	Test	Objective	Remarks
Foundation	Borehole Dilation Test	- To calculate elastic coefficient of foundation for the examination of cracks caused by bending failure by water pressure	

Table 6-5-4.8 Hazards to be Examined its Mitigation Measure (Trial Construction - Field)

Target	Test	Objective	Remarks
Soil-Cement	Compaction Test	- To clear construction method to develop sufficient permeability coefficient such as compaction times, spreading thickness and so on	
Anti-infiltration works (Soil-Cement +Bentonite Sheet)	Abbreviated Initial Pounding Test	- To clear the notice points during construction - To confirm permeability coefficient of constructed anti-infiltration works	- Pond is constructed according to the specification cleared by compaction test.

Table 6-5-4.9 Hazards to be Examined its Mitigation Measure (Trial Construction - Laboratory)

Target	Test	Objective	Remarks
Soil-Cement	Physical Test	- To check the quality of Sand-and-Gavel Coarse and Soil-Cement	
	Compaction Test	- To check the quality of Soil-Cement - To confirm allowable time from arrangement of moisture content to casting (compacting)	
	Permeability Test	- To confirm permeability coefficient of constructed Soil-Cement	- Test is to be carried out for anti-infiltration works itself (Soil-Cement with a sandwiched Bentonite Sheet) as well
	Drying Shrinkage Test	- To confirm the possibility of cracks caused by drying shrinkage	
	Uniaxial Compression Test	- To confirm the quality of constructed Soil-Cement - To confirm uniaxial compression strength of constructed Soil-Cement for the examination of cracks caused by bending failure by water pressure	
Bentonite Sheet	Permeability Test	- To establish quality check structure during construction stage	- Reproduction of inspection conducted by supplier to confirm the permeability of produced Bentonite Sheet

Technical Specification of Trial Construction

(1) Preparation works (3 sites)

1) Location of borrow pit and trial construction yard

Based on the results of test pits survey, north-east area of reservoir is selected as borrow pit of sand-and-gravel and trial construction yards (yards are established at 3 sites). The area around TP-60 is a candidate because there are a few farm lands (see Figure-A), however actual location will be determined through discussion with PIU and local communities.

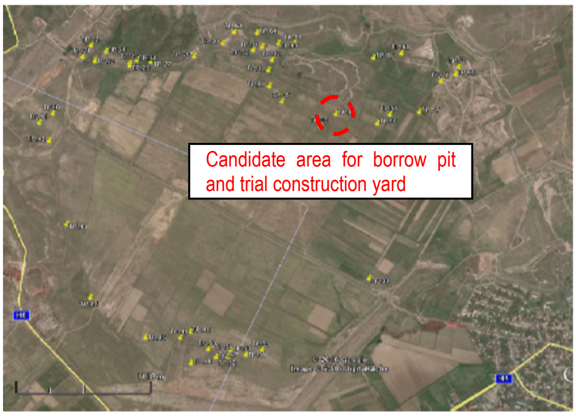


Figure-A Candidate Area for Borrow Pit and Trial Construction Yards

2) Excavation of surface soil (3 sites)

As a trial construction yard, 100m x 100m area shall be arranged. Depth of surface soil is 1.5m and total 15,000m^3 (=100m x 100m x 1.5m) of surface soil shall be removed by the bulldozer. Excavated soil shall be dumped up around the yards and utilized as cover layer for curing later.

3) Ponds excavation (3 sites)

Following the surface soil excavation, pond with bottom area 30m x 30m, depth 2.5m and slope angle 1:6.0 shall be excavated (see Figure-B). The excavated soil (sand-and-gravel) shall be sieved by the self-propelled sieving machine to adjust the gradational condition, reducing contents of the fine particle portion up to 5%. The adjusted sand-and-gravel shall be mounded as stock-pile around trial construction yard and utilized as material for soil-cement.

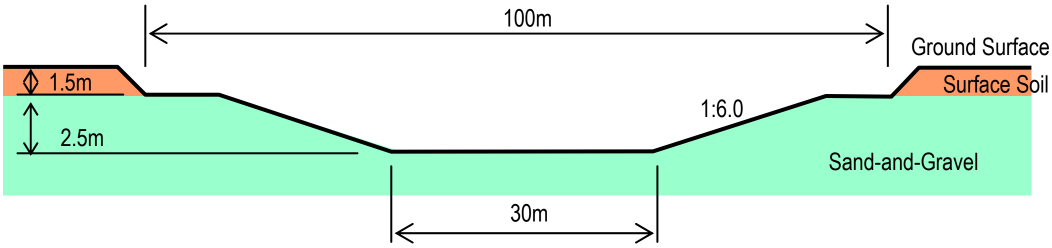


Figure-B Formation of Pond

(2) Trial compaction test to the soil-cement (1 site)

1) Objective

The objective is to decide the detail procedure of compaction work to the soil-cement with cement mixing ratio 10% and the gradational condition corresponding to “sand-and-gravel (coarse)” in the previous laboratory test, and to acquire proficiency in the laying work of bentonite-sheet.

2) Physical soil test to the materials for trial construction (1 site)

Three (3) samples shall be taken out from the sand-and-gravel stock-pile and Moisture content test, Specific gravity tests, Particle size distribution test, Atterberg limit test and Specific gravity & absorption test shall be conducted.

3) Trial mixing of sand-and-gravel with cement powder (1 site)

An inclined and rotation drum mixing machine shall be used. Through trials the adequate time of mixing and the way of adding water for the moisture content adjustment shall be decided. Adequacy shall be evaluated by uniformity; in terms of the mixing time, pH value shall be measured and in terms of the way of adding water, moisture content shall be measured. A pH meter and an electric oven shall be prepared for these measurements. Evaluation shall be made based on the variation coefficient of the measured values..

4) Standard compaction test to the mixed materials (1 site)

In case of soil-cement, it is said that the elapsed time after moisture content adjustment and mixing influences the density of the compacted layer. To grasp the degree of influence, i.e. to know how long the time to spare is till the starting of compaction, the standard compaction test shall be conducted to the five (5) samples adjusted to five (5) kinds of elapsed time.

5) Laboratory soil test to grasp the influence caused by the mixing methods

To grasp the influence caused by the differential of mixing method, Standard Compaction Test, Falling Head Permeability Test and Uniaxial Compression Test shall be conducted to the three (3) samples with 10% of cement mixing ratio and mixed by each two type of mixing machine, field and laboratory. Seven (7) days and 28 days shall be applied as the curing period of the specimens.

6) Falling head permeability test to the bentonite-sheet

Before purchasing the bentonite-sheet used for the trial construction, the detail of the testing method to evaluate the permeability coefficient at the factory shall be grasped, and the suitable permeability tests to reproduce the permeability coefficient of bentonite-sheet shall be examined.

7) Conditions of trial compaction test

i) Compaction machine: 11t vibratory roller
ii) Layer's thickness: 4 cases (15cm x 3 layers, 20cm x 2 layers, 25cm x 2 layers and 30cm x 2 layers)
iii) Passing times: 4 cases (4 vibration+2 non-vibration, 6 viv.+2 non-vib., 8 viv.+2 non-vib. and 10 viv.+2 non-vib.)

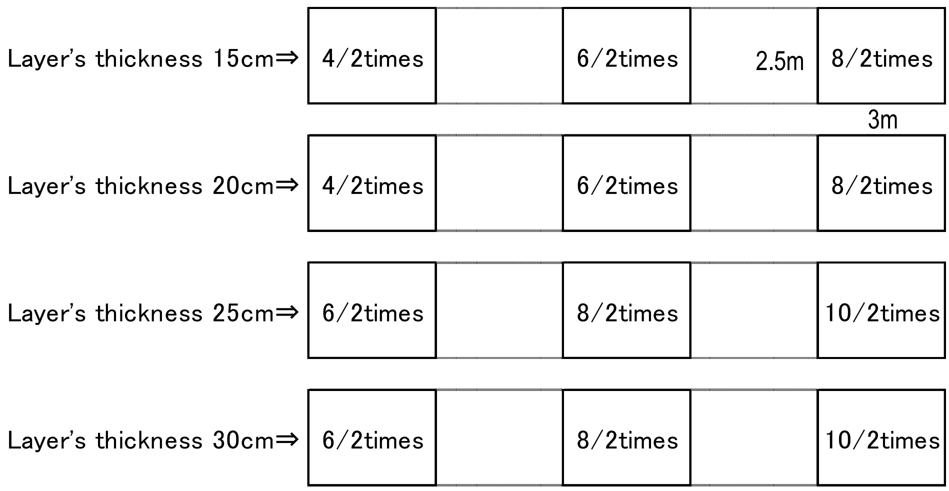


Figure-C Condition of Trial Compaction (Layer Thickness and Passing Times)

vi) Curing: 2 kinds (Soil covering curing and Sprinkle curing)

8) Process and manner of the testing

i) The trial compaction work must be carried out considering the material's property of soil-cement of which compacted density tends to be influenced by the time passage after mixing and of which permeability coefficient might be influenced much by drying due to sunshine and wind on the way of works.

ii) Immediately after the completion of the layers being compacted, soil covering and water spraying shall be provided to the layer's surface.

iii) In 7 days of curing and in 28 days of curing, sampling shall be conducted by using a core-cutter from the compacted soil-cement layer. In the laboratory, Density Test, Falling Head Permeability Test and Unaxial Compression Test shall be conducted in this order to the samples. The target of sampling is collected from both basement and covering layers.

9) Evaluation of the test result

Permeability coefficient of soil-cement shall be n x 10^{-7}cm/sec - n x 10^{-8} cm/sec.

(3) Abbreviated Initial Pounding Test (3 sites)

1) Objective

The objective is to confirm the efficiency and effectiveness of the “Compacted soil-cement layers with a sandwiched bentonite-sheet method” by constructing a considerable size of three (3) ponds.

2) Process and manner of the testing

i) The surface of ponds shall be finished by the shape arrangement work and the compaction work.

ii) On to this surface, spreading and compaction of the basement layer of soil-cement, laying work of bentonite-sheet and spreading and compaction of the covering layer of soil-cement shall be carried out in this order. The compaction work to the soil-cement layer shall be done in the manner decided through the trial compaction.

iii) Curing works selected by trial compaction test shall be provided in a short time after compaction.

vi) Joint shall be settled for each 40m at the bottom. Elastite is assumed as material to fill the joint.

v) In 28 days of curing, sampling shall be conducted by using a core-cutter from the compacted soil-cement layer. In the laboratory, Density Test, Falling Head Permeability Test and Unconfined Compression Test shall be conducted in this order to the samples. The number of sampling point shall be one (1) point per 600 m2 of the soil-cement surface; and three (3) kinds of sample shall be taken out from the one sampling point as follows;

First: from the upper layer,
Second: the portion containing bentonite-sheet,
Third: from the lower layer.

vi) After finishing the sampling, the holes drilled by the core-cutter shall be buried and restored by the bentonite powder and soil-cement compaction.

vii) Water shall be led from the Arzumi-Shamiran canal and stored in the pond. The water depth in the pond shall be recorded by the water pressure meter automatically; and the evaporation depth shall be also recorded in parallel. This situation shall be kept for two months or more.

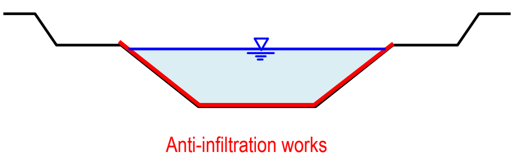
viii) In two (2) months or more, the water in the pond shall be drained and the surface of the soil-cement layer shall be exposed to sunshine to observe whether cracks appear or not on the surface.

3) Evaluation of the construction result

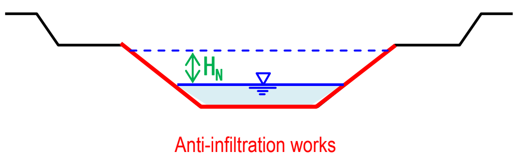
- Permeability coefficient of soil-cement shall be n x 10^{-7}cm/sec - n x 10^{-8} cm/sec.
- Permeability coefficient of anti-infiltration work shall be lower than the sufficientt one.

<u>A measure to evaluate permeability coefficient of anti-infiltration works</u>

(1) Just after pounding



(2) After N days



$$Q_N = A_{H/2} \times (H_N - E_N) = k\frac{h_{H/2}}{b} \times P_{H/2} \times N \times 864$$

$$k = \frac{A_{H/2} \times (H_N - E_N)}{\frac{h_{H/2}}{b} \times P_{H/2} \times N \times 864}$$

Where;

Q_N : Leakage volume within N days (m^3)
$A_{H/2}$: Water surface area at the level with H/2 below from original (m^2)
H_N : Water level lowering depth within N days (m)
E_N : Evaporation within N days (m)
k : Permeability coefficient of anti-infiltration works (cm/sec)
$h_{H/2}$: Average water depth at the level with H/2 below from original (m)
b : Thickness of anti-infiltration works (m)
$P_{H/2}$: Wetted perimeter at the level with H/2 below from original ((m^2)

(c) Measures in case leakage volume is more than allowable one during operation stage

Even if all the counter measures are conducted, risks cannot be cleared away completely. Therefore maintenance under precondition, there is still possibility of leakage more than allowable one, is required.

i) Measures to detect abnormal leakage volume

Measures in Table 6-5-4.9 can be considered as measures to detect abnormal leakage volume, however nothing can detect correct leakage volume.

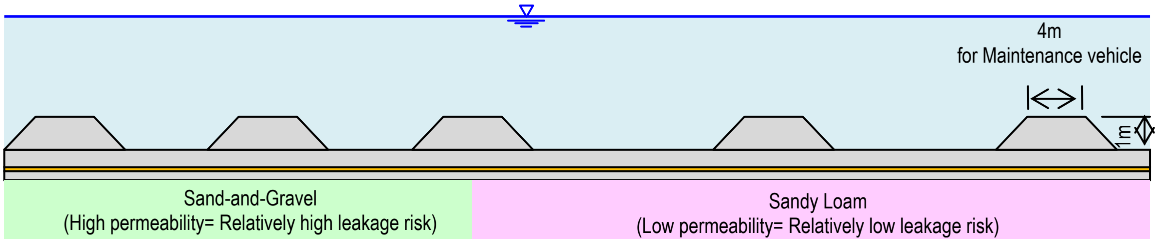
Table 6-5-4.10 Measures to Detect Leakage Volume

Measure	Evaluation
To observe fluctuation of water pressure at the back side of anti-infiltration works by pore pressure meter	It is difficult to observe fluctuation of water pressure due to un-saturation condition at the backside of anti-infiltration works.
To observe fluctuation of ground water level by monitoring wells	The fluctuation of ground water level is assumed as very little and sometimes it is difficult to judge that fluctuation is caused by leakage from reservoir or the other factors such as water from hill side, leakage from canal and so on.
To calculate leakage volume by the gap of discharge volume and fluctuation of reservoir water level	The computational error is considered as huge since reservoir volume of each elevation is very huge, fluctuation of reservoir water level is affected by evaporation and water level value observed by sensor includes margin.

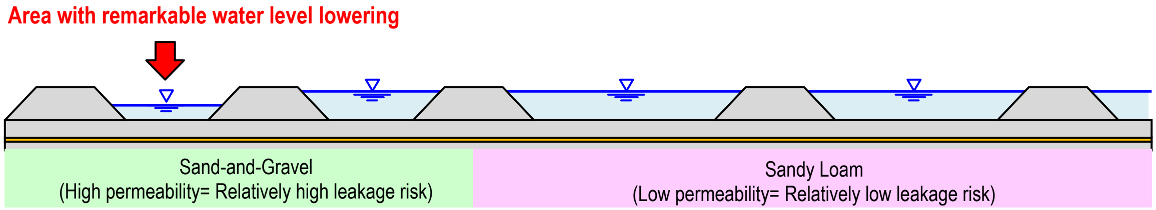
ii) Measures to detect the area of abnormal leakage and its reason

It is difficult to identify the location of abnormal leakage immediately due to wide anti-infiltration works area approx. 550ha. Therefore the following maintenance, to identify the area having relatively huge leakage and repair one after another, is recommended.

I) Division of anti-infiltration works area into small blocks by soil-cement small dike with height 1m
The area of block with sand-and-gravel basement (leakage risk is relatively high) is smaller than that with sandy loam (leakage risk is relatively low).



II) Identification of area with remarkable water level lowering after irrigation season



III) Division of remarkable water lowering area into smaller area (if necessary)

V) Field survey to grasp the reason of leakage and implementation of measures to decrease leakage according to the reason.

6-5-5 Anti-infiltration Works to the Dam Body

The anti-infiltration works to the dam body shall be given as the usual 'core zone' based on the following reasons.

To apply the soil-cement with a sandwiched bentonite sheet to the anti-infiltration work of the dam body would be more effective and economical than to apply the usual core zone. It would be able to say that the soil-cement with a sandwiched bentonite sheet is thin, keen to effectiveness and economical; on the other hand, the usual core zone is thick, dull to effectiveness and less economical; the problem is which is better under the consideration of safety.

The usual core zone is better even considering its disadvantage in economy; 'thin, keen to effective' is fragile once damaged, on the other hand 'thick, dull in effectiveness' is tough against damage or sustainable under a critical condition. And also it would be said that the anti-infiltration work by "core zone" is more reliable than the one by "soil-cement with a sandwiched bentonite sheet" when considering that Armenia is an earthquake country and that there is rare construction experience of concrete face rock-file dams in earthquake countries.

The dam body with the inclined core zone shall be designed in following sections.

6-5-6 Basic Design of the Dams and the Reservoir

(1) Slope protection

The slopes of the reservoir shall be protected against the erosive wave action caused by wind and also against the freezing/thawing effect in the winter season. In this section, the study shall be done in the order of the estimation of wind velocity/direction, the wave height, the requested weight of protection materials, the protection thickness against the freezing/thawing effect, and the selection of protection works and their application plan.

(a) Estimation of wind velocity/direction

1) Interview in the field

The results of the interview about wind velocity/direction to three farmers/villagers in the reservoir/town are as follows.

<u>In what month does the strong wind blow?</u>

Table 6-5-6.1 Answer to the Windy Month

Person	Month	Person	Month
Fa.-1	Oct. ~ Nov.	Vi.-1	Mar. Jun. Aug.
Fa.-2	Oct. ~ Nov.	Vi.-2	Nov.
Fa.-3	Sep. ~ Nov.	Vi.-3	Apr. May Jun. Jul.

<u>How strong is it?</u>

Table 6-5-6.2 Answer to the Wind Velocity

Wind-force class by Beaufort

Wind-force Class	Wind Name	Wind Condition/Appearance	Wind Velocity (m/sec)	Interview					
				Fa.-1	Fa.-2	Fa.-3	Vi.-1	Vi.-2	Vi.-3
0	calm	Smoke rises up streight form the chimney.	0.0～0.2						
1	light air	Wind is recognized by the smoke rising up sidling but the vane does not move.	0.3～1.5						
2	light breeze	Wind is felt on the man's face. Leaves move. The vane begins to move.	1.6～3.3						
3	gentle breeze	Leaves and thin twigs keep moving. Banners move.	3.4～5.5						
4	moderate breeze	Fugitive dust appears. Scrip rises up. Twigs move.	5.5～7.9						
5	fresh breeze	Shrub with leaves begin to move. Water surfaces of ponds have wave crests.	8.0～10.7	○	○	○	○	○	○
6	strong breeze	Big branches of trees move. Wind howls around electric cables. Hard to keep an umbrella open.	10.7～13.8						
7	near gale	Trees sway from the top to the foot. Hard to walk against the wind.	13.9～17.1						
8	gale	Twigs break off. Not able to walk against the wind.	17.2～20.7						
9	strong gale	Some of houses get damaged. Chimeys get broken and roof tiles are blown off.	20.8～24.4						
10	storm	Trees fall down by the root. Many houses get strongly damaged.	24.5～28.4						
11	violent storm	Environments, natural or artificial, are distroyed widely. Occurrence is rare.	28.5～32.7						
12	hurricane		>32.8						

Wind velocity ; mean wind velocity at the height of 10m above the ground.

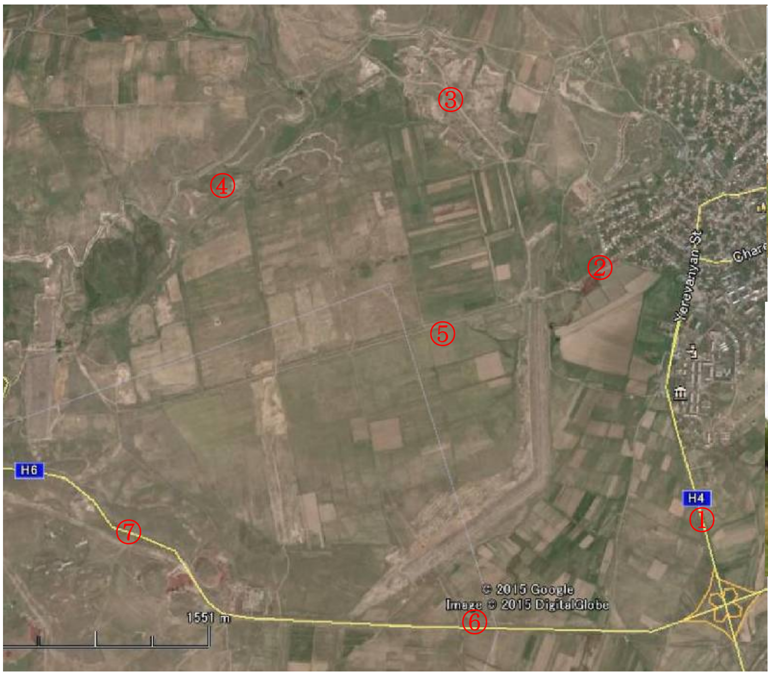
<u>From what direction does the strong wind blow?</u>

Table 6-5-6.3 Answer to the Wind Direction

Person	Direction	Person	Direction
Fa.-1	North	Vi.-1	North
Fa.-2	North	Vi.-2	North
Fa.-3	North	Vi.-3	North

2) Field survey of trees' inclination

The trees' trunks shall be inclined or bent to some direction due to the wind blown from a constant direction. With such expectation, the field survey was carried out; and as a result, the predominance of north or north-east in wind direction was confirmed.



①North→→→South

②South West←←←North East

③ South←←←North

④ South←←←North

⑤ North East→→→South west

⑥ South West←←←North East

⑦ South←←←North

Figure 6-5-6.1 Survey Result to the Tree Trunk's Inclination

3) Observation record in Yeghvard Weather Station

Figure 6-5-6.2 Yeghvard Weather Station, Location and Equipment

Table 6-5-6.4 Maximum Wind Velocity (m/sec)

	1	2	3	4	5	6	7	8	9	10	11	12	Year
1998	3	3	5	5	4	6	6	5	7	6	3	4	7
1999	3	5	7	10	5	8	7	5	5	4	7	2	10
2000	5	3	8	4	4	6	5	7	5	6	3	4	8
2001	8	7	8	8	7	10	11	10	10	7	8	8	11
2008	-	-	-	-	-	-	-	14	12	7	7	6	14
2009	7	8	11	14	10	11	16	14	13	8	10	6	16
2010	7	11	13	12	16	10	12	12	18	6	6	8	18
2011	5	12	11	12	10	15	13	13	13	9	12	6	15
2012	8	8	9	10	11	15	15	16	14	10	11	9	16
2013	13	6	11	10	11	12	15	15	15	11	10	9	15
2014	6	11	14	14	13	12	13	15	17	11	7	6	17

Table 6-5-6.5 Repeatability of Wind Direction and Calmness/Tranquility

Month	North	North east	East	South east	South	South west	West	North west	Tranquility
I	6	48	11	3	15	6	9	2	40
II	6	49	9	3	15	7	9	2	37
III	5	53	9	3	14	7	7	2	28
IV	5	48	7	3	17	10	8	2	23
V	5	53	7	2	15	9	7	2	22
VI	6	63	5	2	11	6	5	2	16
VII	6	73	4	1	7	4	4	1	11
VIII	6	71	4	1	9	5	3	1	11
IX	5	63	4	2	13	7	5	1	19
X	5	55	6	3	16	8	6	1	31
XI	6	47	9	3	17	9	7	2	38
XII	7	45	11	4	15	7	9	2	42
Year	6	56	7	2	14	7	6	2	27

4) Estimation of the wind velocity and the wind direction

More weight shall be given to the observation record than to the farmers'/villagers' feelings. Twenty meter per second (20 m/sec) of the maximum wind velocity shall be suitable to be adopted when considering the maximum value in recent observation records is 18 m/sec and the shortness of the observation period due to some years of missing data.

In terms of the wind direction, it would be able to consider the strong wind to blow down from north or north-east based on the inhabitant's opinion, the direction of tree trunks' inclination and the superiority in the observation record of weather station though it would be recommendable to grasp the relationship between the strong wind and the wind direction by the direct observation in future.

(b) Estimation of the wave height and the rock's weight as the slope protection work

1) Estimation of the wave height

The height of the significant wave is estimated by S.M.B. method based on the wind velocity and the blow-over distance. The wind velocity 20m/sec and the blow-over distance 3.7 km (from the north-eastern end to the south-western end of the reservoir) give the point of wave height 0.85 m.

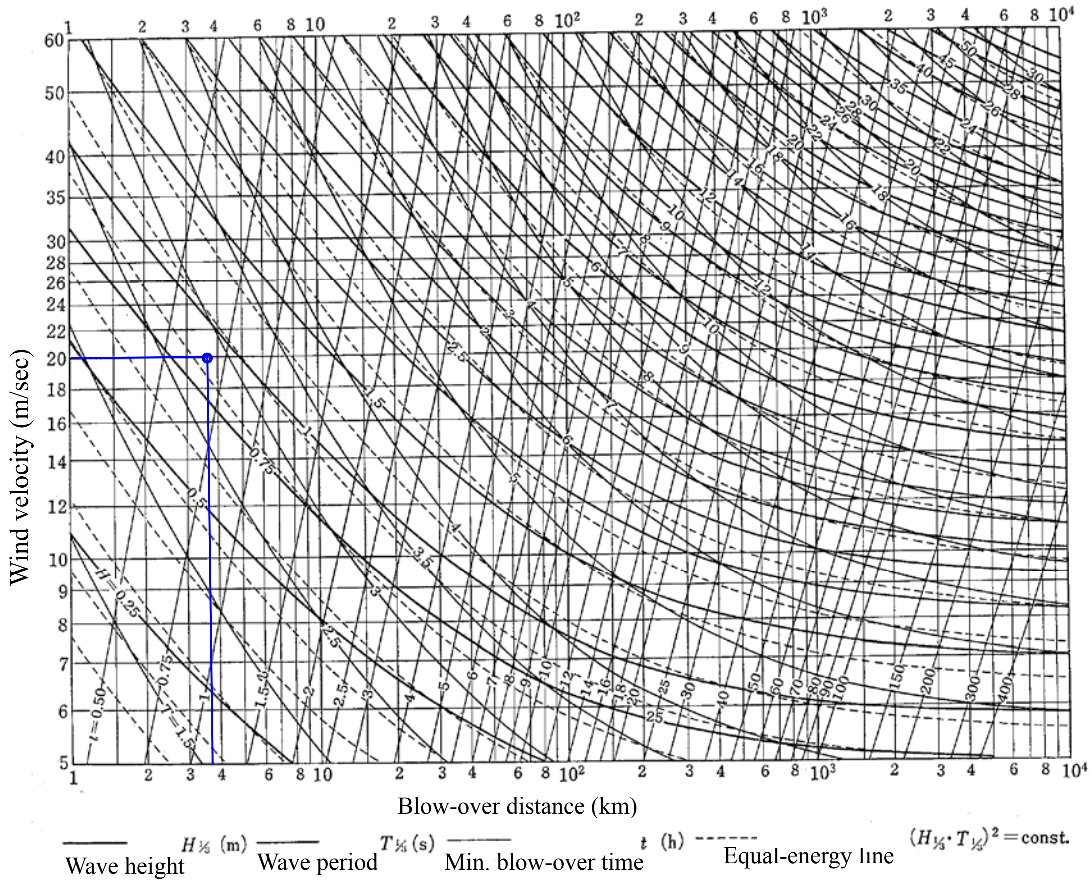


Figure 6-5-6.3 Estimation of the Significant Wave Height by SMB Method

2) Estimation of the rock's weight as the slope protection work

The rock's weight needed as the slope protection work is estimated by the Hudson's formula shown bellow.

$$W = \frac{w_r \bullet H_{1/3}^3}{K_D \bullet \left({w_r}/{w_0} - 1 \right)^3 \cot\alpha}$$

Here, W; Rock's weight (tf)

w_r; unit weight of the rock (tf/m^3)・・・・wr=2.3 tf/m^3(bulk specific gravity)

$H_{1/3}$; significant wave height ・・・・・$H_{1/3}$=0.85 m

w_0; unit weight of water (tf/m^3)・・・・・w_0=1.0 tf/m^3

α; angle between the slope surface and the horizontal line・・・cotα=3.5

K_D; coefficient to the damage percentage

Table 6-5-6.6 K_D Values to the Damage Percentage

Damage percentage	K_D
0～1 %	3.2
1～5 %	5.1
5～15 %	7.2
10～20 %	9.5
15～40 %	12.8
30～60 %	15.9

(by Hudson, 3 layers of slightly rounded rocks)

Table 6-5-6.7 Basis Installation Depth

The maximum depth of soil freezing		
NN	Name of station	The maximum depth, cm
1	2	3
1	Artashat	59
2	Aparan	106
3	Amasia	104
4	Ashtarak	74
5	Artik	110
6	Armavir	70
7	Aragats	77
8	Bazarchai	70
9	Berd	14
10	Verin ghukasyan	125
11	Garni	59
12	Garnahovit	109
13	Gyumri	143
14	Goris	36
15	Dilidjan	63
16	Jajur	123
17	Yerevan	60
18	Yeghvard	79
19	Yeghegnadzor	81
20	Ijevan	35
21	Qarakert	82
22	Krasnoselsk	91
23	Vanadzor	84
24	Tashir	71
25	Gavar	108
26	Kapan	14
27	Lermontov	73
28	Maralik	91
29	Martuni	116
30	Meghri	12
31	Hrazdan	96
32	Hanqavan	88
33	Spitak	103
34	Stepanavan	58
35	Sevan	114
36	Sisian	92
37	Fontan	87
38	Tsakhkadzor	115
39	Tsakhkahovit	115
40	Ararat	41
41	Odzun	42

The rock's weight to the wave height $H_{1/3}$=0.85 m and the damage percentage 0～1 % (K_D=3.2) becomes 0.057 tf/m^3 as follows.

$$W = \frac{2.3 \bullet 0.85^3}{3.2 \bullet \left({2.3}/{1.0} - 1 \right)^3 \bullet 3.5} = 0.057$$

When reckoning the rock to be sphere, the grain diameter is about 40 cm as follows.

$$(4/3) \times 3.14 \times r^3 \times 2.3 = 0.057$$

$$2r = 0.36 \fallingdotseq 0.40 \text{ m}$$

(c) Protection thickness against the freezing/thawing effect

1) Thickness required for the protection coverage

The compacted soil layer shall be loosened by the repetitive action of the freezing and thawing and lose its resisting strength against shearing force so that this soil layer shall be covered by the suitable materials with the function of mitigating the conveyance of low temperature such as sand-and-gravels.

In Armenia, there is the standard in terms of the thickness of cover layer to protect the pipe from being frozen. According to this standard, 79 cm of thickness is adopted in Yeghvard area. This thickness, 80 cm rounded out from 79 cm, shall be applied also to the protection coverage over the compacted soil layer on the slopes of the reservoir and the dam body.

2) Material for the protection coverage

Sand-and-gravels that lie on the slopes north-side to the reservoir shall be suitable based on the following points.

- Sand-and-gravels have the function of mitigating the conveyance of low temperature due to the existence of void air.
- The frost heaving phenomenon seldom occurs in sand-and-gravel layers.
- Even if the frost heaving phenomenon occurs, the internal friction angle of sand-and-gravels does not decrease less than its repose angle; and the repose angles of sand-and-gravels are confirmed to range from 33 degree to 41 degree in the field survey to the existing embankments.

And also, Scoria shall be suitable as a part of the protection coverage in case of Scoria being used as the buffer material between the anti-infiltration work and the slope protection work.

(d) Examination of the slope protection works and their application plan (Construction Norms Ⅳ-10.01.01-2006)

1) Candidate of the slope protection works

Rock rip rap

The rock rip rap is most common as the protection work to the upstream slope of the dam body. In this reservoir's case, this protection work shall be composed of lava rocks with the grain size of the passing percentage 50% larger than 40 cm and shall have the layer thickness of 80 cm.

And moreover, the rock rip rap shall be bedded by the 50 cm thick sand-and-gravel layer, i.e. 30 cm from 80 cm in total of the rock rip rap is assumed to be effective against freezing/thawing effect, as the anti-freezing buffer in case of the slope being provided with the soil layer of anti-infiltration work. If the impermeable liner such as the rubber sheet is provided with as the anti-infiltration work to the slope, the thickness of sand-and-gravel shall be 30 cm as the buffer material between the sheet and the rock rip rap.

Figure 6-5-6.4 Example of Rock Rip Rap

Soil-cement protection

The slope protection works by soil-cement are highly regarded in USA recently based on their performances to the big floods from 1983 to 2005 on the Santa Cruz and Rillito Rivers in Tucson, Arizona, etc. In these floods, the slope protection works by soil-cement only survived in spite of many other protection works were damaged hard or lost. (Refer to "Performance of Flood-tested Soil-cement Protected Levees, by Kenneth D. Hansen etc., 31st US Society on Dams (USSD) Conference)

6. Flow in Santa Cruz River north of Congress St. Bridge,

Figure 6-5-6.5 Flow in Santa Cruz River north of Congress St.Bridge, 1n 1993

In terms of the weathering durability of soil-cement, the performance of the US Bureau of Reclamation (USBR) soil-cement test section in the Bonny Reservoir built in 1951 provides a positive example of the one exposed long to the wave action and an average of 140 freeze-thaw cycles per year as shown in Figure 6-5-6.6.

[Extraction from the literature above]

As shown in Figure 15, taken in 2008, there has been some breakage of soil-cement layers due to poor bond between the individual 6-inch thick soil-cement layers. The lower portion of the lifts were thus subject to wave erosion due to lower cement content at the bottom of the layers that is typical of the in-place mixing method together with lower density in this area due to the compaction method.

Based on the long-term performance of exposed soil-cement constructed with adequate cement content at Bonny Reservoir and other projects subjected to freeze-thaw cycles, a small amount of deterioration may be expected. This is usually at the outer edges of layers where lower density occurs due to lack of restraint of the edge when compacted. Once this minor loose material is washed away, the soil-cement is sound and has shown very fine weathering durability.

Figure 6-5-6.6 Soil-cement Slope Protection

And the test results of freezing/thawing test, slaking test and sodium sulfate soundness test conducted in this Survey indicate high durability of soil-cement against weathering (refer to Chapter 4-3-5 (3)).

An advantage of the slope protection work by soil-cement is that this can function not only as the protection against wave erosive actions but also as the protection coverage against the freezing/thawing effect. 45 cm in thickness shall be given to this protection work from the view point of the weight needed to wave actions and 35 cm thick buffer/filter layer shall be provided with between the upper protection and the lower anti-infiltration work; then total thickness of 80 cm functions against the freezing/thawing effect.

Cobble-gravel rip rap

The area of hilly slopes north-side to the reservoir produces sand-and-gravels from which cobble-and-gravels for the rip rap use shall be obtained through screening. An advantage of this material is that the layer can function not only as the protection against wave actions but also as the coverage against the freezing/thawing effect. In addition, the construction easiness of the materials being spread and compacted layer by layer on the slope surface is also a big advantage.

Figure 6-5-6.7 Example of Cobble-Gravel Rip Rap

But this type of protection work is applicable only to the north and the east slopes where wave actions are little because the grain size/weight of cobbles is not enough to stand wave actions on the slopes on the lee.

2) Selection of slope protection works and their application plan

Table 6-5-6.8 Selection of Slope Protection Works and their Application Plan

Slope / Protection work	Dam No.1		Dam No.2		North slope		South slope	
	Wave action hard	Freezing-thawing	Wave action not hard	Freezing-thawing	Wave action not hard	Freezing-thawing	Wave action hard	Freezing-thawing
Rock rip rap	work	not work	work	not work	work	not work	work	not work
Cobble-gravel rip rap	not work	work	work	work	work	work	not work	work
Soil-cement	work	work	work	work	work	work	work	work
Adoption	Soil-cement		Cobble-gravel rip rap (due to economy)		Cobble-gravel rip rap (due to economy)		Soil-cement	

- convergence of wind direction⇒hard wave action to Dam No.1 & south slopes
- rock rip rap⇒work against hard wave action, not work against freezing-thawing due to large void
- cobble-gravel rip rap⇒not work against hard wave action, work against freezing-thawing
- soil-cement⇒work against hard wave action and freezing-thawing
- economy; Cobble-gravel rip rap < Soil-cement < rock rip rap (refer to Table 6-5.6.9~ 6-5.6.11)
  (4.5 US\$/m^2) (8.6 US\$/m^2) (9.8 US\$/m^2)

Table 6-5-6.9 Cost Estimation of Cobble-gravel Rip Rap (per 1,000 m^2 of Construction)

No.	BOQ	Normative base	Description of works	Measurement unit	Quantity	Unit price AM drams		Unit price of works, AM drams	Overall sum, AM drams
						Salary AM drams	Machinery operations AM drams		
1	1.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3	0.0472		57,070	57,070	2,694
2	1.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3	0.0472		252,739	252,739	11,929
3	1.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.0472	6,362	157,948	164,310	7,755
4	1.3	**C310-1-1**	Transportation of soil up to 1 km	ton	40		734	734	29,438
5	2.1	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.566	9,720	240,917	250,637	141,861
6	2.2	**C310-1-1**	Transportation of soil up to 1 km	ton	283		734	734	207,653
7	2.3	**331430**	Work of sieving machine	machine/ hour	6.90		4,757	4,757	32,817
8	2.4	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.3	9,720	240,917	250,637	75,191
9	2.5	**C310-2-1**	Transportation of clay-sandy soil up to 2 km	ton	585		897	897	524,637
10	2.6+2.7	**E36-5**	Construction of upper part of the dam core and screen, any soils except rocks, Compactor capacity-heavy	1000m3	0.3	33,186	337,257	370,442	111,133
11	3.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3			57,070	57,070	
12	3.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3			252,739	252,739	
13	3.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3		6,362	157,948	164,310	
14	3.3	**C310-1-1**	Transportation of soil up to 1 km	ton			734	734	
15	4.1	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.5	9,720	240,917	250,637	125,319
16	4.2	**C310-1-1**	Transportation of soil up to 1 km	ton	975		734	734	715,413
17	4.3		Work of sieving machine	machine/ hour			4,757	4,757	
18	4.4	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3		9,720	240,917	250,637	
19	4.5	**C310-2-1**	Transportation of clay-sandy soil up to 2 km	ton			897	897	
20	4.6+4.7	**E36-5**	Construction of upper part of the dam core and screen, any soils except rocks, Compactor capacity-heavy	1000m3	0.5	33,186	337,257	370,442	185,221
			Total						**2,171,061**
									4,511 US$

Table 6-5-6.10 Cost Estimation of Soil-cement Coverage (per 1,000 m² of Construction)

No.	BOQ	Normative base	Description of works	Measurement unit	Quantity	Unit price AM drams: Salary AM drams	Unit price AM drams: Machinery operations AM drams	Unit price AM drams: Measurement unit	Unit price AM drams: Demand for initial unit of work	Prices: Material unit price, AM drams	Prices: Overall price for initial unit of work, AM drams	Unit price of works, AM drams	Overall sum, AM drams
1	1.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3	0.0944		57,070					57,070	5,387
2	1.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3	0.0472		252,739					252,739	11,929
3	1.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.0472	6,362	157,948					164,310	7,755
4	1.3	**C310-1-1**	Transportation of soil up to 1 km	ton	40		734					734	29,438
5	2.1	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.583333	9,720	240,917					250,637	146,205
6	2.2	**C310-1-1**	Transportation of soil up to 1 km	ton	569		734					734	417,325
7	2.3	**331430**	Work of sieving machine	machine/ hour	7.11		4,757					4,757	33,822
8	2.4	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.35	9,720	240,917					250,637	87,723
9	2.5	**C310-2-1**	Transportation of clay-sandy soil up to 2 km	ton	683		897					897	612,076
10	2.6+2.7	**E36-5**	Construction of upper part of the dam core and screen, any soils except rocks, Compactor capacity-heavy	1000m3	0.35	33,186	337,257	m3	100			370,442	129,655
11	3.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3	0.0499		57,070					57,070	2,848
12	3.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3	0.0499		252,739					252,739	12,612
13	3.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.0499	6,362	157,948					164,310	8,199
14	3.3	**C310-1-1**	Transportation of soil up to 1 km	ton	42		734					734	31,122
15	4.1	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.5625	6,362	157,948					164,310	92,425
16	4.2	**C310-1-1**	Transportation of soil up to 1 km	ton	478		734					734	350,828
17	4.3	**331430**	Work of mixing machine	machine/ hour	1.91		8,787					8,787	16,806
18	4.4	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.45	6,362	157,948					164,310	73,940
19	4.5	**Market**	Cement price with transportation	ton	36			ton	1	41,667	47,542	47,542	1,711,500
20	4.7	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.45	6,362	157,948					164,310	73,940
21	4.9+4.1	**E27-5-1 x 3 layers**	Soil-Cement Mixture spreading, compacting, curing, Pabble - crushed stone - sandy fine soil, Layer thickness 150mm	100m2	10	7,364	21,605					28,969	289,687
			Total										**4,145,221**
			including										**8,613 US$**

Table 6-5-6.11 Cost Estimation of Rock Rip rap (per 1,000 m^2 of Construction)

No.	BOQ	Normative base	Description of works	Measurement unit	Quantity	Unit price AM drams: Salary AM drams	Unit price AM drams: Machinery operations AM drams	Prices of materials: Description of materials	Prices of materials: Measurement unit	Prices of materials: Demand for initial unit of work	Prices: Material unit price, AM drams	Unit price of works, AM drams	Overall sum, AM drams
1	1.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3	0.0472		57,070					57,070	2,694
2	1.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3	0.0472		252,739					252,739	11,929
3	1.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.0472	6,362	157,948					164,310	7,755
4	1.3	**C310-1-1**	Transportation of soil up to 1 km	ton	40		734					734	29,438
5	2.1	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.833	9,720	240,917					250,637	208,781
6	2.2	**C310-1-1**	Transportation of soil up to 1 km	ton	708		734					734	519,537
7	2.3	**331430**	Work of sieving machine	machine/ hour	8.85		4,757					4,757	42,106
8	2.4	**E1-1563**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil III	1000m3	0.5	9,720	240,917					250,637	125,319
9	2.5	**C310-2-1**	Transportation of clay-sandy soil up to 2 km	ton	850		897					897	762,292
10	2.6+2.7	**E36-5**	Construction of upper part of the dam core and screen, any soils except rocks, Compactor capacity-heavy	1000m3	0.5	33,186	337,257	Water	m3	100		370,442	185,221
11	3.1	**E1-1610**	Excavation by bulldozer 96Kvt or 130 hourse-power, replacing excavated soil up to 10m, soil grade I	1000m3	0.0425		57,070					57,070	2,425
12	3.1	**E1-1617**	Additional 50m replacment by bulldozer 96Kvt or 130 hourse-power, soil grade I	1000m3	0.0425		252,739					252,739	10,741
13	3.2	**E1-1561**	Excavtion by excavator on crawler, bucket capacity 2,5 - 3m3, loading excavated soil to dump track, grade of soil I	1000m3	0.0425	6,362	157,948					164,310	6,983
14	3.3	**C310-1-1**	Transportation of soil up to 1 km	ton	37		734					734	27,287
15	4.1	**E3-106**	Loosening of V grade soil by blasting with blasthole charges using rotary-percussion drilling machin, hummer dimameter 105mm	$100m^3$	2	9,229	37,775	Drilling crowns	item	0.09	3,120	99,322	158,915
16	4.2	**60234+140551**	Hydro-Hummer work , which is attached to excavator	machine/ hour	0.48		17,312					17,312	8,310
17	4.3	**E1-1541**	Excavtion by excavator on crawler or wheeled, bucket capacity 0,8-1m3, dumping excavated soil a side, grade of soil V	1000m3	0.8	12,783	560,917					573,700	458,960
18	4.4	**C310-5-1**	Transportation of clay-sandy soil up to 5 km	ton	1,440		1,359					1,359	1,956,686
19	4.5	**E38-1**	Rockfill in dam body, Thickness of layer under 1m	1000m3	0.8	13,235	225,454	Water	m3	300		238,689	190,951
			Total										**4,716,331**
													9,800 US$

(2) Dam crest protection

The dam crest shall be protected against the freezing and thawing effect and also against the damage caused by the wheel load or friction of vehicles.

In Armenia, in the area around Yerevan, roofs of residential houses are made of concrete with a 25 cm thick heat-insulating layer of coarse Scoria between the outer slab and the inner slab. According to this manner, a 25 cm thick Scoria layer shall be provided to the crest as the protection against the freezing and thawing effect.

Over this Scoria layer, 30 cm thick sand-and-gravel layer shall be provided as the protection against the vehicles' wheels. This sand-and-gravel layer shall have the supplemental effect to the heat-insulating function of the Scoria layer.

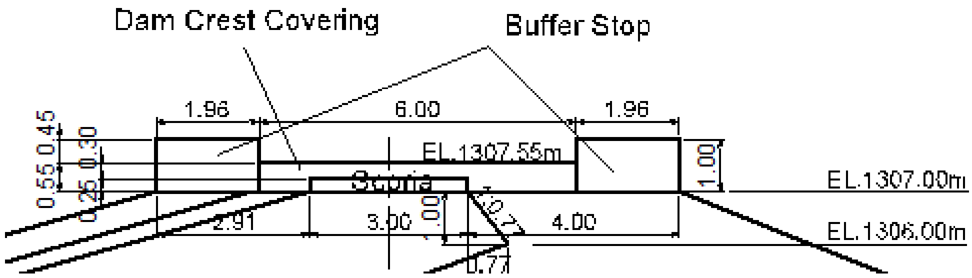


Figure 6-5-6.8 Illustration of the Dam Crest Protection

(3) Freeboard elevation of the dam body

(a) Applied standard and the calculation formula

The freeboard elevation of the dam body is given by the following formula.

$$H_{fr}=H_f+h_w+h_c+1 \text{ (in case of } h_w+h_c<1.0,\ H_{fr}=H_f+2.0)$$

Here, H_{fr}; Freeboard elevation of the dam body
H_f ; Full water surface elevation in the reservoir・・・H_f=E.L. 1,305.0 m (Reservoir plan)
h_w ; Height of wave run-up
h_c ; Height of wave caused by an earthquake

* The reservoir is not provided with a spillway so that the freeboard elevation is decided to the full water surface.

(b) Height of wave run-up

The calculation formula of wave run-up is shown by Van der Meer and Janssen in their work "Wave run-up and wave overtopping at dikes, 1995" as follows.

General formula ; $R_{u2\%}/H_{1/3}=1.6\gamma_b\gamma_f\gamma_\beta\xi_{op}$

$\xi_{op}=\tan\alpha/(s_{op})^{1/2}$

To the rock slopes ; for $\xi_{op}<1.5$・・・$R_{u2\%}/H_{1/3}=0.88\xi_{op}$

for $\xi_{op}>1.5$・・・$R_{u2\%}/H_{1/3}=1.1(\xi_{op})^{0.46}$

Here,

$R_{u2\%}$; Wave run-up
$H_{1/3}$; significant wave height (H$_{1/3}$ =0.85, from the examination of slope protection)
ξ_{op} ; breaker parameter
γ_b ; reduction factor for a berm (in case of straight slope, γ_b=1.0)
γ_f ; reduction factor for slope roughness (in case of smooth slope, γ_f =1.0)
γ_β; reduction factor for oblique wave attack (in case of perpendicular wave, γ_β=1.0)
α ; slope angle (now, tanα=1/3.5)
s_{op} ; wave steepness (on the slope gentler than 1/3, wave breaks. At the moment of wave breaking, wave steepness s_{op} is 1/7.)

Then, in case of smooth slope ; $\xi_{op}=\tan\alpha/(s_{op})^{1/2}=(1/3.5)/(1/7)^{1/2}=0.76$

$$R_{u2\%}=1.6\gamma_b\gamma_f\gamma_\beta\xi_{op}\, H_{1/3}=1.6\times1.0\times1.0\times1.0\times0.76\times0.85=1.03 \text{ m}$$

in case of rock slopes ; $R_{u2\%}=0.88\xi_{op}\, H_{1/3}=0.88\times0.76\times0.85=0.57$ m

(c) Wave height caused by an earthquake

The calculation formula of wave height caused by an earthquake is shown below.

$$h_c=\frac{1}{2}\bullet\frac{k\bullet\tau}{\pi}\bullet\sqrt{g\bullet H_0}$$

Here, h_c ; wave height caused by earthquake (m)
k ; earthquake coefficient (now, k=0.12)
τ; seismic wave cycle (usually τ=1.0 second is applied)
H_0 ; water depth in the reservoir at the time of full water level (H_0=16 m)
g ; acceleration of gravity (g=9.8 m/s^2)

Then, $h_c=\frac{1}{2}\bullet\frac{k\bullet\tau}{\pi}\bullet\sqrt{g\bullet H_0}=\frac{1}{2}\bullet\frac{0.12\bullet1.0}{3.14}\bullet\sqrt{9.8\bullet16.0}$ =0.24 m

(d) Freeboard elevation of the dam body

In case of smooth slopes ; $h_w+h_c=1.03+0.24=1.27>1.0$

$H_{fr}=H_f+h_w+h_c+1$=E.L.1,305.0+1.03+0.24+1=EL.1,307.27 m

In case of rock slopes ; $h_w+h_c=0.57+0.24=0.81<1.0$

$H_{fr}=H_f+2.0$= E.L.1,305.00+2.0=E.L.1,307.00 m

[Dam-No.1]

The soil-cement slope protection is applied to the upstream slope of Dam No.1. The upper portion beyond the full water level shall be constructed layer by layer spread horizontally considering the slope to be provided with steps, the surface of the slope protection not to become smooth and maintenance workers not to slip down into the reservoir. Then, the elevation E.L.1,307.00 shall be applied to the freeboard elevation here.

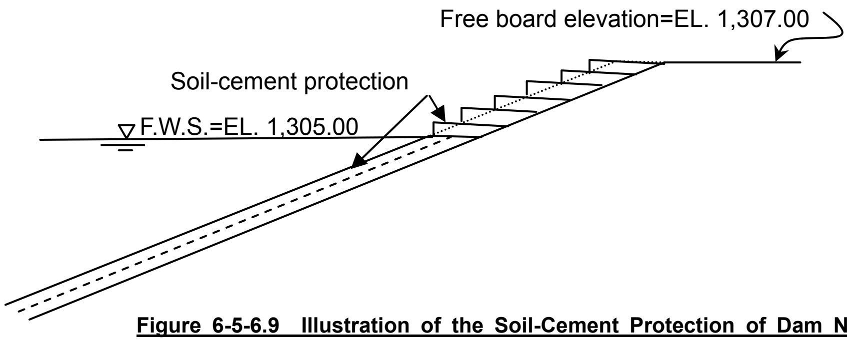


Figure 6-5-6.9 Illustration of the Soil-Cement Protection of Dam No.1

[Dam-No.2]

The cobble-gravel rip rap protection is applied to the slope of Dam No.2 which is treated as the rock slope so that the elevation E.L.1,307.00 shall be given as the freeboard elevation.

(4) Dam crest elevation

The dam crest elevation can be given by adding the dam crest protection thickness to the freeboard elevation of the dam body.

Then, Dam crest elevation = Freeboard elevation + Crest protection thickness

= E.L. 1,307.0 + 0.55
= EL. 1,307.55

(5) Typical cross-section of dams

1) Dam type and Zoning

During the Soviet era, a part of dam body (a part of Sand-and-Gravel zone) was constructed. According to the results of field surveys, these existing dam bodies have enough strength and it is judged these existing dam body can be one part of newly constructed dam bodies. Therefore, for the effective use of existing dam bodies, inclined core type is selected for both Dam No.1 and Dam No.2.

Since Dam No.1 does not have enough height, Sand-and-Gravel zone is newly constructed on existing dam body and Core zone (impervious zone) is constructed at the surface of upstream side. On the other hand, Dam No.2 has enough height then only Core zone for upstream surface is required.

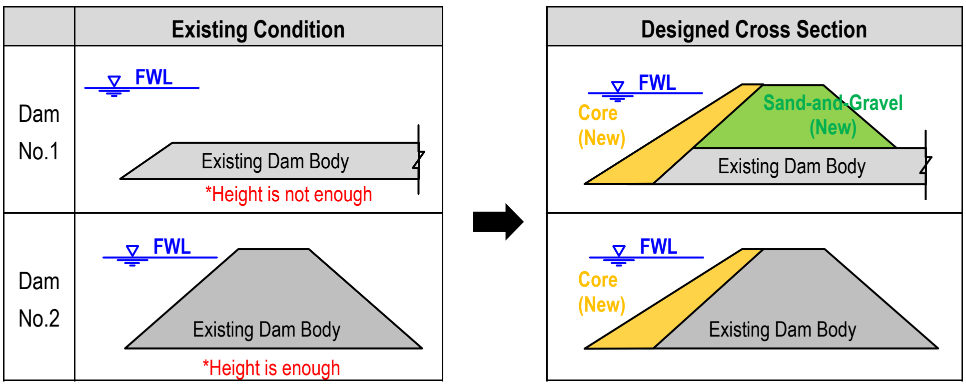


Figure 6-5-6.10 Outline of Designed Cross Section

Core zone is arranged with its minimum width more than 50% of head as shown in the Figure 6-5-6.11. Due to this condition and effective use of existing dam bodies, slope angle of upstream 1:3.5 and downstream 1:2.75 are selected.

Filter zone is arranged in front of core zone to prevent Core zone material to efflux and filter zone is protected by slope protection.

Figure 6-5-6-12 show typical cross section designed according to the conditions above.

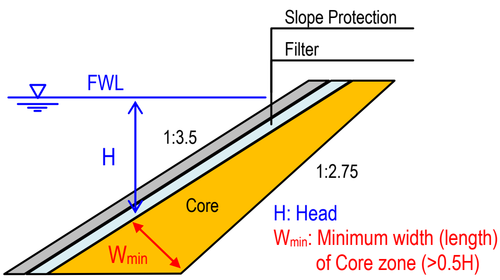


Figure 6-5-6.11 Arrangement of Core Zone

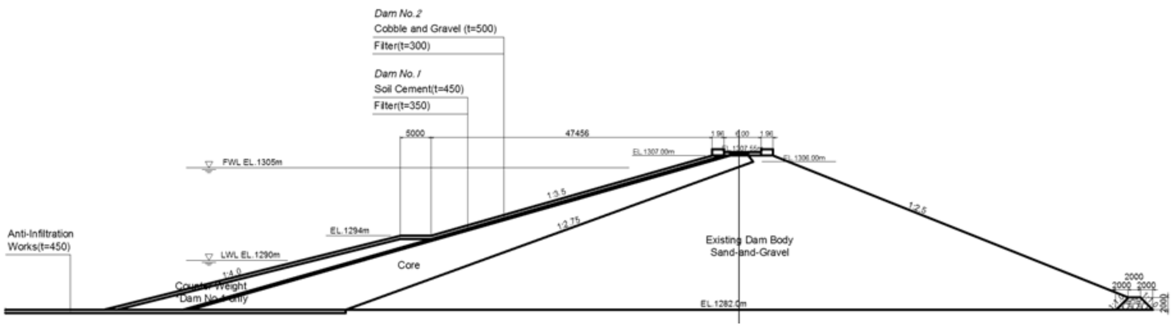


Figure 6-5-6.12 Typical Cross Section

3) Stability analysis

i) Required safety factor

Safety factor Fs is determined according to the formula below.

$$Fs = \frac{R}{\Sigma(\gamma_f F)} \geq \gamma_{lc} \times \gamma_n$$

$$(Required\ Safety\ Factor) = \gamma_{lc} \times \gamma_n = 1.0 \times 1.25 = 1.25$$

Where;

R: Bearing capacity

F: Force Factor

γ_f: Loading reliability coefficient (=1.0 in normal condition, 0.95 in earthquake condition)

γ_{lc}: Loading combination coefficient (=1.0)

γ_n: Reliability coefficient by structure(=1.25)

Table 6-5-6.12 Reliability Coefficient by Structure γn

Dam Class	I	II	III	IV
γ_n	**1.25**	1.20	1.15	1.10

Dam Classification

Criteria to determine the class of dam are shown in Table 6-4-5.13 to 6-4-5.16. and results of checking condition of Yeghvard reservoir against these criteria are shown as below. As a result, Yeghvard reservoir is classified as **Class-I.**

Criterion-1: Dam height

25.55m with rock foundation → **Class III**

Criterion-2: Social-Economic Responsibility

Dam capacity= 94 MCM → **Class III**

Irrigation area= 13,000ha → **Class IV**

Criterion-3: Protective Structures

-

Criterion-4: Consequence of possible accidents

Number of injured person -

Number of affected person -

Economic Damage -

Areas=2Marzs → **Class I**

-: Not identified in this Survey

Table 6-5-6.13 Criterion-1: Dam Height

Structure	Base Soil Type*	Class			
		I	II	III	IV
Earth Fill Dam	A	More than 80 m	From 50 to 80m	From 20 to 50m	Less than 20 m
	B	More than 65 m	From 35 to 65m	From 15 to 35m	More than 15 m
	C	More than 50 m	From 25 to 50m	From 15 to 25m	More than 15 m

*A: Rock, B: Solid or Semi-Solid sand, C: Coarse and clay

Table 6-5-6.14 Criterion-2: Social-Economic Responsibility

	Class			
	I	II	III	IV
Dam Capacity (MCM)	More than 1,000	From 200 to 1,000	From 50 to 200	Less than 50
Irrigation Area (thousands ha)	More than 300	From 100 to 300	From 50 to 100	Less than 50

Table 6-5-6.15 Criterion-3: Protective Structures

*Estimated submerge depth (m)

		Class			
		I	II	III	IV
Housing Density at Downstream Side (m^2/ha)	More than 2,500	More than 5	More than 5	More than 3	-
	From 2,100 to 2,500	More than 8	More than 8	More than 5	More than 2
	From 1,800 to 2,100	More than 10	More than 10	More than 8	More than 5
	Less than 1,800	More than 15	More than 15	More than 10	More than 8
Leisure, Health and Sanitation Structure		-	More than 15	More than 15	More than 10
Industrial organizations (MAS*/year)	More than 50	More than 5	Up to 3	Up to 2	-
	From 10 to 50	More than 8	Up to 5	Up to 3	Up to 2
	Less than 10	More than 8	Up to 8	Up to 5	Up to 3
Cultural and Natural Monuments		More than 3	Up to 3	-	-

*MAS: Minimal Amount of Salary

Table 6-5-6.16 Criterion-4: Consequences of Possible Accident

	Class			
	I	II	III	IV
Number of Inhabitants Who Will Be Injured by the Accident (persons)	More than 3,000	From 500 to 3,000	Up to 500	-
Number of Peopled Whose Living Conditions Will Be Affected by the Accident (persons)	More than 20,000	From 2,000 to 20,000	Up to 2,000	-
Possible Economic Damage (MAS*1)	More than 50	From 10 to 50	From 1 to 10	Less than 1
Areas where will be emergency situation by the accident*2	Within two or more Marzs, or territory of neighboring country	Within one Marz or two or more formations of neighboring country	Within one Marz	Within one Marz

*1: MAS: Minimal Amount of Salary

*2: The collaption of dam causes the over flow of Kasakh River for both Kotayk Marz and Aragatsotn Marz side.

ii) Analysis case

Two (2) analysis cases are selected taking into consideration of the combination of water level and PGA coefficient k shown in Table 6-5-6.17. Analysis case in case flood is not necessary because all the water flowing into reservoir is controlled one at intake point of Hrazdan river and at the inlet of feeder canals, and flood never flow into the reservoir.

Table 6-5-6.17 Analysis Cases

Case		Water Level	k	Required Safety Factor Fs
Case-1	Normal Condition with maximum scale earthquake	FWL EL.1305m	0.12	1.25
Case-2	Sudden water lowering with half sale earthquake	FWL EL.1305m ➔ LWL EL.1290m	0.06	1.25

iii) Physical Property

Physical properties utilized for stability analysis are shown in the Table 6-5-6.18 (determination of these values is described in the Appendix J).

Table 6-5-6.18 Physical Properties for Stability Analysis

Zone	Wet Density γ_t (kN/m³)	Saturated Density γ_{sat} (kN/m³)	Cohesion c (kN/m²)	Internal Friction Angle φ (Degree)
1. Core	18.99	19.19	21.40	24.30
2. Filter	19.25	20.00	0	38.00
3. Existing Dam Body*	19.30	19.97	0	38.00
4. Slope protection	22.00	22.00	0	38.00
5. Dam Crest Covering	19.30	19.97	0	33.00
6. Counter Weight	19.30	19.97	0	33.00

* Same values are applied to Sand-and-Gravel zone

iv) Results of analysis

Stability analysis is conducted by Armenian method and Japanese method, and results are shown in Table 6-5-6.19. According to the results, calculated safety factor is more than required one by Japanese method but less than in Armenian method. Also the calculated safety factor is quite different.

Table 6-5-6.19 Results of Stability Analysis (Calculated Safety Factor)

	Armenian Method				Japanese Method			
	Upstream slope		Down Stream Slope*		Upstream slope		Down Stream Slope*	
Case-1	0.85 < 1.25	NG	0.70 < 1.25	NG	1.44 > 1.25	OK	1.43 > 1.25	OK
Case-2	1.13 < 1.25	NG	-		1.26 > 1.25	OK	-	

*Sine it is clear that calculated safety factor of case-2 is more than case-1, the calculation of case-2 is omitted.

The reasons why the calculated safety factors has such difference are considered to be caused by the following two matters.

a) Increasing ratio of PGA coefficient k

In case earthquake happens, acceleration of dam crest is higher than that of bottom. Figure 6-5-6.13 shows the vertical distribution of acceleration. k is PGA coefficient and k_Y is acceleration coefficient at the point Y m below from dam crest.

Figure 6-5-6.13 shows vertical distribution of acceleration increase ratio (=k_Y/k) in this Survey and determined in Japanese standard. Additionally, distribution from the results of FEM analysis and observed data of dams in Japan are shown as references as well. Increasing ratio of Japanese standard and references at dam crest (Y=0) is 2 or 3, however the value is 5 in this Survey, calculated value according to Armenian standard. This value is almost two times of Japanese standard.

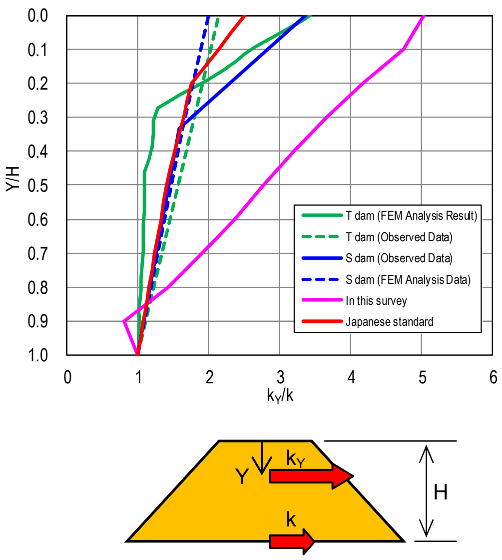


Figure 6-5-6.13 Increasing of k

In case big earthquake happens, dam body is deformed by earthquake shaking, on the other hand, dumping ratio of soil materials becomes bigger as the deformation becomes big. In this case, acceleration increasing ratio at dam crest is not so high.

It is supposed that the effect of this damping ration is not considered well in Armenian standard.

Since dams designed using this Japanese standard has no experience of collapse by earthquake, vertical distribution of acceleration increase ratio calculated by Armenian standard is expected as excessive value.

Calculation of vertical distribution of acceleration increase ratio shall be discussed in Detail Design Stage to design appropriate dam structure.

b) Evaluation of shearing strength of non-cohesive materials

There are some methods to evaluate shearing strength of non-cohesive materials. Major evaluation is shown in Table 6-5-6.20 and in Figure 6-5-6.14. Method No.2 and No.3 is based on the theory that non-cohesive material has no value of cohesion (c) and No.2 method, considering internal friction as only a factor of shearing strength, is selected in this Survey. Internal friction angle is estimated by field survey, not by laboratory tests. On the other hand, some value of c is applied for non cohesion materials in the design conducted during Soviet era.

Shearing strength under low lateral pressure σ is quite different depending on the methods especially. Therefore in Detail Design Stage, laboratory test and appropriate evaluation of shearing strength targeting non-cohesive materials shall be conducted.

Table 6-5-6.20 Major Evaluation Methods of Shearing Strength of Non-Cohesive Material

No.	Outline of Method	Formula
1	c and φ are calculated utilizing the results of laboratory test.	$\tau = c + \sigma \tan\varphi$
2	c and φ are calculated utilizing the results of laboratory test but only φ is applied as shearing strength factor.	$\tau = \sigma \tan\varphi$
3	τ is shown by an exponential function and parameter A and b is calculated utilizing the results of laboratory test	$\tau = A\sigma^{b}$

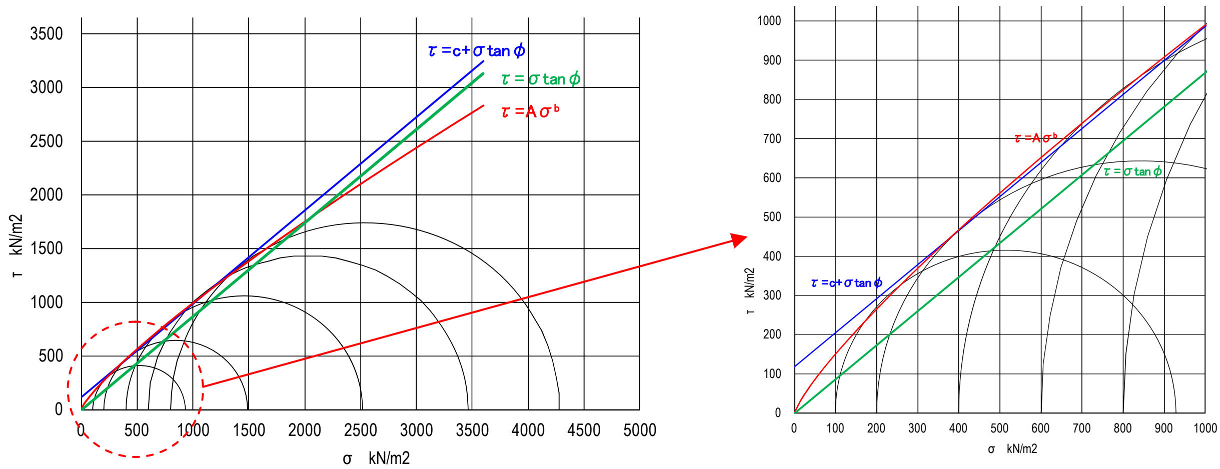


Figure 6-5-6.14 Major Evaluation Method of Shearing Strength of Non-Cohesive Material

6-5-7 Basic Design of Related Facilities (Emergency Discharge Structure)

(1) Specific condition for Yeghvard reservoir

As already described in "4-3-8 Situations Related to the Safety of Facilities," emergency discharge volume shall be examined taking into consideration Yeghvard reservoir's own situations shown as below.

a) Main emergency situation is damage on the reservoir by earthquake,
b) Destination of discharging is Kasakh Rrver,
c) Water is discharged through pile line
d) Facilities along Kasakh river will suffer from flood damage in case huge volume of water is discharged from Yeghvard reservoir and,
e) For Nor Yerznka village, water level shall be lowered as fast as possible (emergency discharge volume shall be as much as possible) to mitigate risk of dam collapse and damage in case dam collapse.

Taking into account these conditions, here sets two (2) kinds of emergency situations caused by earthquake shown as below and discharge volume is set for each condition.

Low Emergency (Low possibility of dam collapse)

[Conditions]
- Some observed parameters indicate mild abnormal tendency such as increasing of leakage volume or decreasing of water pressure regardless of the fluctuation of water level.

[Measure]
- Discharge water with its volume less than flow capacity of Kasakh River

High Emergency (High possibility of dam collapse)

[Conditions]
- Some observed parameters indicate serious abnormal tendency such as sudden increasing of leakage volume or sudden decreasing of water pressure regardless of the fluctuation of water level.
- Some deformations which indicate sliding failure of dam body such as faulting at upper area or swelling at lower area.

[Measures]
- Make alarming to Nor Yerznka village to evacuate to high land area to mitigate damage by flood caused by dam collapse
- Make alarming along Kasakh river to notice to the people to evacuate far from the river to mitigate damage by flood caused by emergency discharging
- Discharge water with maximum volume (*Along Kasakh river will be flooded.)
- Discharge water through outlet No.1 as well (*Beneficiary area covered by Arzni Branch canal will be flooded.)

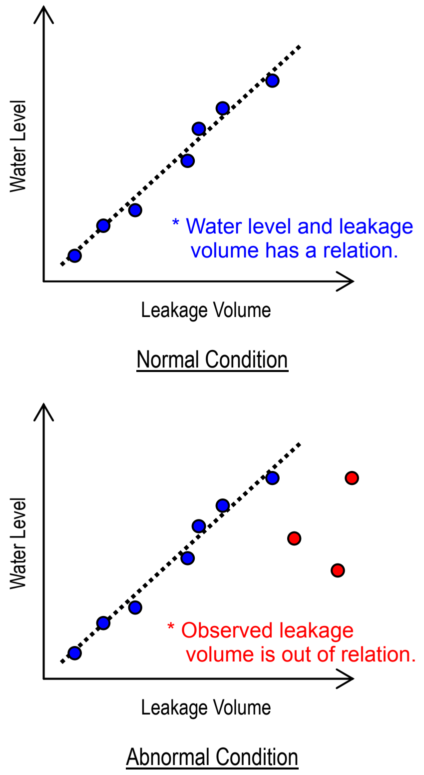


Figure 6-5-7.1 A sample of Abnormal Trend (Leakage Volume)

(2) Discharge volume under Low Emergency Condition

1) Flow capacity of Kasakh River

Interview survey targeting main facilities along Kasakh river is conducted to grasp the historical flood damage. Figure 6-5-7.2 shows the location of target facilities and Table 6-5-7.1 shows the summary of survey results.

According to the results, it is judged that maximum discharge volume at Ashtarak observation station (almost same as discharge destination point) which does not cause flood along Kasakh river is 13.7m^3/s and this value is selected as flow capacity of Kasakh river.

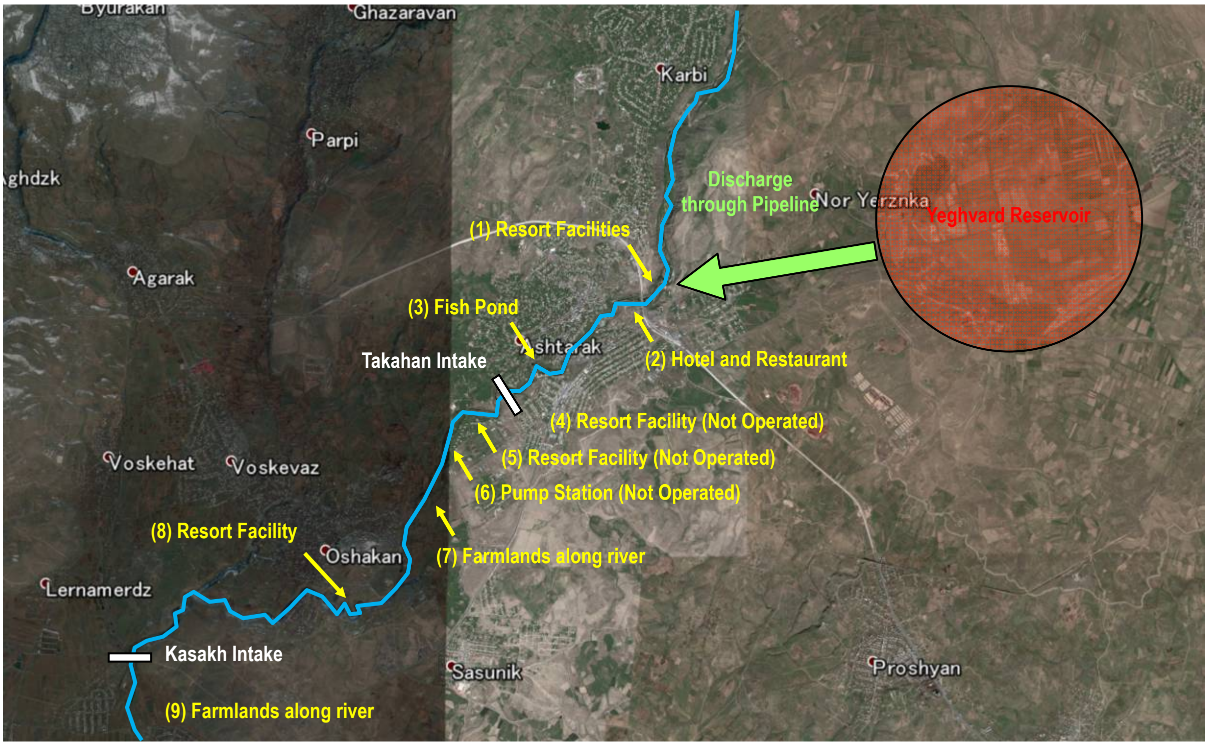


Figure 6-5-7.2 Location of Main Facilities along Kasakh River

Table 6-5-7.1 Summary of the Interview Survey Results

No.	Target Facility		Results on Interview Survey	Flow Capacity
1	Resort Facilities		- Facilities are located at relatively higher area to mitigate flood damage. - River bank protection was constructed by the fund of the owner. **The height of protection is higher than the water level which occurs as in previous years.** - Even if facilities suffer damage from flood, no compensation is provided from government. Rehabilitation of the facilities is done by the fund of the owner.	13.7m^3/s (Minimum Flood volume in the record)
2	Hotel and Restaurant		- Facilities are constructed 4 or 5 years ago. - **After construction, no flood damage has happened.** *Interview results of guard man because the owner was not there	42.2m^3/s (Minimum Flood volume for last 4 years)

No.	Target Facility		Results on Interview Survey	Flow Capacity
3	Fish Pond		- Flood damage has not happened on the facilities after interviewee started work as a guard man (started year is not sure). - Flood damage has not happened on intake facilities as well. *Interview results of guard man because the owner was not there	13.7m^3/s (Minimum Flood volume in the record)
4	Resort Facility		- Facilities are not operated and could not contact the owner. Same as the other facilities, it is assumed that **this facility has safety against flood which occurs as in previous year.**	13.7m^3/s (Minimum Flood volume in the record)
5	Resort Facility		- Facilities are not operated and could not contact the owner. Same as the other facilities, it is assumed that **this facility has safety against flood which occurs as in previous year.**	13.7m^3/s (Minimum Flood volume in the record)
6	Pump Station		- Facilities are not operated and could not contact the owner. Same as the other facilities, it is assumed that **this facility has safety against flood which occurs as in previous year.**	13.7m^3/s (Minimum Flood volume in the record)
7	Farmlands along the river		- There is a channel at the upstream edge of the farmlands to divert a part of flood so that **serious damage has not happened by the flood occurs as in previous year.** - The area damaged by flood occurs as in previous years are limited to the area just besides the river.	13.7m^3/s (Minimum Flood volume in the record)
8	Resort Facility		- Facilities are located at relatively higher area. Therefore same as the other facilities, it is assumed that **this facility has safety against flood which occurs as in previous year.** *Interview survey was not conducted.	13.7m^3/s (Minimum Flood volume in the record)
9	Farmlands along the river		- There is river bank protection along the river so that **flood damage has not happened for last 14 or 15 years.**	130m^3/s (Minimum Flood volume for last 15 years.)

*"Flood volume" means the annual maximum volume at Ashtarak observation station.

2) Discharge volume from Yeghvard reservoir

At the destination of discharging, there is a flow from upstream. Therefore the gap of volume between flow capacity of Kasakh river and flow from upstream can be discharge volume from Yeghvard reservoir Q_Y as shown in the Figure 6-5-7.3.

Q_Y varies according to the season and water level of Yeghvard reservoir varies as well. Therefore, Q_Y by water level is defined as shown in the Figure 6-5-7.4. Discharge facility is designed with capacity to discharge at least this volume at each water level.

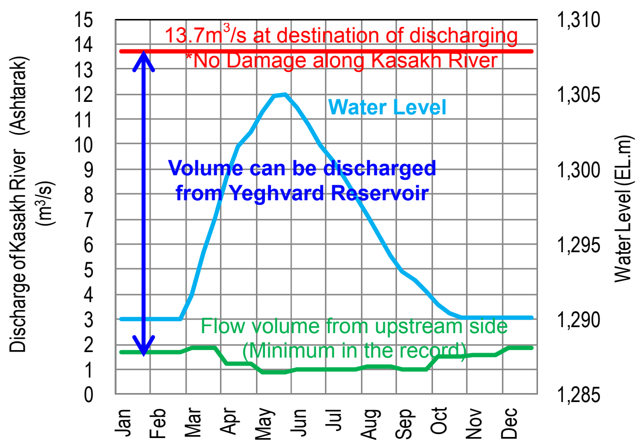


Figure 6-5-7.3 Discharge volume from Yeghvard Reservoir

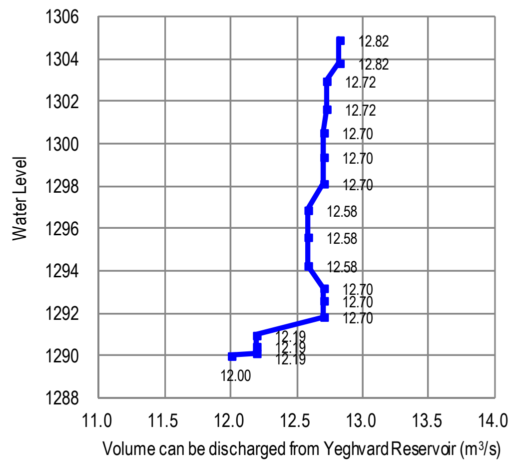


Figure 6-5-7.4 Design Condition of Emergency Discharge Facility

(3) Discharge volume under high emergency condition

In case of High Emergency Condition, discharge control valve is fully opened and maximum volume of water is discharged to lower water level as soon as possible.

The maximum discharge volume of each water level is shown in the Figure 6-5-7.5. In this case, discharge volume is more than the flow capacity of Kasakh river and areas along the river is flooded.

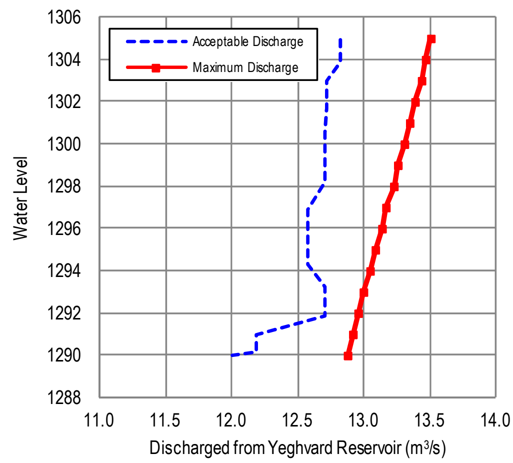


Figure 6-5-7.5 Discharge volume under High Emergency Condition (=Maximum Discharge Volume)

Also it takes about 80 days to lower the water level from FWL to LWL. There are some standards prescribing days to empty the reservoir or velocity of water level lowering in the other countries' standard, such as i) Empty reservoir within 10 days or ii) Lower water level with velocity 1m/day (Kaps applies this prescribing). For a dam constructed crossing river, downstream side will not be flooded even if stored water is discharged according to the prescribing above because downstream side is developed with safety capacity against flood and this flood volume is bigger than emergency discharge amount. However as already described, Yeghvard reservoir is constructed closing plane area by two (2) dam bodies and destination of discharging is Kasakh river, condition is quite different from general dams. If prescribing for emergency discharge above is applied to Yeghvard reservoir, scale of discharge facility becomes very huge and development of downstream side of discharging destination is needed. In this case huge amount of construction cost is required. Therefore it is judged that just to apply other countries' prescribing is not appropriate for Yeghvard reservoir and original regulation shall be defined.

(4) Operation plan of emergency discharge

Table 6-5-7.2 shows tentative operation procedure of emergency discharge after earthquake and concerning matters in each step. The detail examination, especially threshold to conduct each activity, will be conducted during Detail Design stage.

Table 6-5-7.2 Operation Procedure of Emergency Discharging (Tentative)

		Activity	Concerning matter	Necessary items
1	Happening of Earthquake	- Confirm scale of earthquake by data observed by devises	-	- Seismometer
2	Data collection	- Collect observed data, such as leakage volume and water pressure - Check if observed data shows abnormal trend	-	- Leakage measurement structure - Water pressure devise - Water level gauge - System to compile observed data
3	Patrolling	- Patrol and check the condition of structures _Dam body_ Sliding failure, deformation, cracks _Concrete structure_ Cracks _Boundary of concrete and soil structure_ Leakage _Gate_ Deformation of gate, shaft, door stop	-	- Patrol vehicle(s)
4-1	Data is normal and there are no strange event	- To continue normal operation	-	-
4-2	Trend of data or condition of structure is judged as Low emergency condition	- Discharge to Kasakh River with volume less than flow capacity of Kasakh River	Total discharge volume from Yeghvard Reservoir and upstream shall be less than flow capacity of Kasakh River (13.7m^3)	- Data transfer system from Ashtarak station to operation system
4-3	Trend of data or condition of structure is judged as High emergency condition	1) Alarming to Nor Yerznka village to evacuate to higher area (to mitigate damage in case dam collapse) 2) Alarming to the area along Kasakh River to evacuate far from river (to mitigate damage by flood caused by emergency discharge) 3) Discharge to Kasakh River with volume less than flow capacity of Kasakh River 4) Confirm all the persons in and around Khasakh River evacuate 5) Open discharge control valve fully and discharge maximum volume	3) Total discharge volume from Yeghvard Reservoir and upstream shall be less than flow capacity of Kasakh River (13.7m^3)	- Data transfer system from Ashtarak station to operation system - Alarming system to Nor Yerznka village - Alarming system to the area along Kasakh River - Evacuation plan for Nor Yerznka village and areas along Kasakh River

6-5-8 Safety Facilities of the Dams and the Reservoir

(1) Safety control of the dams and the reservoir

(a) Safety control of the dams

In fill-type dam's case, it is the standard to monitor the leakage quantity from the dam body, deformation of the dam body and the seepage condition in the dam body as the safety control of the dam.

As for the leakage from the dam body, a measurement system composed of a channel and a weir shall be installed at the toe of the downstream of dam body slope to Dam No.1 and Dam No.2.

As for the deformation monitoring, a deformation survey network and survey facilities for checking deformation after an earthquake shall be introduced to the whole area of downstream/upstream slope and the dam crest to Dam No.1 and Dam No.2.

As for the seepage condition, it is usual to install the wells for observing seepage water table to grasp the seepage condition as ”a seepage line”. But in case of Dam No.1 and Dam No.2, the impervious zone is provided with as an inclined core zone the width of which is narrow and most of which lay under water beneath the upstream slope so that it is difficult to install the observation wells and get the accurate data regarding the seepage water table. Considering such points, pore pressure gauges shall be installed in place of the observation wells.

(b) Safety control of the reservoir

For the reservoir of which slopes are completely covered by anti-infiltration works, backpressure behind the anti-infiltration works is crucial to keep the storage function of the reservoir in normal because the excess backpressure can easily destroy the anti-infiltration works due to its light weight. Some tens of pore pressure gauges shall be installed to check and monitor the backpressure condition and to grasp the occurrence of abnormal conditions.

(2) Monitoring of leakage from the reservoir

Monitoring of the leakage by the observation wells shall be done in the long span of time and area. The disadvantage of pore pressure gauges is mortality due to the measurement system being maintained by electricity. Monitoring system by wells shall not function as the keen system to catch the abnormal condition quickly but function effectively to catch the change of condition in the long span of time. Several to about ten observation wells about 30m deep shall be installed around the reservoir except for the four (4) deep observation wells already installed in this preliminary survey stage.

(3) Safety facilities for the maintenance works and the visitors

(a) Safety facilities to the maintenance work

The maintenance or surveillance work shall be executed by vehicles. To avoid vehicles dropping accidentally from the dam crest, a row of safety barricade by placed rocks shall be installed at along the edge of the dam crest.

(b) Safety facilities for the visitors

Parks for the recreation activities of inhabitants shall be constructed, where circumstances and facilities for the visitors to enjoy the water safely shall be prepared and arranged.

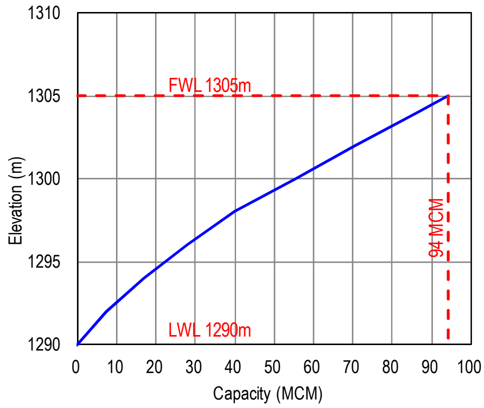
6-6 Drawings

6-6-1 Specification of Facilities

Table 6-6-1.1 Specification of Reservoir and Dams

Item		Specification			
Reservoir		Catchment Area		-*1	km^2
		Reservoir area		8.08	km^2
		Reservoir Capacity		94	MCM
		HWL		EL. -	m
		FWL		EL. 1,305.00	m
		LWL		EL. 1,290.00	m
Dams	Dam No.1	Type		Inclined core type	
		Height		25.55	m
		Crest Length		1,140	m
		Volume*2		923,000	m^3
		Elevation	Crest	EL. 1,307.55	
			Top of Core zone	EL. 1,307.00	m
		Slope Angle	Upstream	1:3.50	
			Downstream	1:2.50	
	Dam No.2	Type		Inclined core type	
		Height		14.05	m
		Crest Length		2,610	m
		Volume*2		394,000	m^3
		Elevation	Crest	EL. 1,307.55	
			Top of Core zone	EL. 1,307.00	
		Slope Angle	Upstream	1:3.50	
			Downstream	1:2.50	
Spillway*3		Nil			

Capacity Curve (H-V curve)



*1: Since all the water is supplied from Hrazdan River through Arzni-Shamiram Canal, reservoir does not have own catchment area.

*2: Volume newly constructed in this project (not including existing dam volume)

*3: Since all the water is supplied after controlled its volume by Hrazdan Intake and inlet of Feeder Canals and flood water does not flow into reservoir, spillway is not required.

Table 6-6-1.2 Specification of Irrigation Facilities

Name of Facilities		Purpose	Type	Specification				Target Discharge
Feeder Canals	Feeder Canal 1	Inflow to Reservoir	Pipeline	Diameter	φ=	1.60(1.6km), 1.72(1.94km))	m	1.11* - 9.00 m^3/s *) Except Arzni-branch 0.39m^3/s
				Length	L=	4.70=1.16(approach canal)+ 3.54(pipe)	km	
	Feeder Canal 2	Inflow to Reservoir	Open Canal	Width	B=	ave. 4.00	m	2.20 - 13.00 m^3/s
				Length	L=	0.33	km	
Outlet Canals	Outlet Canal 1	Outflow to Yeghvard WUA	Pipeline	Diameter	φ=	1.20	m	0.22 - 2.33 m^3/s
				Length	L=	0.73	km	
	Outlet Canal 2	Outflow to Kasakh River	Pipeline and canal	Diameter	φ=	1.72	m	0.16 - 12.82 m^3/s (for irrigation purpose) Maximum 13.7m^3/s (in case of emergency)
				Length	L=	4.70(pipe)+0.5(dissipater)	km	

6-6-2 Drawings of Reservoir Plan

Figure 6-6-2.1 General Plan of the Project

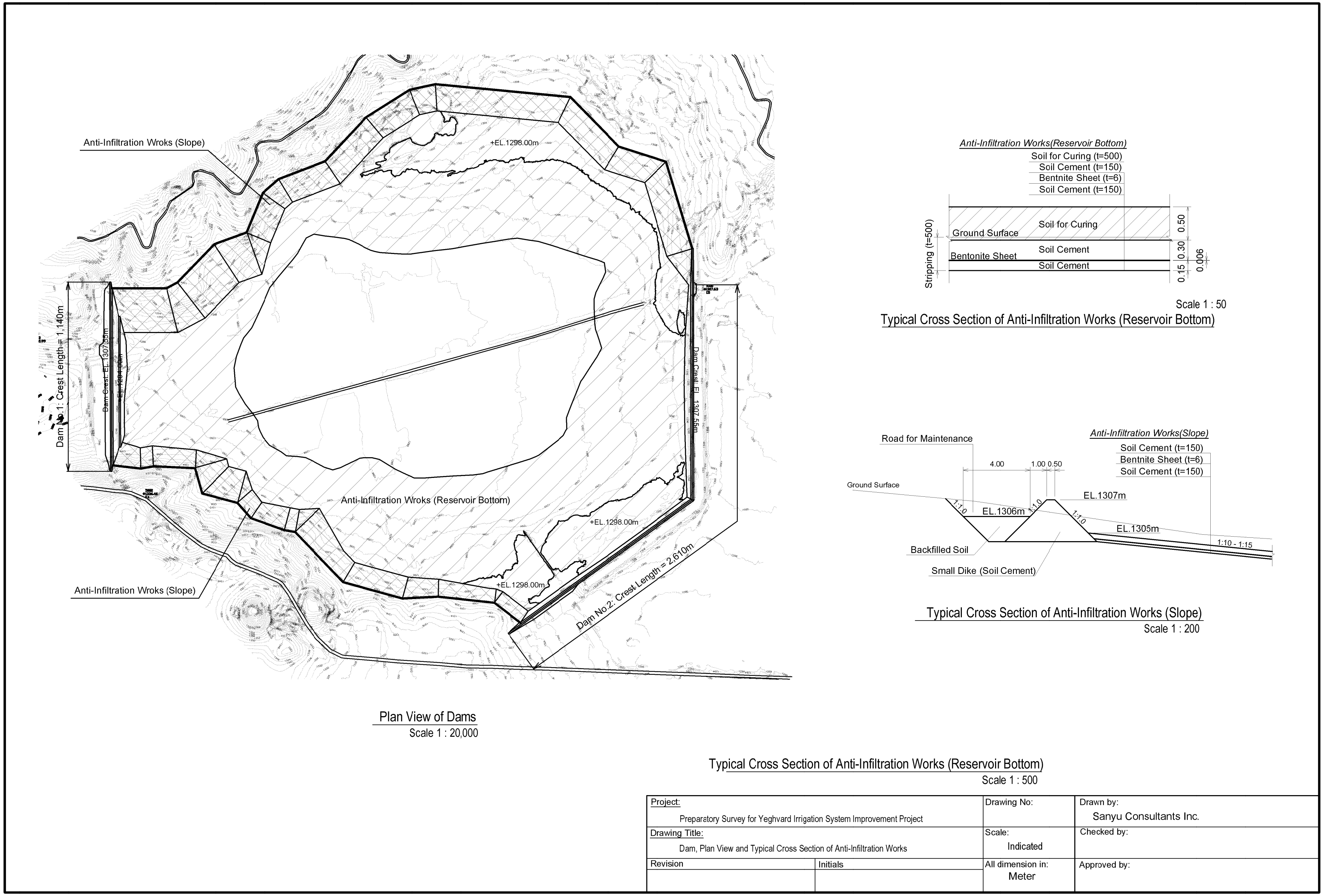


Figure 6-6-2.2 Plan View of Dams and Typical Cross Section of Anti-Infiltration Works

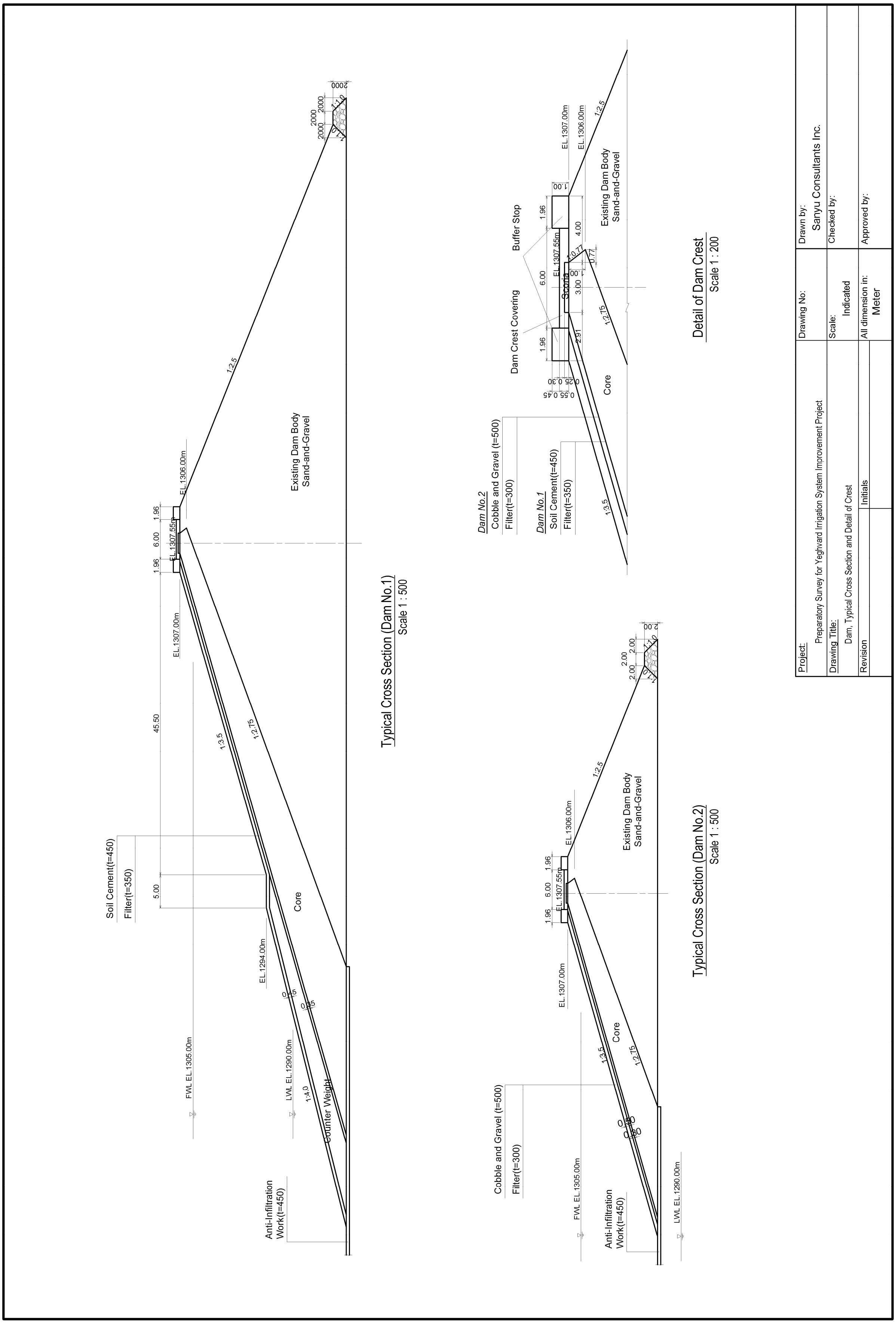


Figure 6-6-2.3 Typical Cross Section of Dams and Detail of Dam Crest

6-6-3 Drawings of Irrigation Plan

(1) Feeder canal 1 and outlet canal 1

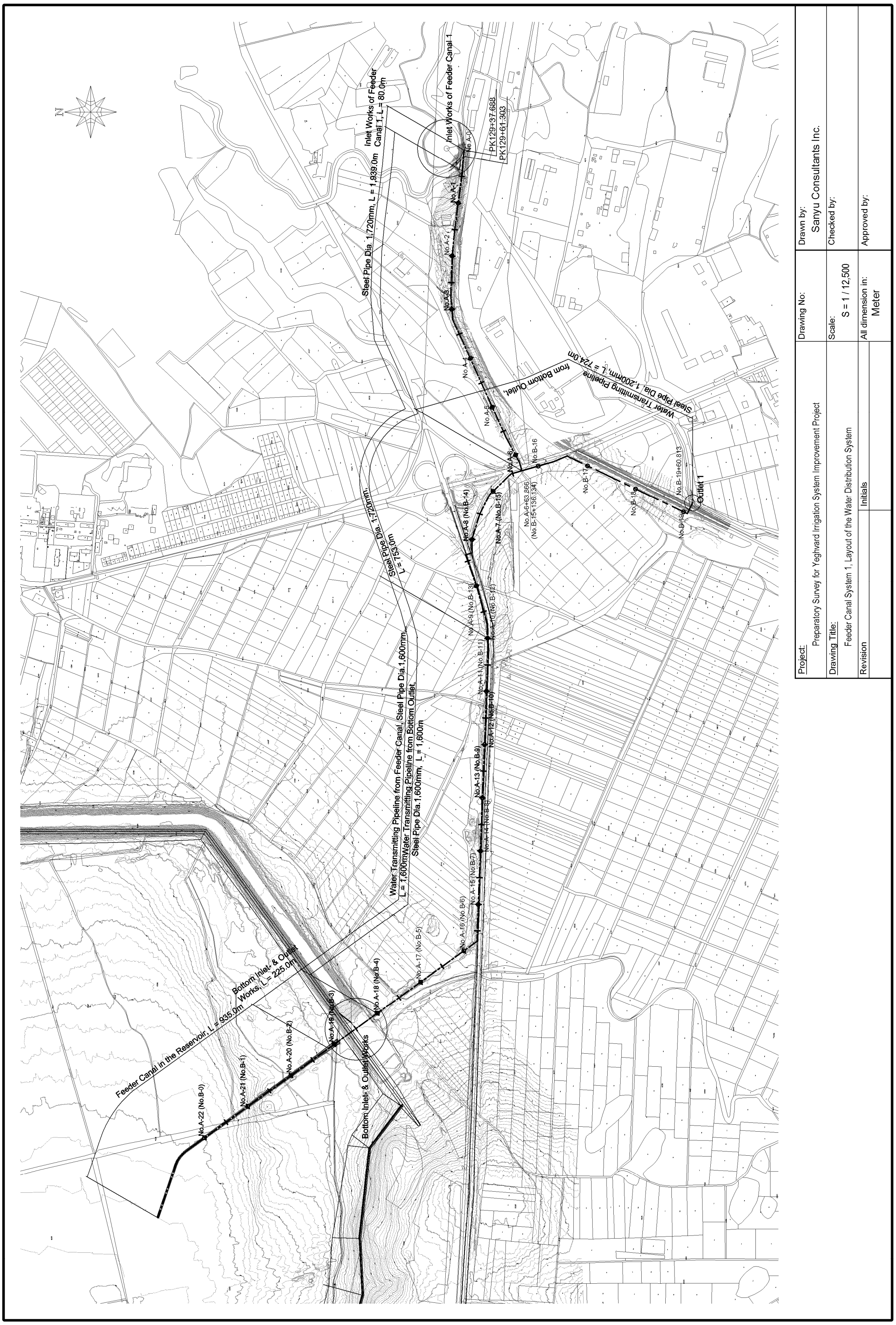
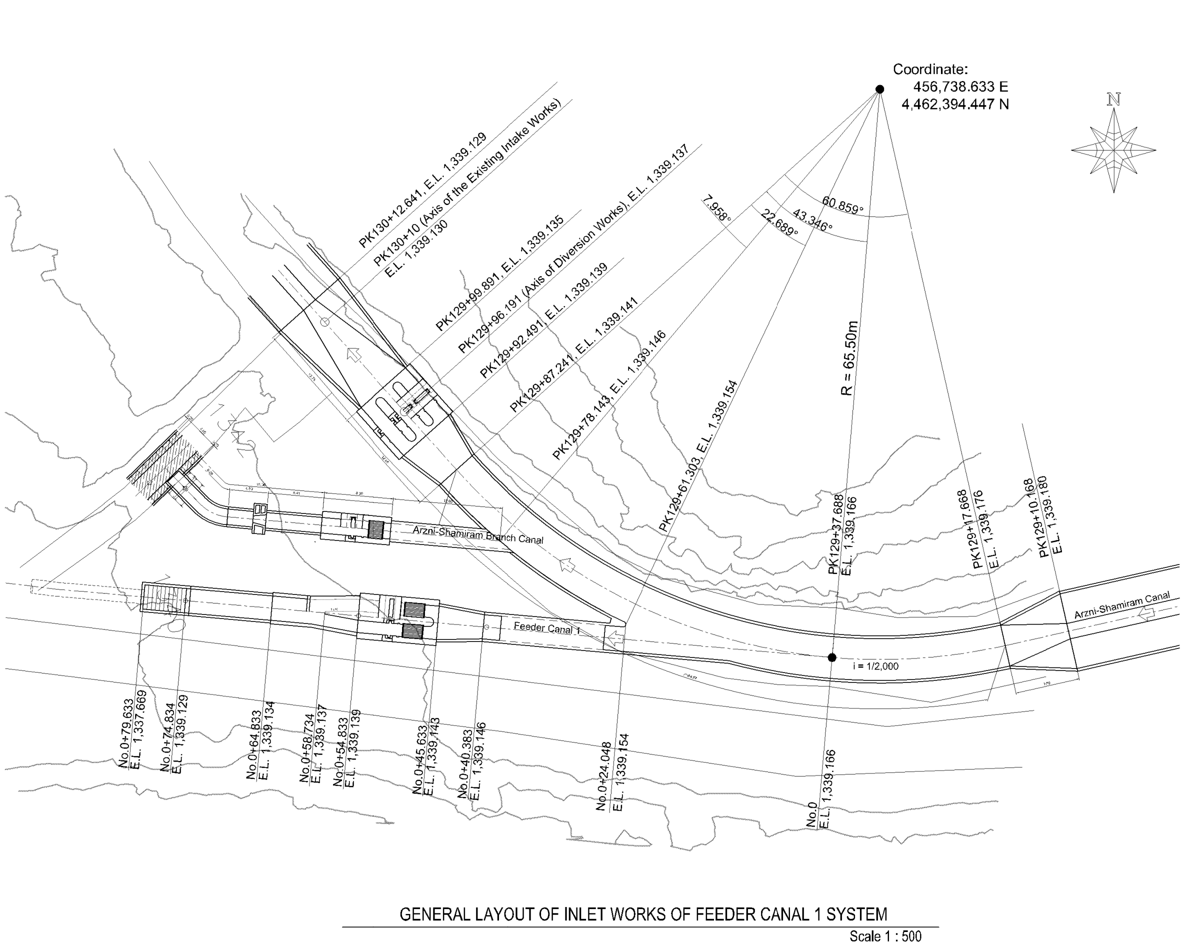


Figure 6-6-3.1 Layout of the Water Distribution System



Water Distribution Plan for Feeder Canal 1 System

		A. S. Canal ~PK130	Diversion Works			A. S. Canal PK130 ~
			Feeder Canal 1	Canal to A. Branch	Total Discharge	
		(1)	(2)	(3)	(4) = (2) + (3)	(5) = (1) - (4)
Mar	1st	7.00	7.00	0.00	7.00	0.00
	2nd	15.50	9.00	0.00	9.00	6.50
	3rd	14.40	9.00	0.00	9.00	5.40
Apr	1st	22.00	9.00	0.00	9.00	13.00
	2nd	19.20	8.72	0.28	9.00	10.20
	3rd	11.20	7.84	1.16	9.00	2.20
May	1st	18.50	7.67	1.33	9.00	9.50
	2nd	15.40	8.00	1.00	9.00	6.40
	3rd	5.50	1.11	0.39	1.50	4.00

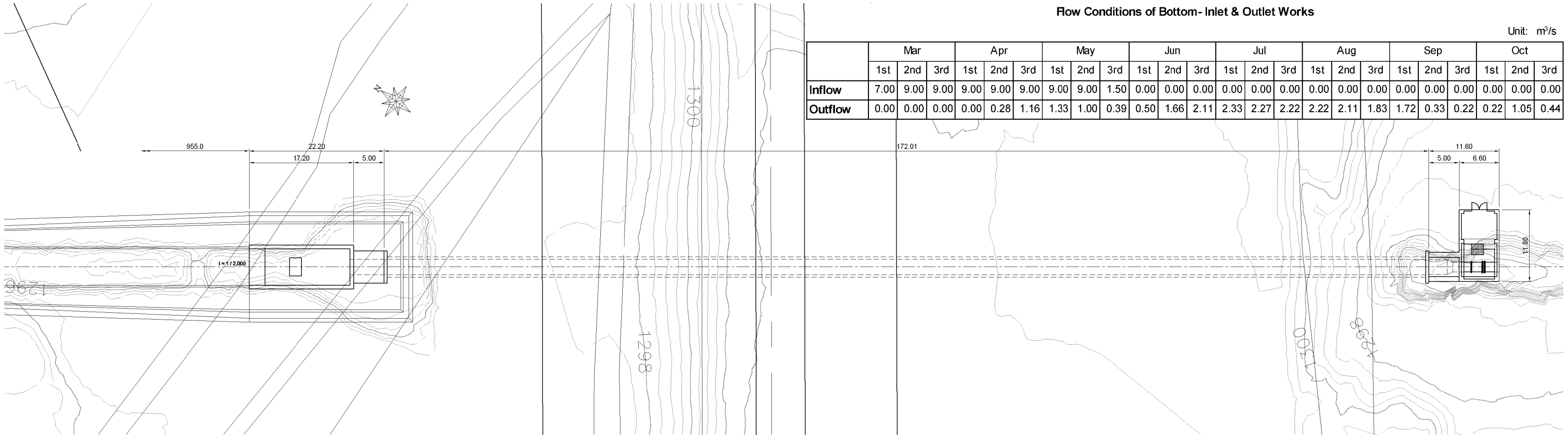
Project: Preparatory Survey for Yeghvard Irrigation System Improvement Project		Drawing No:	Drawn by: Sanyu Consultants Inc.
Drawing Title: Feeder Canal System 1, General Layout of Inlet Works		Scale: Indicated	Checked by:
Revision	Initials	All dimension in: Meter	Approved by:

Figure 6-6-3.2 Layout of Inlet Works

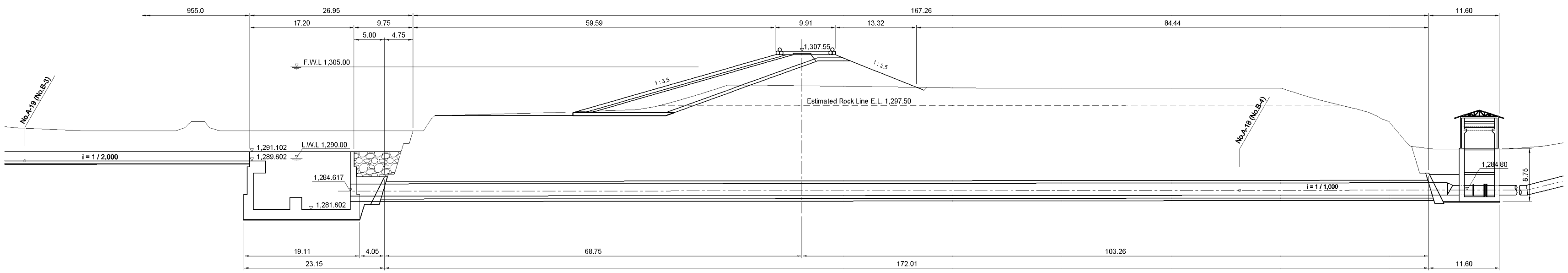
Flow Conditions of Bottom- Inlet & Outlet Works

Unit: m^3/s

	Mar			Apr			May			Jun			Jul			Aug			Sep			Oct		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Inflow	7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outflow	0.00	0.00	0.00	0.00	0.28	1.16	1.33	1.00	0.39	0.50	1.66	2.11	2.33	2.27	2.22	2.22	2.11	1.83	1.72	0.33	0.22	0.22	1.05	0.44



PLAN VIEW
Free Scale



SECTION
Free Scale

Project: Preparatory Survey for Yeghvard Irrigation System Improvement Project	Drawing No:	Drawn by: Sanyu Consultants Inc.
Drawing Title: Feeder Canal System 1, Bottom Inlet- and Outlet- Works under the Dike No.2	Scale: Free Scale	Checked by:
Revision / Initials	All dimension in: Meter	Approved by:

Figure 6-6-3.3 Bottom Inlet and Outlet Works under Dam No.2

(2) Feeder canal 2

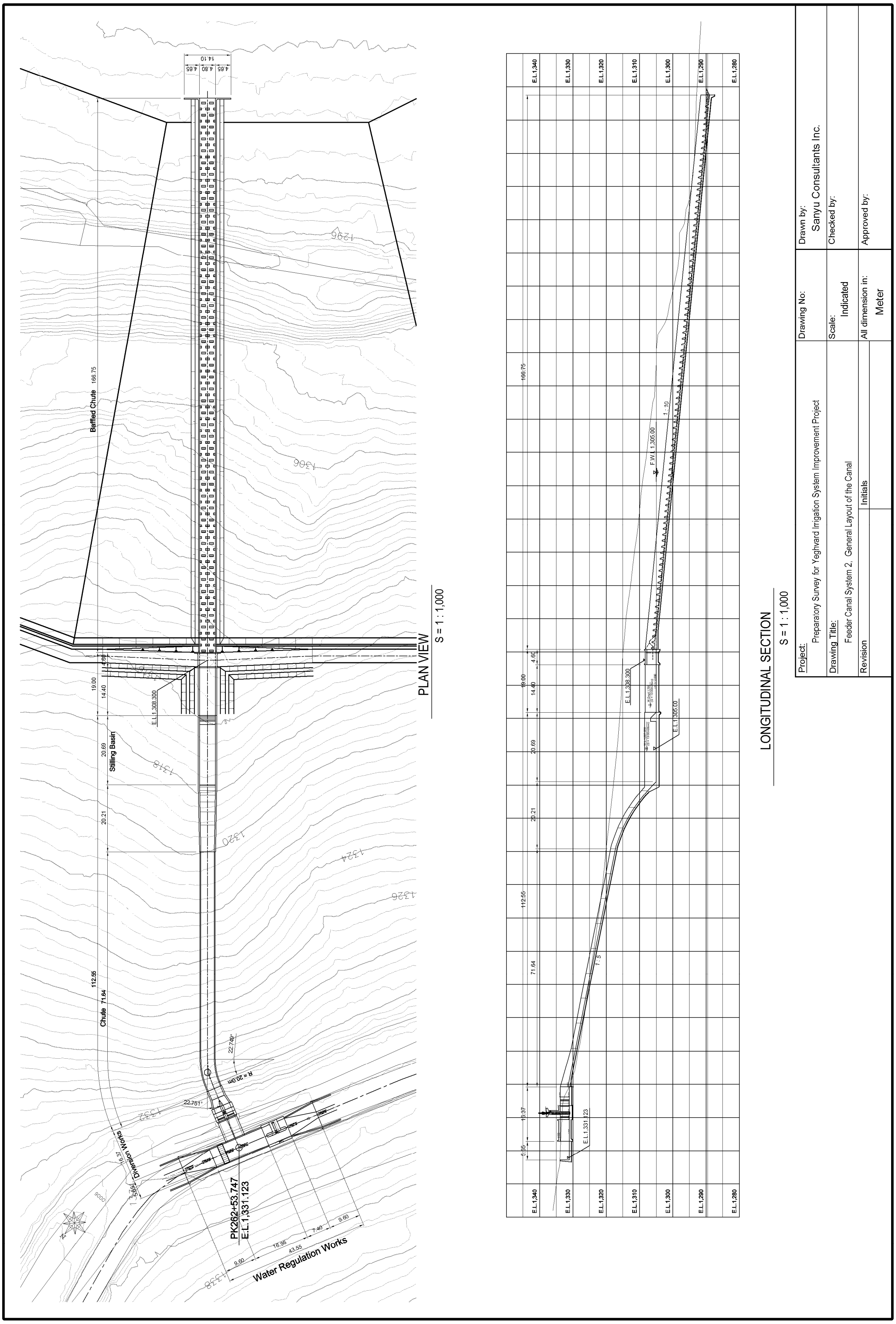


Figure 6-6-3.4 General Layout of Feeder Canal 2

(3) Outlet canal 2

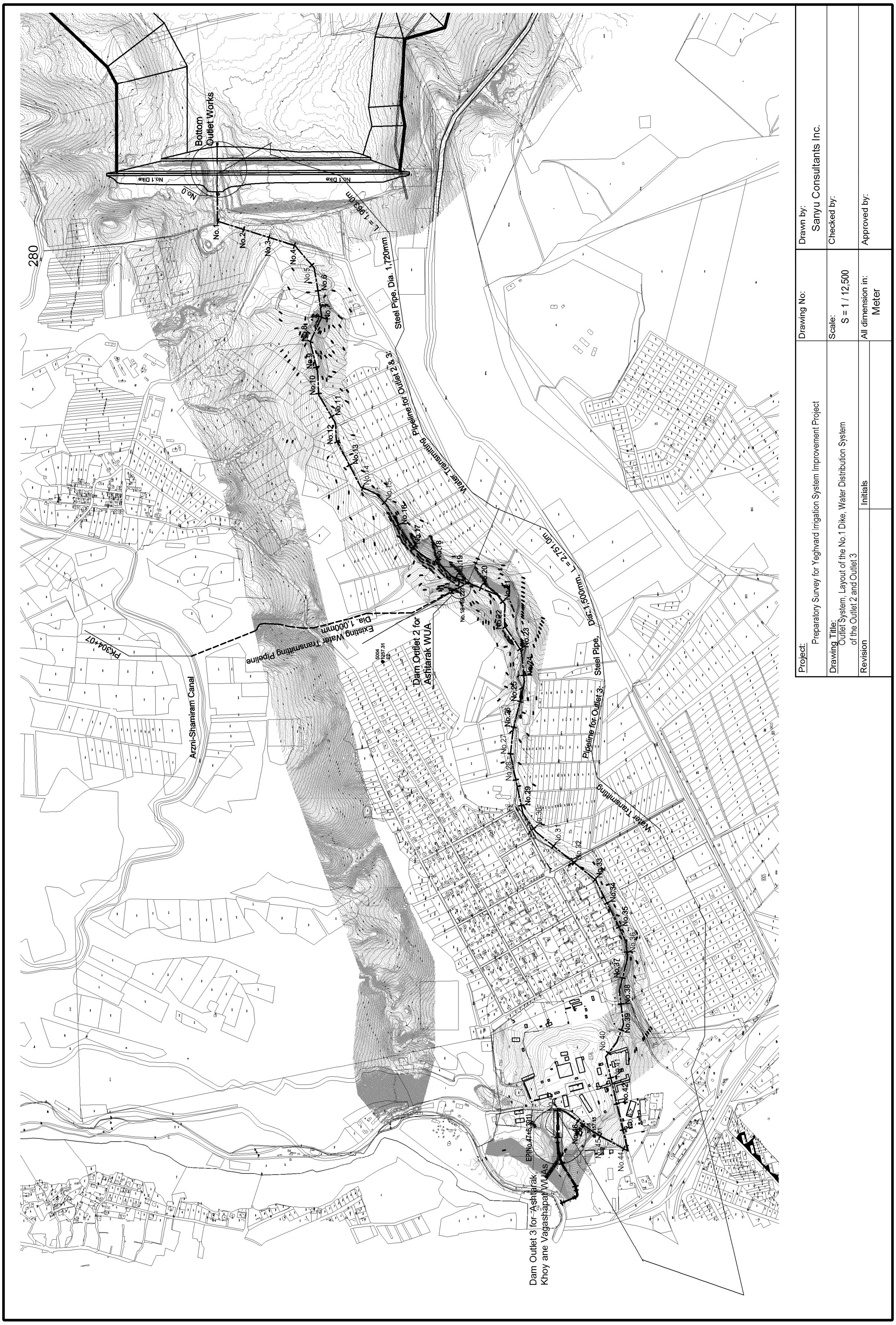
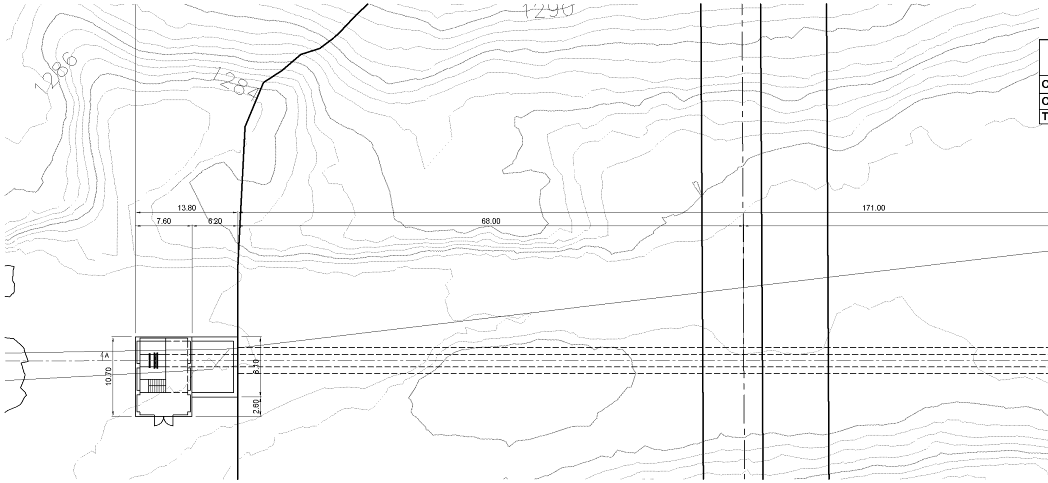


Figure 6-6-3.5 General Layout of Outlet Canal 3

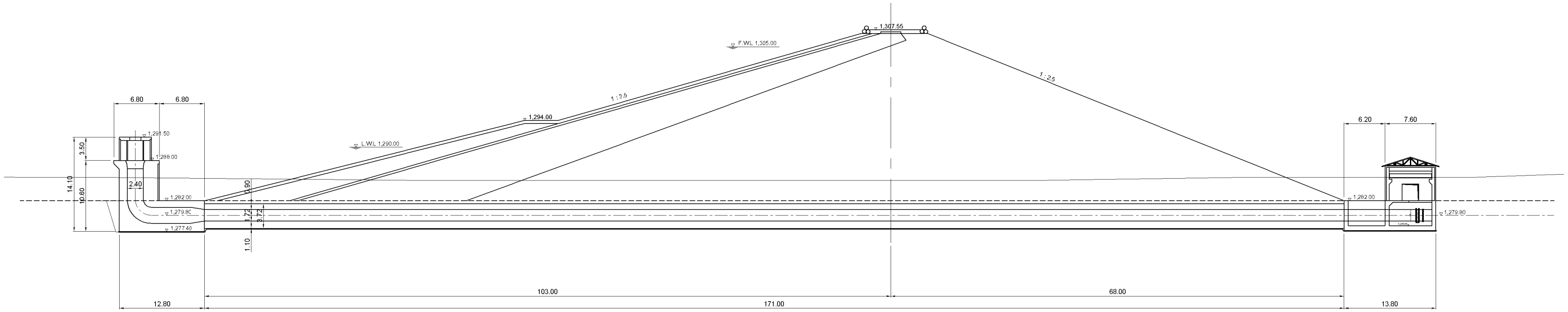
Flow Conditions of Bottom Outlet Works

Unit: m^3/s

	Mar			Apr			May			Jun			Jul			Aug			Sep			Oct		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Outlet 2	0.00	0.00	0.00	0.00	0.07	0.28	0.32	0.24	0.09	0.12	0.40	0.51	0.56	0.55	0.54	0.54	0.51	0.44	0.42	0.08	0.05	0.05	0.25	0.11
Outlet 3	0.00	0.00	0.00	0.00	0.16	0.66	0.75	0.56	0.22	6.48	8.24	8.99	6.61	6.88	6.75	5.95	5.69	5.13	3.37	2.39	3.32	3.02	0.59	0.25
Total	0.00	0.00	0.00	0.00	0.23	0.94	1.07	0.80	0.31	6.60	8.64	9.50	7.17	7.43	7.29	6.49	6.20	5.57	3.79	2.47	3.37	3.07	0.84	0.36



PLAN VIEW
S = 1 : 600



LONGITUDINAL SECTION (A - A)
S = 1 : 600

Project: Preparatory Survey for Yeghvard Irrigation Improvement Project
Drawing No:
Drawn by: Sanyu Consultants Inc.
Drawing Title: Outlet System, Structural Drawing of the Bottom Outlet Works for Outlet 2 and Outlet 3 (1/2)
Scale: S = 1 : 600
Checked by:
Revision
Initials
All dimension in: Meter
Approved by:

Figure 6-6-3.6 Structural Drawing of the Bottom Outlet Works

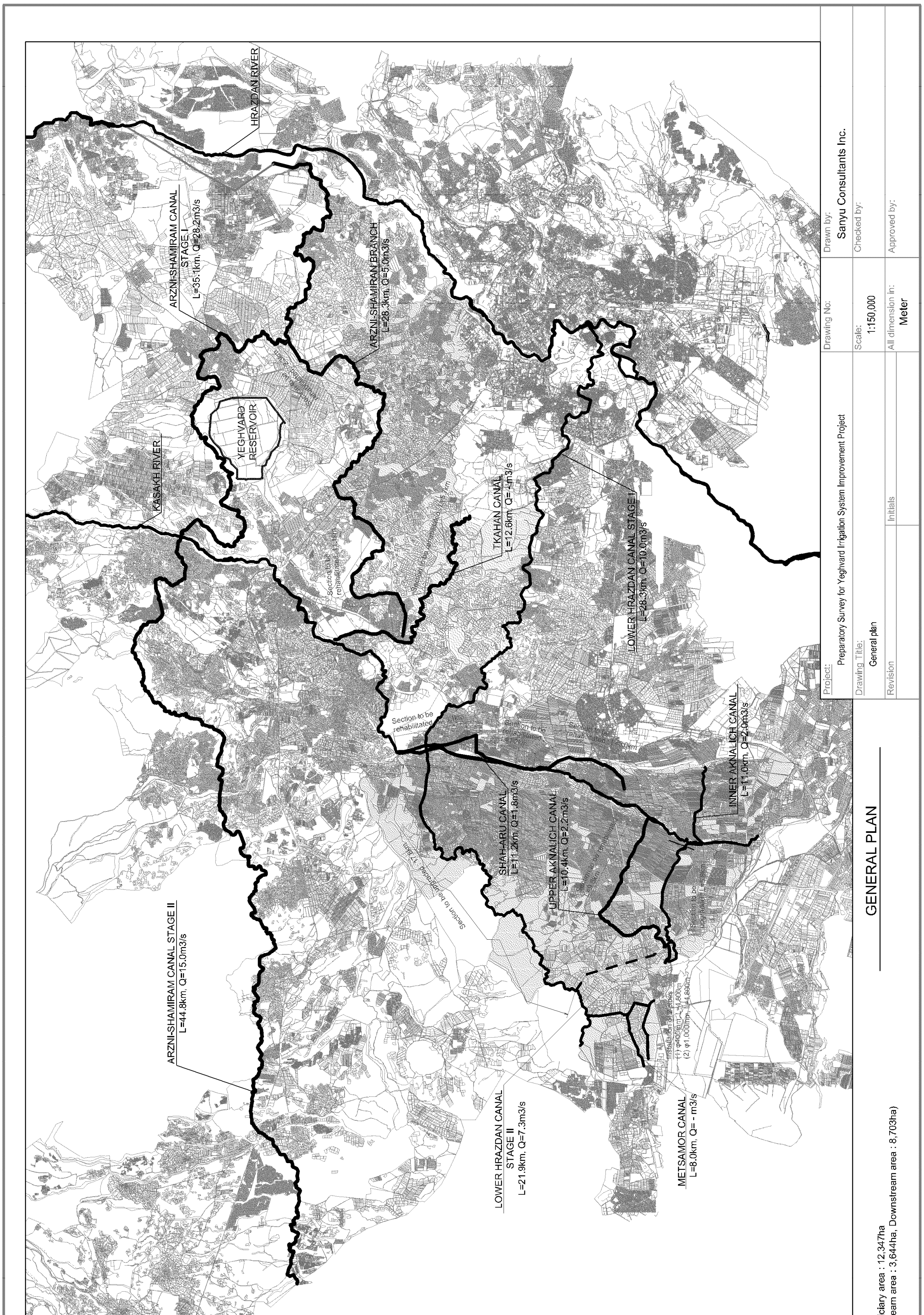


Figure 6-6-3.7 General Plan of Target Canals

6-7 Project Cost Estimation

6-7-1 Summary and Policy of Cost Estimation

Project cost is estimated according to the current regulatory systems and norms of Armenia. The estimate was developed for each of following contents.

(1) Reservoir bottom anti-infiltration works
(2) Rising and surface protection of existing Dam No.1 and Dam No.2
(3) Feeder canals and Outlet canal
    1) Feeder canal 1(Arzni-Shamiram canal to Dam No.2)
    2) Feeder canal 2(Arzni-Shamiram canal to reservoir)
    3) Outlet canal 1(Dam No.2 to Arzni-Branch canal)
    4) Outlet canal 2(Dam No.1 to Kasakh river)
(4) Irrigation systems
    1) Rehabilitation of Arzni-Shamiram canal (N9)
    2) Connection canal Lower Hrazdan canal part 2
    3) Arzni-Branch canal, BP. to PK120
    4) Arzni-Branch canal, PK120 to EP (PK165+19)
    5) Takahan canal
    6) Shah-Aru canal
    7) Upper Aknalich canal

For the decision of the construction method of the reservoir bottom anti-infiltration works, following 4 methods are considered. The drawing of each method is shown in Figure 6-7-1.1.

(1) Bentonite sheet
(2) Soil-cement coverage
(3) Bentonite-soil mixture
(4) Soil-cement with a sandwiched bentonite sheet

Project cost is estimated and compared above 4 methods.

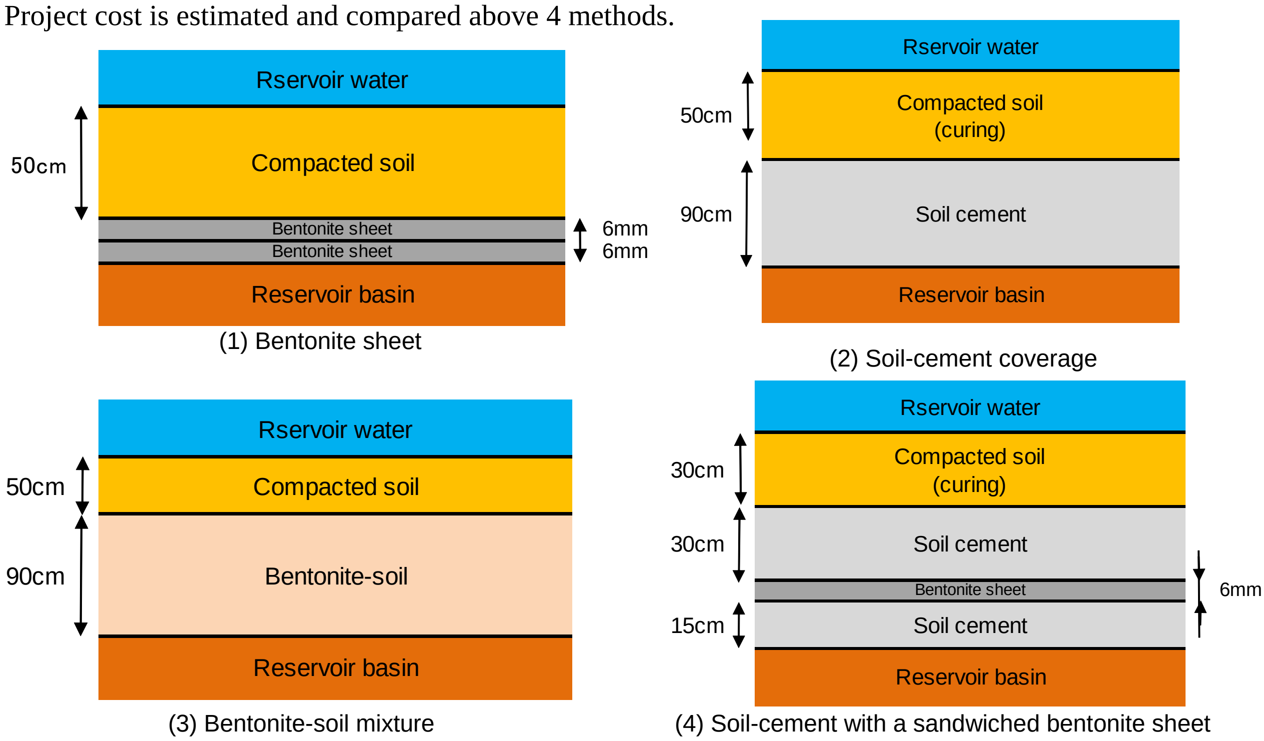


Figure 6-7-1.1 Anti-infiltration Method

6-7-2 Project Cost

Estimated project costs of 4 construction method are shown in Table 6-7-2.1. Among the 4 method, The method of “Soil-cement with a sandwiched bentonite sheet” is selected due to economical advantage.

Table 6-7-2.1 Project Cost

Contents (Unit: Million USD)		1. Bentonite sheet (2 layers)		2. Soil-Cement coverage		3. Bentonite-soil mixture		Soil-Cement with a Sandwiched Bentonite sheet					
								4. Total		5. Excepted irrigation system		6. Irrigation system only	
		Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%	Project Cost (million USD)	%
R. Bottom Anti-Infiltration		80.6	66.8	111.8	73.6	83.3	67.6	78.3	66.2	78.3	75.1	0	0.0
Exisiting Dam (No.1, No.2)		6.8	5.6	6.8	4.5	6.8	5.5	6.8	5.7	6.8	6.5	0	0.0
Feerder canal, Outlet canal		17.6	14.6	17.6	11.6	17.6	14.3	17.6	14.9	17.6	16.9	0	0.0
Irrigation system, other works		15.6	12.9	15.6	10.3	15.6	12.7	15.6	13.2	1.6	1.5	14.0	100.0
Direct Construction Cost		120.6	100	151.8	100	123.3	100	118.3	100	104.3	100	14.0	100.0
Overhead expenses	13.3%	16		20.2		16.4		15.7		13.9		1.9	
sub-total		136.6		172.0		139.7		134.0		118.2		15.9	
Contractor profit	11.0%	15.0		18.9		15.4		14.7		13.0		1.7	
sub-total		151.6		190.9		155.1		148.7		131.2		17.6	
Expenses on Temporary buildings & Climate impact	4.1%	6.2		7.8		6.4		6.1		5.4		0.7	
Indirect expenses		37.2		46.9		38.2		36.5		32.3		4.3	
Construction Cost		157.8		198.7		161.5		154.8		136.6		18.3	
Consultant Service	6.0%	9.5		11.9		9.7		9.3		8.2		1.1	
sub-total		167.3		210.6		171.2		164.1		144.8		19.4	
Price Contingency	10.24%	17.1		21.6		17.5		16.8		14.8		2.0	
Physical Contingency	5.0%	8.4		10.5		8.6		8.2		7.2		1.0	
Sub-total		25.5		32.1		26.1		25.0		22.0		3.0	
Grand Total		192.8		242.7		197.3		189.1		166.8		22.4	
VAT	20%	38.6		48.5		39.5		37.8		33.4		4.5	
Grand Total with VAT		231.4		291.2		236.8		226.9		200.2		26.9	

6-7-3 Cost Reduction

From the results of geological survey, soil mechanical test and groundwater simulation, the loamy sand distributed in the center area of the reservoir has enough low permeability. Leakage from the center area is very low and allowable therefore it is judged that anti-infiltration works are not necessary at the center area of the reservoir. The cost of anti-infiltration works can be deduced from the Project cost. Reduction of direct cost of anti-infiltration works is about 51 million USD tabulated in Table 6-7-3.1.

Table 6-7-3.1 Cost Reduction of Anti-infiltration

Anti-infiltration work			Unit cost of Anti-infiltration (USD/m2) (4)	Direct cost of reduction (USD) (5)=(3)x(4)
Original area (m2) (1)	Necessary area (m2) (2)	Deducted area (m) (3)=(1)-(2)		
9,000,000	5,443,000	3,557,000	14.482	51,512,474

6-7-4 Construction Schedule

(1) Matters for Consideration on the Construction

During the construction, many construction vehicles are operated around Yeghvard reservoir therefore temporary land acquisition of surrounding private area is necessary. Land owners have to stop their productive activities even though land acquisition is temporary, compensation for the acquisition is also necessary. After completion of construction work, these lands will be back to the land owners.

(2) Quality Control Plan

Quality control for the construction is on the initiative of contractor and the consultant of the Project is checked and confirmed. Structure and contents of quality control is shown in Figure 6-7-4.1.

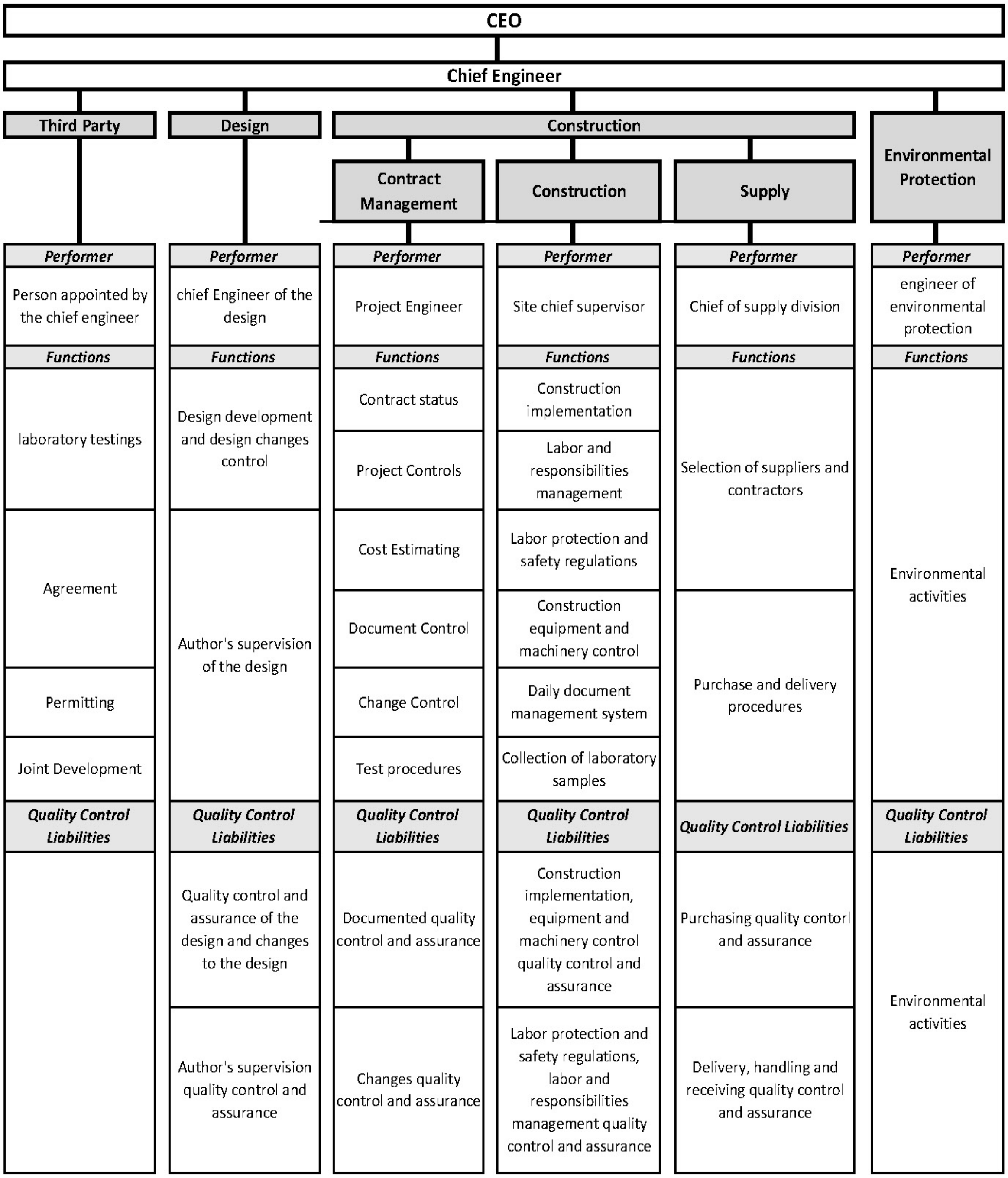


Figure 6-7-4.1 Quality Control Structure

(3) Safety Control Plan

1) Local standards and norms related to safety and quality control

Construction work in Armenia has to obey several safety regulations. These regulations define not only safety measures during several kinds of construction works but method of safety management like safety training. Table 6-7-4.1 shows standards and norms related to safety.

Table 6-7-4.1 Standards and Norms Related to Safety and Quality Control

Standard and norm	Related contents of standard and norm
HHSHN 33-01-2014: General conditions of construction norm for hydraulic structures	- Safety assurance of structures and effectiveness - Safety requirements during construction - Safety requirements during maintenance - Safety requirements during reconstruction or removal
N 074-N Safety rules for engineers in water resources management systems.	- Safety rules for maintaining organizations of hydraulic structures - Training about safety rules - Procedure of knowledge test about safety rules - Norm and rules of safety assurance - Safety equipment and work protection process - Safety zone and requirements for workers
Building regulations SNIP III-4-80, Safety in Construction	- Safety in isolation works - Safety in earth works - Safety in concrete works

2) Departments in charge of safety and quality control in the Implementation Unit

In Armenian construction rule, safety control is planed and conducted by contractors and project engineer (consultant) checks and confirms it. Implementation unit has free of direct responsibility for safety. The person in charge of the Project in the implementation unit just confirms the situation of safety control by the contractor.

3) Assignment plan of safety control staff for the Japanese loan project

The person in charge of the Japanese loan project in the implementation unit confirms the safety control by the contractor.

4) Capacity and experience of staff in charge of safety and quality control

The responsible person in the implementation unit has several experiences to handle safety control in other similar projects.

5) Structure of confirming safety and quality control in the Implementation Unit

The responsible person in the implementation unit confirms the safety report from the project engineer. The implementation unit is not in a direct responsible position, however the responsible person usually goes on regular patrol in the construction site and checks as-built drawings and supplementary drawings voluntarily.

6) Organization control in the implementation unit to accidents

In the case of an accident, project engineer and contractor handle the accident response. After initial response, project engineer report to the responsible person in the implementation unit, then accident information is distributed in the implementation unit.

7) Method of a confirming training programs in safety and quality control by contractors

Contractor has to prepare the safety and quality control plan including safety training program and submit to the project engineer. Project engineer judged the appropriateness of the plan and approve of it. Project engineer confirms the safety plan submitted from the contractor.

8) Agencies having jurisdiction over safety issues

Public agency has jurisdiction over safety issues in Armenia is Ministry of Labor and Social Affairs.

(4) Procurement schedule

In Armenia, general construction materials and equipment is available in domestic market. However, bentonite sheet shall be imported for the Project. Some special construction equipment, valves and gates are to be procured from Europe or neighbor countries.

(5) Construction Schedule

1) Critical path of the construction

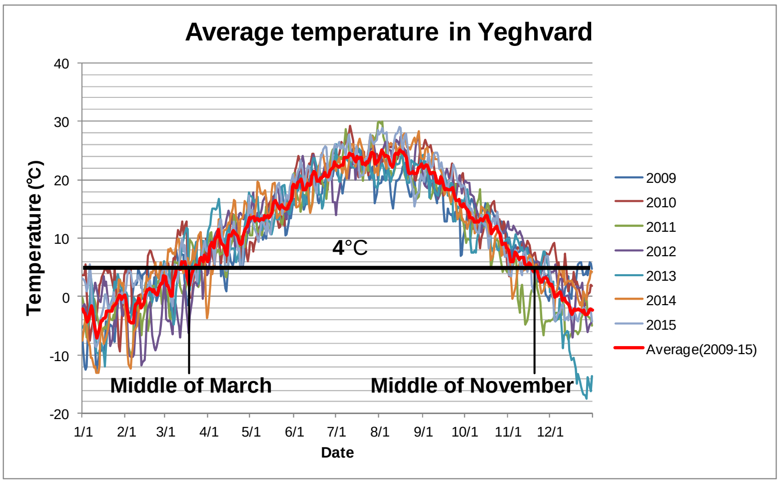
Construction works are divided into 4 parts. First is reservoir bottom anti-infiltration works. Second is earth filling of dam bodies. Third are feeder canals and outlet canals. Final is a rehabilitation of Arzni-Shamiram canal and irrigation system at the downstream. Among 4 construction works, reservoir bottom anti-infiltration works, which has the largest construction volume, is the critical path of the Project.

2) Workable days

Construction work is restricted weather condition such as temperature, rain fall and snow fall.

a) Temperature

For maintaining the quality of anti-infiltration works by soil-cement, management of temperature when casting soil-cement is important. High temperature exerts a bad influence on proper curing of soil-cement and deteriorates its stability and permeability. Special casting method correspond to cold temperature is necessary during soil-cement casting under 4°C. Soil-cement in the reservoir is required high anti-infiltration, therefore meticulous care to casting is indispensable. Average temperature in Yeghvard from 2009 to 2015 is shown in Figure 6-7-4.2. To prevent leakage from reservoir result from improper workmanship, soil-cement casting work is ceased in four months from the middle of November to the middle of March.

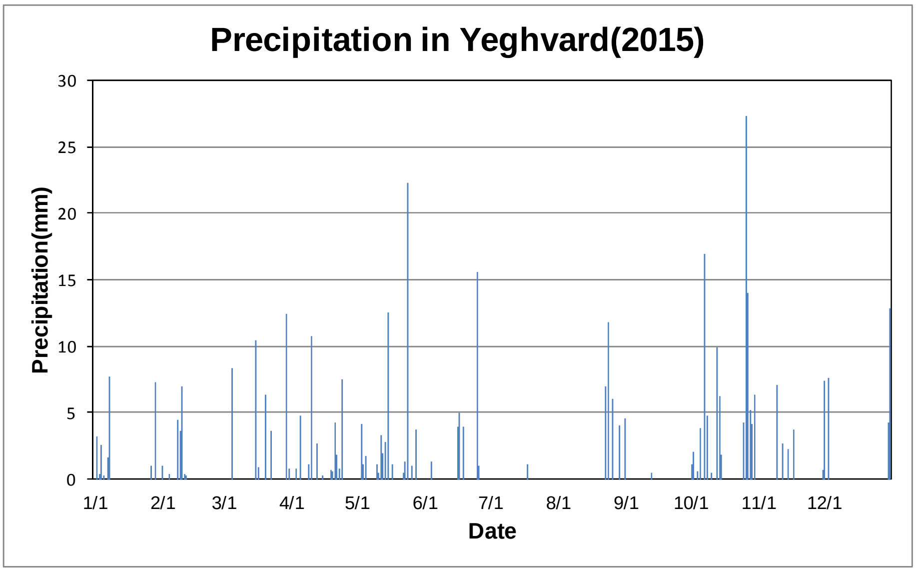


Source: Armenian State Hydrometeorological and Monitoring Service

Figure 6-7-4.2 Average Temperature in Yeghvard

b) Precipitation

Precipitation during casting soil-cement has an adverse affect on quality of soil-cement. In general, casting does not recommend when precipitation is over 4 mm/hour.



Source: Armenian State Hydrometeorological and Monitoring Service

Figure 6-7-4.3 Precipitation in Yeghvard

Precipitation in Yeghvard in 2015 is shown in Figure 6-7-4.3. The maximum precipitation is 27mm/day so that high intense precipitation which interferes with soil-cement casting does not continue long time. Therefore cessation of construction by precipitation is not considered.

c) Holiday

Considering safety of labors and maintenance of machineries, working days in a week is set as 6 days.

d) Number of workable days

From the consideration of ceasing of construction work, annual workable days are calculated as 206 days (see Table 6-7-4.2).

Table 6-7-4.2 Workable Days of Soil-cement Work

Annual days (1)	Constrain for work			Actual workable days (5)=(1)-(2)-(3)-(4)
	Construction of temperature (2)	Precipitation (3)	Holiday (4) = (2)x1/7	
360 days	30 days/month x 8 months = 240 days	0 day	34 days	206 days

3) Construction period

In anti-infiltration works, transportation of the raw materials of soil-cement such as sand and cement and also mixed soil-cement requires many trucks for the construction in the reservoir basin.

Calculation result of necessary number of trucks per 1,000 m^2 is shown in Table 6-7-4.3. Necessary number of trucks for soil-cement work per 1,000m^2 is 5.42.

Table 6-7-4.3 Necessary Number of Trucks for Soil-cement Work

No.	Materials	Transportation route	Operation hours of dump truck (hr/1,000m2)	Operation hour (hr/day)	Necessary Nos of dump truck (Nos/1,000m2)
1	Top soil	Basin to disposal	8.4	6	1.4
2	Quarry soil	Quarry to sieving machine	4.1		0.68
3	Sand & gravel	Sieving machine to mixing machine	6.9		1.15
4	Cement	Stock yard to mixing machine	0.69		0.12
5	Soil-cement mixture	Mixing machine to basin	2.6		0.43
6	Soil-cement mixture(1laye:15cm)	Basin	3.34		0.56
7	Soil-cement mixture(2layer:15cmx2)	Basin	6.5		1.08
	Total		32.53	-	5.42

Table 6-7-4.4 shows the necessary volume of soil-cement work and number of trucks. In the case of 3-year construction period, 48 trucks are needed in the site. These trucks concentrate to quarry site, disposal area and work place of anti-infiltration works and be forced to wait construction work. Work volume also is reduced.

In the case of considering 4-year construction period, 36 trucks are adequate for meeting required work volume. The movement of truck are not conflict each other and adequate work control is possible. Therefore, construction period is decided as 4 years.

Table 6-7-4.4 Necessary Volume of Soil-cement Work and Trucks

Construction area of soil-cement (m2) (1)	Yearly working days (day) (2)	Necessary daily work volume(m2/day) (3) = (1)/(2)x year		Necessary Nos of dump truck (Nos/1,000m2) (4)	Necessary Nos of dump truck (Nos/day) (5)=(3)x(4)
5,344,000	206	for 3 years	8,807	5.42	48
		for 4 years	6,606		36

(4) Implementation schedule

The Project will start from 2-year Detail Design and tender of construction after the Feasibility study. Then start 4-years construction. After completion of the reservoir and irrigation facilities, initial impoundment is plan to conduct taking 1 year. Total Project period is estimated 7 years as shown in Figure 6-7-4.4. The rehabilitation of canals such as Arzni-Shamiram and irrigation system is restricted to its construction period considering distribution of irrigation water in Armenia. Rehabilitation works are conducted in winter season preventing stopping water in irrigation season.

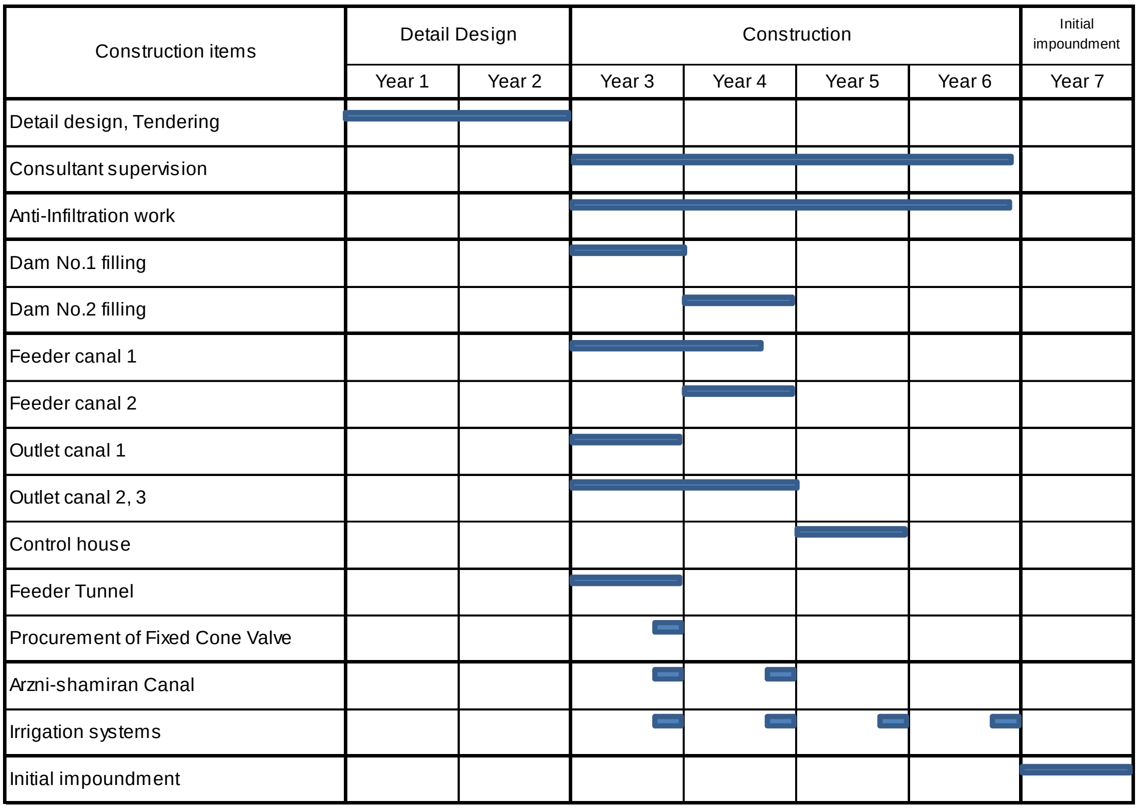


Figure 6-7-4.4 Implementation Schedule

6-8 Operation and Maintenance (O&M) Plan

6-8-1 O&M Plan of the Reservoir

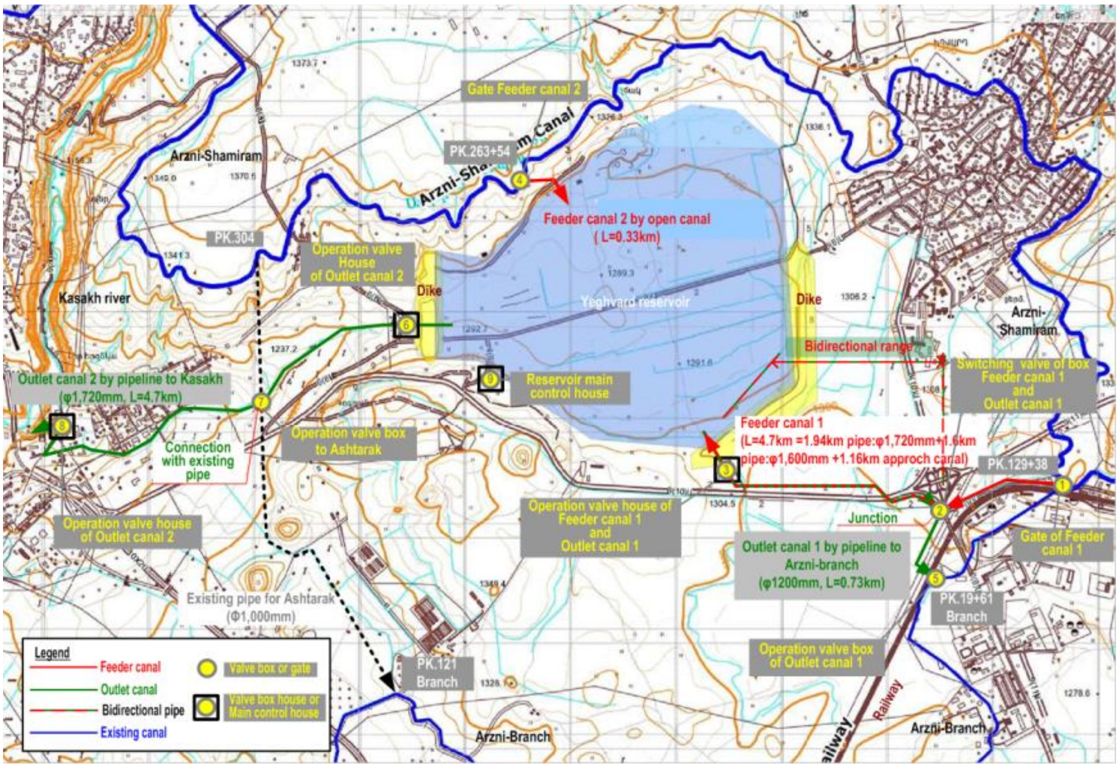
(1) Demarcation of operation and maintenance

Yeghvard reservoir will be administrated by the Sevan-Hrazdanyan-Jrar CJSC. The CJSC should be responsible for the operation and arrangement of staff for Yeghvard reservoir. Two Feeder canals and two Outlet canals should be demarcated to WSA and WUAs in the view of operation. However, the maintenance for the related facilities of reservoir shall be conducted by WSA because the integrated maintenance by single organization could be smooth and effective to interactive relation in each facilities of reservoir. **WSA shall be recommended to be main responsible agency for reservoir and related facilities.**

The suggested demarcation for operation is shown in Table 6-8-1.1.

Table 6-8-1.1 Operation Demarcation of Reservoir and Related Facilities around Yeghvard Reservoir

Facility	Conveyance	Maintenance	Operation				
				WUAs			
		WSA	WSA	Yeghvard	Ashtarak	Vagarshapat	Khoy
1.Gate of F.C. 1	Pipeline	●	●				
2.Switching valve box of F.C.1 and O.C.1	Pipeline	●	●				
3.Operation valve house of F.C.1 and O.C.1	Pipeline	●	●				
4.Gate of F.C. 2	OP.canal	●	●				
5.Operation valve box of O.C.1	Pipeline	●		●			
6.Operation valve box of O.C.2 at Dike 1	Pipeline	●					
7.Operation valve house of O.C.2 at connection	Pipeline	●			●		
8.Operation valve house of O.C.2 at Kasakh	Pipeline	●				●	●
9.Main control house of Yeghvard Reservoir		●	●				
Reservoir body		●	●	-			



(2) Operation unit of reservoir

Yeghvard reservoir as large irrigation facility could seriously affect to social environment, if an unexpected accident arises. To avoid these damages and serious situation, necessary persons shall be stationed at reservoir facilities to regular observation and report, in addition, unexpected situation shall be taken measure and/or secured safety by these assigned experts.

Especially, in case of consultation on engineering matters for reservoir, PIU should support and assist the operation unit.

Table 6-8-1.2 Recommended Experts of Operation Unit

Persons		Responsibility	
Operation and management	3	Resident persons for operating season and as required situation should be assigned. Manager(1), staff for feeder canals(1), staff for outlet canals (1)	General administration, such as report and record, should be conducted.
Dam Engineer	1	Person for operating season and as required situation should be assigned.	Regular and difference situation should be observed and investigated in accordance with monitoring plan in ordinary and extraordinary. Especially, in extraordinary, engineer should check dam body condition and internal facility of reservoir.
Electric Engineer	1	Person for operating season and as required situation should be assigned.	Regular and difference situation should be observed and investigated in accordance with monitoring plan in ordinary and extraordinary. Especially, in extraordinary, engineer should check all of electric facility.
Mechanical Engineer	1	Person for operating season and as required situation should be assigned.	Regular and difference situation should be observed and investigated in accordance with monitoring plan in ordinary and extraordinary. Especially, in extraordinary, engineer should check all of mechanical facility.

(3) Maintenance

(a) Maintenance in regular situation

To secure the safety situation of reservoir, following items should be observed by visual and/or equipment.

1) Leakage water volume from dam body and foundation

The facility for leakage measurement like collecting water structure should be stationed at edge of dam body. Prior to apply this method and facility, other water factor into measurement facility shall be ensured by actual observation or analysis. Since the observed water would include individual water source such as surface, spring, leakage from dam body and foundation. In addition, appeared muddy color water from dam body could be recognition of leakage or suction of core zone material (impervious maerial) . It would be identified by visual inspection.

2) Deformation of dike

In usual, targets to measure deformation of dam body are established on the surface of dam body. The surface should be stationed 10 - 15 bench marks to observe by topographic survey. The bench marks should be arranged to likely matrix with equal distance in order to dully and inclusively ensure the reaction of dike.

3) Pore water pressure inside of dam body and foundation

Pore water pressure could be measured in order to ensure quality control and inspection during construction, in this case, it should be installed at a few section with interval of 10m. To make observation after construction for the purpose of dike safety, it should be stationed.

4) Water level in reservoir

To ensure and observe the stored volume, water level gauge shall be stationed at location which is enable to visual observe easily. In addition, Arzni-Shamiram canal, Arzni-Branch canal and Kasakh river at which are closed to and connected with Feeder canal and Outlet canal, should be stationed water gauge or SCADA system.

5) Water level in deep well around reservoir

This is in relation with observation of leakage water from reservoir. According to the geological condition of Yeghvard reservoir, the ground water level is at approx. 100m below surface. It could be affected to ground water by reservoir leakage. Deep wells are aim at observation for reaction of ground water.

6) Reaction of dike and foundation for earthquake

Equipment of seismometer should be stationed at edge and crest of dam body so that it would observe earthquake motion precisely. In addition, seismometer equip with the function to be able to measure maximum accretion.

7) Visual observation for pipeline

At most of pipeline is under ground, visual inspection of the most part is not easy. These ground section of the pipeline should be inspected at least before and after the irrigation season. The visual inspection should be performed by trained and qualified staff. In addition, every a few years or in case of unusual conditions, a complete inspection for pipeline should be conducted by qualified and experienced engineer , and using remote observation vehicles.

(b) Maintenance in unusual situation

In unusual situation, all of facilities in relation with reservoir shall be a inspected by eligible and experienced engineer. Especially, the inspection should be performed not only analyze measured value by equipment but also visual investigation.

(2) Operation of each Canal at reservoir

(a) Regular operation

To convey the irrigation water to irrigation filed, five of canals connected reservoir should be dully operated to in-flow and out-flow. These canals have the different discharge and have to be operated in accordance with following water allocation.

Table 6-8-1.3 Water Allocation of Feeder and Outlet Canals (m^3/s)

	Jan.			Feb.			Mar.			Apr.			May			Jun.		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Arzni-Shami. note1)	0.00	0.00	0.00	0.00	0.00	0.00	7.00	15.5	14.4	22.0	19.2	11.2	18.5	15.4	5.50	7.00	5.00	6.00
Arzni-Branch note2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.16	1.33	1.00	0.39	0.00	0.00	0.00
Feeder C. 1	0.00	0.00	0.00	0.00	0.00	0.00	7.00	9.00	9.00	9.00	8.72	7.84	7.67	8.00	1.11	0.00	0.00	0.00
Feeder C. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	5.40	13.00	10.20	2.20	5.90	3.40	0.00	0.00	0.00	0.00
total inflow	0.00	0.00	0.00	0.00	0.00	0.00	7.00	15.5	14.4	22.0	18.92	10.04	13.57	11.40	1.11	0.00	0.00	0.00
Outlet C. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.66	2.10
Outlet C. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.28	0.32	0.24	0.09	0.12	0.40	0.51
Outlet C. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.66	0.75	0.56	0.22	6.48	8.24	8.99
total outflow											0.23	0.94	1.07	0.80	0.31	7.10	10.30	11.60
Operation	<- - -		no-operation			- - ->	<-		Inflow to Reservoir		<-		Outflow from Reservoir		->			->>

	Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Arzni-Shami. note1)	6.00	7.00	13.0	13.0	13.0	13.0	8.00	8.00	8.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
Arzni-Branch note2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feeder C. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feeder C. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 1	2.33	2.27	2.22	2.22	2.11	1.83	1.72	0.33	0.22	0.22	1.05	0.44	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 2	0.56	0.55	0.54	0.54	0.51	0.44	0.42	0.08	0.05	0.05	0.25	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Outlet C. 3	6.61	6.88	6.74	5.94	5.68	5.13	3.36	2.39	3.33	3.03	0.59	0.25	0.00	0.00	0.00	0.00	0.00	0.00
total outflow	9.50	9.70	9.50	8.70	8.30	7.40	5.50	2.80	3.60	3.30	1.90	0.80	0.00	0.00	0.00	0.00	0.00	0.00
Operation	<<-				Outflow from Reservoir							->	<- - -			no-operation		- - ->

Note1) Arzni-Shamiram canal convey water to only Part2 section from 1st period June to3rd period October. Other area is irrigated by Reservoir water

Note2) Arzni-Branch canal of intake is available from 2nd period April to3rd period May to Yeghvard WUA.

(b) Emergency operation

Special attention has to be paid shortly after the earthquake and similar situation. To prevent the dangerous situation for reservoir, the emergency operation shall be executed. The detailed operation in emergency refers to "6-5-7 Basic Design Related Facilities (Emergency Discharge Structure)".

(3) Necessary observation facility and equipment

Yeghvard reservoir should be equipped with as following facilities and equipment.

Table 6-8-1.4 Recommended Facilities and Equipment

Items	Location and number
Pore water pressure-meter	3 section of dam body with interval of 10m for 1 section
Bench marks	15 marks on surface of dike
Water gauge	2 set : Yeghvard reservoir 4sets : Arzni-Shamiram canal at shortly US. and DS. of intake of Feeder canal 1(PK129+196) and at shortly US. and DS. of intake of Feeder canal 2(PK263+20) 2 sets : Arzni-Branch canal at PK16 and PK121 1 set : at connection with Kasakh river and Outlet canal 3
Flow meter	2 sets : Arzni-Shamiram canal at shortly US. of intake of Feeder canal 1 (PK129+196) and at shortly DS. of intake of Feeder canal 2(PK263+20) 1 set : At connection with Kasakh river and Outlet canal 3 2 set : Feeder canal 1 and 2 3 sets : Outlet canal 1, 2 and 3
Equipment of seismometer	2 set for Dam No.1 and No.2
Remote observation vehicle	1 set (inspection in the pipeline)
Vehicle	2 cars : At main control house
Small vessel	1 vessel : At reservoir
Record system computer	1 set : At main control house

(4) Observation

In order to operate reservoir and related facilities permanently, necessary maintenance works and regular inspection should be conducted periodically. After the irrigation season, the reservoir and conveyance pipeline will be emptied. The timing of regular inspection should be almost no irrigation season.

Table 6-8-1.5 Observation Plan

Action	Period	Subject
Vegetation control	Twice per year	Dam body and surrounding area
Inspection of erosion and damage by visual	Once per year	Dam body and bottom of reservoir and related facilities
Minor embankment, earthwork and erosion repair	as required	Dam body and bottom of reservoir
Erosion protection	as required	Dike and bottom of reservoir
Concrete repair	as required	Related facilities for reservoir
Trash rack cleaning	Once per year	Feeder canal 1 and 2 Outlet canal 2 and 3
Mechanical maintenance ・lubricate mechanical parts ・Paint or grease ferrous metal parts ・Fix loosen bolts and parts	Once per year	Pipe, gates and valves at Feeder canal 1 and 2 Pipe, gates and valves Outlet canal 1, 2 and 3
Electrical maintenance ・Check permanent power supply ・Emergency power supply	Once per year	Main control houses Valve houses
Calibrate monitoring equipment	as specified by suppler or maker	Main control houses Valve houses
Snow and ice clearing	as required, winter season	Feeder canal, Outlet canal and access road

All data regarding reservoir observation and maintenance records in digital should be documented as evidence of safe operation and maintenance. In addition, design construction document shall be stored in main control house in order to use as required.

6-8-2 O&M Plan of the Facilities in the Target Irrigation Area

In the targeted area, open canal, pipeline and distribution gates compose the irrigation system. Regular inspection and maintenance of these structures and facilities should be conducted. In the Project, some structures will be rehabilitated and reconstructed, but these works do not install new function and unseen structure. Most of structures succeed to the original function and structural form. One irrigation engineer is assigned at each WUA in general and those engineers can fix irrigation facilities if damaged. In addition, all WUA have established their own internal rules related to operation and maintenance of irrigation facilities. Therefore, present inspection and maintenance will be continuously implemented by WUAs. Format of inspection and record sheet to support current operation and maintenance activities is suggested as shown in Table 6-8-2.1;

Table 6-8-2.1 Inspection and Record Sheet

Picket distance

Filling Date: DD / MM /YY

General Information

Type: Open canal	Length: m	Height (inside): m	Width (inside): m
		Constructed Year:	Last Rehabilitated Year:

Canal

Damage

Condition			Measure
1. No damage			
2. Small damage on concrete surface		point(s)	Repair by concrete
3. Serious damage (e.g. appearance of steel bar)		point(s)	Request support to WSA or Gov.

Leaking

Condition			Measure
1. No leaking			
2. Small leaking from crack or construction joint		point(s)	Repair by cement mortar
3. Serious leaking from crack or construction join		point(s)	Request support to WSA or Gov.

Pipeline

Condition			Measure
1. No damage			
2. Small damage or leakage on surface		point(s)	Repair by welding
3. Serious damage (e.g. separated joint and large hole)		point(s)	Request support to WSA or Gov.

Gate and Gate Guide

Condition		Measure
1. No rust		
2. Some rust		Rub rust and paint
3. Many rust		Rub rust and paint
4. Hole(s) doe to rust		Change gate

Gate Shaft

Condition		Reason		Measure
1. Easy to operate				Apply oil or grease
2. Not easy to operate				Apply oil or grease
3. Difficult or impossible to operate		1. Rust on shaft		Change shaft
		2. Rust on or deformation of gate		Change gate
		3. Rust on or deformation of gate guide		Change gate guide

Water Tight Rubber

Condition				Measure
1. No deterioration				
2. Some deterioration		1. No leaking		
		2. Some leaking		Change rubber
3. Totally deteriorated				Change rubber

Canal Picture

Typical Cross Section

Special information

CHAPTER 7 PROJECT IMPLEMENTATION ASPECTS

7-1 Project Implementation Structure

7-1-1 Related Agencies to the Project Implementation

(1) State Committee of Water Economy (SCWE)

While SCWE is the state agency to take responsibility for the planning, implementation and operation of the large scale water infrastructures including reservoir, irrigation system and water supply/sanitation investments, the SCWE is placed as implementing body of this F/S of the Project and recognized as the undertaker on ESIA towards the Project implementation. As shown in Figure 7-1-1.1, the SCWE is mainly consisted of administrative office to the Chairman, 5 departments, namely; 1) water supply & sanitation systems, 2) irrigation collector drainage systems 3) real estate & investment, 4) financial economic & accounting and 5) legal & control and 3 divisions with 100 officials in total.

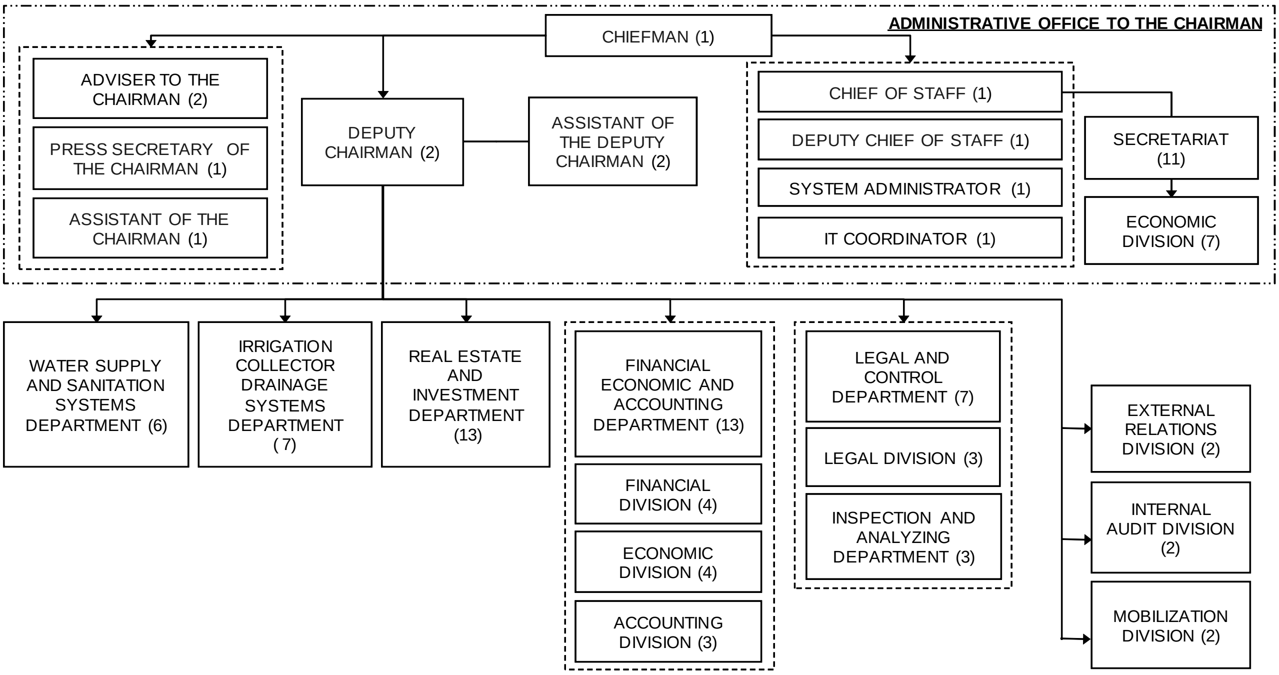


Figure 7-1-1.1 Organization Chart of State Committee of Water Economy (SCWE) as of April 2016

Table 7-1-1.1 Budget of SCWE in Recent Last 4 Years

1USD=486.99AMD Unit: thousand USD

Description		2013	2014	2015	2016
1.	Recurrent budget				
1.1	SCWE maintenance	58	63	64	72
1.2	Salary	218	319	431	475
	1.Sub-total	**276**	**382**	**495**	**548**
2.	Development capital budget				
2.1	Projects, construction works	59,381	52,748	52,141	44,989
2.2	Subsidy	12,153	15,706	19,897	20,801
2.3	Drainage system maintenance	194	194	246	661
2.4	Surveys	23	24	24	24
	2.Sub-total	**71,751**	**68,673**	**72,308**	**66,475**
	Total (1+2)	**72,027**	**69,055**	**72,803**	**67,023**

Source) Website of SCWE, RA

And as shown in Table 7-1-1.1, budget of SCWE in recent last 4 years is steady with a level of 70 million USD annually.

(2) Water Sector Project Implementation Unit (PIU)

Water Sector PIU was created by the SCWE in 1994 supported by WB to manage the implementation of irrigation improvement projects mainly with dam/reservoir construction funded by international agencies, such as Kaps by KfW, Vedi by AFD, Mastara by EDB and other donors. Out of total number of 36 PIU staff currently, shown in Table 7-1-1.2, 12 specialists are engaged with financed by AFD loan, and 5 specialists and other staff are engaged their works with burden of Armenian national budget.

While PIU consists of 6 units, those are; 1) administration, 2) accountancy, 3) construction, 4) procurement, 5) design and 6) WUA support, main task of PIU are a) preparation of preliminary project schedule and cost estimate, b) assessment of planning and facility design, c) preparation of tender documents, tendering and its evaluation, d) construction supervision / monitoring of project implementation, e) quality control of construction works, f) assistance to ESIA and RAP assessment, g) assistance to applications for loan/grant projects, h) clarification for contents of loan agreement, etc.

Table 7-1-1.2 Number of Staff in Water Sector Project Implementation Unit (PIU) as of April 2016

Section/Unit	Position	Number
1. Administration unit	Director	1
	Head of irrigation system improvement project implementation	1
	Secretary / Computer operator	1
	Senior technical translator	1
2. Accountancy unit	A chief accountant and 3 accountants	4
3. Construction unit	Construction technical supervision engineers	3
4. Procurement unit	Senior experts in procurement & contracts	2
5. Design unit	Planning and design engineers	4
	Engineer (Geodesist)	1
	Engineer (Irrigation)	1
	Environmental specialist	1
	Social specialist	1
	GIS specialist	1
6. WUA support unit	Operation and maintenance engineer	1
	Support team coordinator	1
	Water accounting, planning and management specialist	2
	Institutional development specialist	2
	WUA governance bodies coordinator	1
	Electricity and pump station specialist	1
7. Support staff	Communication specialist	1
	IT expert	1
	Office management	1
	Driver	3
	Total	**36**

Source) PIU, SCWE

Table 7-1-1.3 shows budget of PIU. Since PIU staff engage with their tasks based on the project including international and national funded, allocation of the budget is fluctuant in annual. Since Marimaric Reservoir (24MCM) Project burden of national budget assisted by WB completed in 2012, development capital budget in 2013 was reached to the bottom. On the other hand, Geghardalich Reservoir Project (in Kotayk Marz) started in 2015, therefore, it changed to incremental trend in 2014. Accordingly, number of PIU staff also increased by 48 including 12 specialists assisted by AFD from 30 numbers in 2012.

Table 7-1-1.3 Budget of Water Sector PIU in Recent 4 Years

1USD=486.99AMD Unit: thousand USD

Description		2013	2014	2015	2016
1.	Recurrent budget				
1.1	PIU maintenance budget	95	185	96	175
1.2	Salary	219	466	418	468
	1.Sub-total	**314**	**651**	**514**	**643**
2.	Development capital budget				
2.1	Construction works	1,436	2,803	8,930	18,334
2.2	Consulting services	0	973	471	6,375
2.3	Procurement	0	65	758	1,117
	2.Sub-total	**1,436**	**3,841**	**10,159**	**25,826**
	Total	**1,750**	**4,492**	**10,673**	**26,469**

Source) PIU, SCWE

(3) Water Supply Agency (WSA)

Two (2) WSAs, namely; Sevan-Hrazdanyan-Jrar and Akhuryan-Araks-Jrar CJSCs are currently selling water to users of irrigation systems, out of eight (8) WSAs existed in Armenia. Sevan-Hrazdanyan-Jrar (the WSA for the Project) is the one to take responsibility for water fee collection, water distribution as well as operation & maintenance in the Project area at present. And Table 7-1-1.4 shows composition of the WSA which covers 4 WUAs in the Project area and other irrigation schemes in the basins of Hrazdan and Kasakh Rivers. The composition indicates several types of work such as a) administration, b) water discharge measurement, c) regulator operation, d) maintenance of canal and pump station, e) water fee collection, etc.

Table 7-1-1.4 Number of Staff in WSA (Sevan-Hrazdanyan-Jrar CJSC)

	Staff	Permanent	Temporary	Total
1.	Management	4	-	4
2.	Administrator	38	-	38
3.	Head of section	16	-	16
4.	Hydraulic engineer	4	3	7
5.	Hydraulic assistant	17	4	21
6.	Electrical engineer	11	-	11
7.	Water measurement specialist	6	2	8
8.	Maintenance staff	14	-	14
9.	Mechanic	5	1	6
10.	Non-engineer	4	1	5
11.	Accountant	6	-	6
12.	Electrical operator	62	8	70
13.	Regulator operator	14	74	88
14.	Water dispatcher	4	5	9
15.	Sentry	17	-	17
16.	Driver	11	-	11
17.	Machine operator	7	-	7
18.	Other	20	3	23
	Total	**260**	**101**	**361**

Source: WSA, SCWE, RA

Table 7-1-1.5 Budget of Water Supply Agency (WSA) in Recent 4 Years

1USD=486.99AMD Unit: thousand USD

Description		2012	2013	2014	2015
1.	Recurrent budget				
1.1	WSA Salary & maintenance	2,728	4,083	5,194	6,092
2.	Development capital budget	0	0	0	0
	Total (1+2)	**2,728**	**4,083**	**5,194**	**6,092**

Source) WSA, SCWE, RA

Table 7-1-1.5 indicates incremental trend of budget allocation to the WSA. Development capital budget is not allocated to the WSA while SCWE and PIU shoulder the allocation of water infrastructural development.

(4) Ministry of Agriculture (MOA)

MOA is a superstructure to agencies of SCWE and PIU, of which organization chart is shown in Figure 7-1-1.2. The MOA mainly consists of sections; 1) Staff of the Minister, 2) Staff of the Ministry, 3) Joint Stock Companies and 3) State Non-profit Companies. “2) Staff of the Ministry” as main body of the MOA composed of 10 departments and 9 divisions, carries agricultural planning, policy making and institutional arrangements such as a) agricultural development programs, b) plant growing /protection, c) livestock, d) agro-processing development, e) agricultural machinery, f) cooperative support, g) research/coordination of support center, h) land use/melioration and i) food security, etc. And “3) Joint Stock Companies” supports regional development for 10 Marzes and other specified subjects.

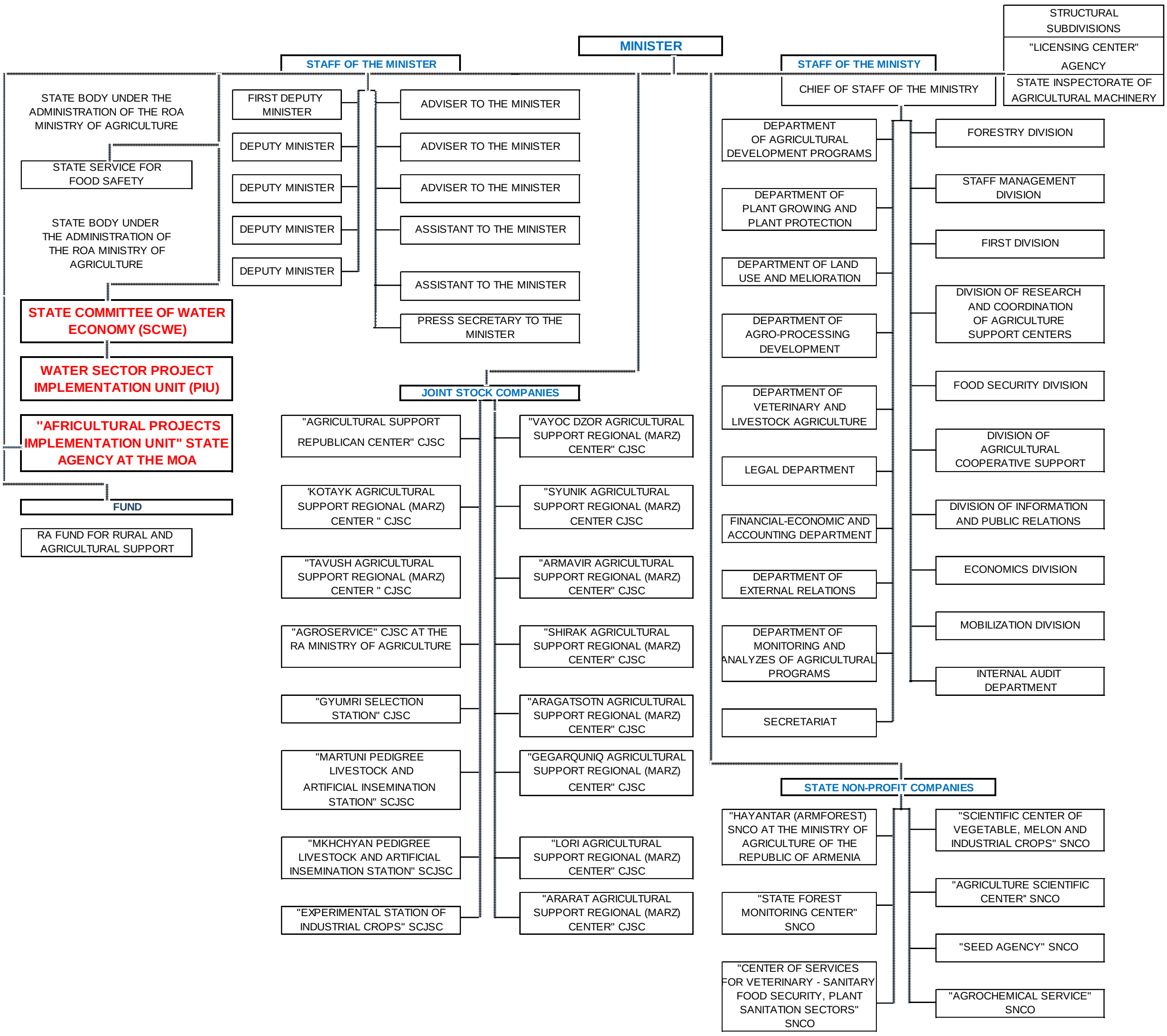


Figure 7-1-1.2 Organization Chart of MOA

It is suggested that the MOA should conduct following five (5) agricultural supporting projects by national fund or other sources, through “Agricultural Projects Implementation Unit” in accordance with the progress of implementation in order to be the Project sustainable and effective;

1) Pilot agricultural cooperatives development,
2) Enhancement of agricultural credit system,
3) Establishment of monitoring and inspection system of pesticide residue,
4) Enhancement of agricultural research to promote market oriented, and
5) Vitalization of agricultural extension.

Considering budget described in Table 7-1-1.6, it is recommended to allocate budget in appropriate timing for conducting agricultural supporting projects shown in the above.

Table 7-1-1.6 Budget of Ministry of Agriculture (MOA) in Recent 4 Years

1USD=486.99AMD Unit: thousand USD

Description		2013	2014	2015	2016
1.	Recurrent budget				
1.1	MOA maintenance	152	159	156	159
1.2	Salary	609	890	1,161	1,153
	1.Sub-total	**761**	**1,049**	**1,318**	**1,312**
2.	Development capital budget				
2.1	Consultation for agricultural inputs	2,886	3,000	3,023	3,070
2.2	Consultation to farmers	2,332	2,971	3,555	3,561
2.3	Monitoring/supervision	112	112	112	112
2.4	Subsidy	2,432	2,921	8,733	8,733
2.5	International projects	3,442	4,230	5,061	5,734
	2.Sub-total	**11,204**	**13,233**	**20,484**	**21,210**
Total		**11,965**	**14,282**	**21,802**	**22,522**

Source: Website of MOA, RA

7-1-2 Proposed Implementation Structure and Procedure

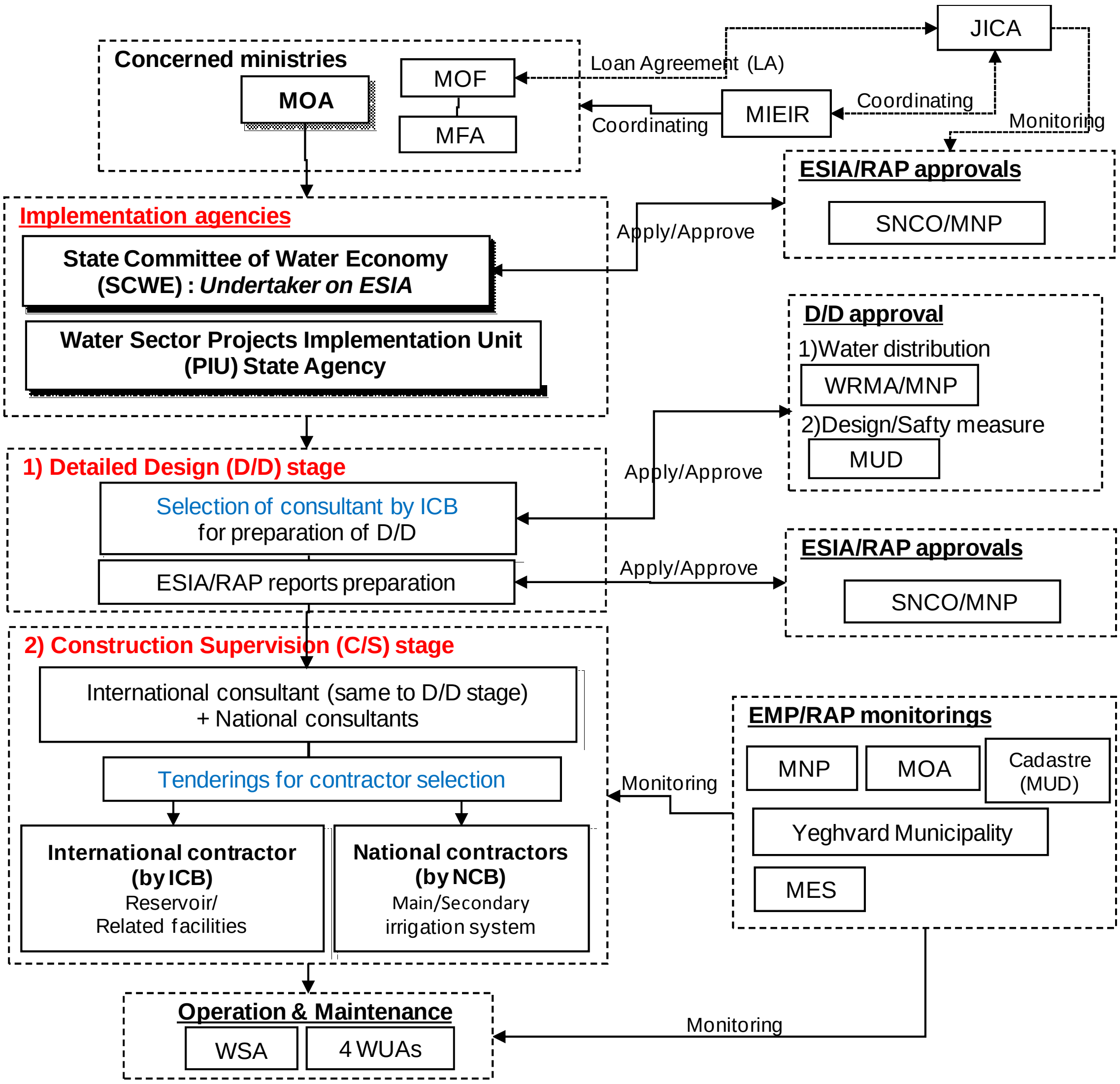
As described in Figure 7-1-2.1, project implementation agency as well as undertaker on ESIA will be SCWE in cooperation with PIU which will supervise international consultant to be selected by International Competitive Bidding (ICB). Since PIU has enough specialists within their office with experience of international funded projects, a new organization body is not required to mobilize for the Project implementation.

Concerned ministries to the Project implementation, those are; Ministry of Finance (MOF), Ministry of Foreign Affairs (MFA) and MOA will assist to SCWE in coordination with Ministry of International Economic Integration & Reforms (MIEIR) after the Loan Agreement signed by and between MOF and JICA which will be financial agency to disburse Japanese ODA Loan.

Contents of Detailed Design (D/D) including design, drawing, cost estimate, construction schedule and so on to be prepared by the selected consultant, will be applied for their approval by Water Resource Management Agency (WRMA)/MNP and Ministry of Urban Development (MUD). Also, ESIA and RAP reports to be prepared by the international consultants will be applied for their approval by SNCO/MNP.

Tender documents for the selection of construction contractors for both international and national will be prepared by the international consultant through the consultation of PIU. And tendering will be carried out by PIU assisted by the international consultant so that contractors will be selected through ICB and National Competitive Bidding (NCB). It is recommended that Yeghvard reservoir and related facilities around would be under the ICB and rehabilitation of Arzni-Shamiram canal including other main/secondary canals under the NCB respectively.

In Construction Supervision (S/C) stage, Environmental Management Plan which prepared by international consultant and approved by SNCO/MNP and RAP will be monitored by MNP, MOA MES and Yeghvard municipality.



Abbreviations

MOF	:Ministry of Finance	WRMA	:Water Resources Management Agency (MNP)
MFA	:Ministry of Foreign Affairs	WSA	:Water Supply Agency
MIEIR	:Ministry of International Economic Integration & Reforms	WUA	:Water Users Associations
MOA	:Ministry of Agriculture	ICB	:International Competitive Bidding
MNP	:Ministry of Nature Protection	NCB	:National Competitive Bidding
MTAD	:Ministry of Territorial Administration Development	ESIA	:Environmental and Social Impact Assessment
MES	:Ministry of Emergency Situations	RAP	:Resettlement Action Plan
MENR	:Ministry of Energy & Natural Resources	EMP	:Environmental Management Plan
MUD	:Ministry of Urban Development	Cadastre	:State Committee of the Real Estate Cadastre
SNCO	:State Non-commercial Organization		

Figure 7-1-2.1 Proposed Implementation Structure

7-2 Cost Burden of the Armenian Government

Since most of consultant fee, cost of civil works will be eligible for Japanese ODA loan sponsored by JICA during D/D and C/S stages, 1) technical supervisor fees of EMP/RAP monitoring, 2) general administration expenses of Armenian staff, 3) Tax and duties including VAT, 4) compensation for resettlement/crops are non-eligible portions under the JICA guideline.

Also, it is recommended that the Government of Armenia shoulder the costs for; 1) agricultural supporting projects and 2) on farm level irrigation system improvement. The amount is estimated at 35 to 45 million USD.

Table 7-2.1 Eligible/Non-eligible Portions for Japanese ODA Loan and Cost Burden of Armenian Government

Portion	Contents	Source	Cost burden Armenia
1. Consultant fee	1) Consultant fee during Detailed Design (D/D) stage	Japanese ODA Loan	-
	2) Consultant fee during Construction Supervision (C/S) stage	Japanese ODA Loan	-
	3) Technical supervisor fee for Environmental Management Plan (EMP) during C/S	Japanese ODA Loan	-
	4) Technical supervisor fee for EMP during operation stage	Armenia	TBE[1)]
	5) Technical supervisor fee for Monitoring Plan during C/S	Japanese ODA Loan	-
	6) Technical supervisor fee for RAP Monitoring Plan during operation stage	Armenia	TBE[1)]
2. Cost of civil works	1) Reservoir construction	Japanese ODA Loan	-
	2) Main Irrigation system construction/Rehabilitation	Japanese ODA Loan	-
	3) Secondary canal system construction/Rehabilitation	Japanese ODA Loan	-
	4) On farm level irrigation system improvement	Armenia	1.8
3. Agricultural supporting projects		Armenia	TBE[1)]
4. Machinery Procurement	1)Soil cement mixing machinery, etc.	Japanese ODA Loan	-
5. Price escalation	1)Construction materials, fuel labor cost, etc.	Japanese ODA Loan	-
6. Physical contingency	1)Extreme weather phenomena earthquake, etc.	Japanese ODA Loan	-
	2)War, labor trouble, etc.	Japanese ODA Loan	-
7. General administration expenses such wage of organization/agencies related to the Project implementation		Armenia	TBE[1)]
8. Tax and duties	1) Value Added Tax (VAT), etc.	Armenia	35.4
9. Compensation for resettlement/crops, etc.		Armenia	0.9 (11.6)[2)]
	Total (Million USD)		**38.1+ (48.8+)**

Notes) 1) TBE: To be estimated during detailed design
2) Including compensation cost of communal land

CHAPTER 8 PROJECT EVALUATION

Project evaluation is carried out in order to determine the economic viability of the Project. The analysis compares the situations “without” and “with” Project, and is carried out on the point of view of the national economy. As indicators of project efficiency, economic internal rate of return (EIRR), net present value (NPV), and benefit-cost ratio (B/C) have been calculated.

There are another important indicator; FIRR, which is an indicator evaluating projects on the point of view of private companies, however, the Project does not profit-oriented. In fact, the main proposed beneficiaries are farmers, on the other hand, Armenian government is planning to be fully responsible for initial investment, and WSA will be in charge of O&M of the reservoir and other main facilities. It means that the beneficiary is not consistent with the burdens. In this respect, the project cannot be evaluated in terms of financial costs and returns, therefore, FIRR is out of analysis in this evaluation.

8-1 Basic Conditions of Economic Evaluation

1) Following “conservatism principle” of ordinary project evaluation theory, all of benefit and cost has to be estimated conservatively.

2) Referring to similar projects in the agriculture sector in Armenia, the economic life of the Project is designed at 35 years.

3) Project costs and benefits are calculated in USD. The current exchange rate, as of averaging February- April 2016, is set at 1USD = 486.99 AMD (Central Bank of Armenia).

4) The opportunity cost of capital in Armenia is not established yet. Referring to previous reports (Pre-F/S of this study), it is 8% in the WB (2013a)[1], 5-12% (three cases) in KfW (2014)[2], and 4% in AFD (2014)[3]. From the point of view of “conservatism principle”, the highest ratio within the donors i.e. 12% is selected. The percentage “12%” is widely employed as a reference opportunity cost of capital by the WB, ADB and JICA in the sector of irrigation/agriculture development in the world.

5) Price escalation is not considered in economic analysis because the evaluation should be done in real price. Transfer items such as taxes (including VAT), interests, and subsidies are excluded from economic price since it is “zero-sum” when it is aggregated in whole economy.

6) Incremental operation and maintenance (O&M) cost is assumed at 1.00 % of initial investment referring to similar projects in the agriculture sector in the other country (See Appendix-M).

7) In addition to incremental O&M cost, large rehabilitation cost is considered in case of water leakage problem due to unexpected disaster such as earthquake.

   Assuming that 1 (one) large maintenance will be needed during the evaluation periods, for instance, due to a large earthquake. The rehabilitation cost is assumed 50% of initial investment of reservoir consisting of construction cost, indirect cost, consultant fee, price escalation, and physical contingency. Since there is a difficulty of forecasting when such large rehabilitation will be needed, therefore, uniform probability (i.e. 1/30 probability every year) is assumed. With these conditions, the expected rehabilitation cost per year is about 2.5 million USD (150 million USD/2/30), or almost equivalent to 1.0% of the Project costs shown in Table 8-2.1 – Table 8-2.4.

[1] World Bank (2013a), “*Project appraisal document on a proposed loan in the amount of US$30 million to the republic of Armenia for an irrigation system enhancement project*”

[2] KfW (2014), “*Integrated Water Resource Management/Akhouryan River – Construction of Kaps Reservoir and Gravity Irrigation System – Task I Update of feasibility study, Draft feasibility report.* ”

[3] AFD (2014), “*Construction of the Vedi Reservoir for irrigation in the Ararat Valley – Task1: Feasibility Study*”

Summing up incremental O&M cost and large rehabilitation cost, the annual O&M cost is 2.0%.

8) The percentage of accrued costs and benefits over the evaluation periods are summarized in Table 8-1.1.

- ➢ Increase in livestock production is supposed to be realized gradually over a 4-year period as on site-producers shift their agriculture systems step by step.
- ➢ Pumping irrigation system will be shifted to gravity irrigation system. Taking into account that it may take times to change the customs, it is assumed that it will pass 4 years to abolish the pump station completely.
- ➢ The amount of water distribution from Lake Sevan has been controlled by WSA so it is reasonable assumption that the benefit of conservation of Lake Sevan has been accrued just after the completion of construction.

Table 8-1.1 List of Percentage of Project Costs and Benefits accrued over the Evaluation Periods

Costs and Benefits over the periods		Year									
		2017	2018	2019	2020	2021	2022	2023	2024	2025	After 2026
(-)	Project Costs	4%	1%	38%	28%	20%	9%	0%	0%	0%	0%
(-)	O&M	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
(-)	Opportunity cost of HPPs	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
(-)	Land Compensation Cost	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
(+)	Increase in Cropping Income	Calculated in Annual Cash Flow by Crops (See Appendix-M)									
(+)	Increase in Livestock Production	0%	0%	0%	0%	0%	25%	50%	75%	100%	100%
(+)	Net Saving in Pump O&M cost	0%	0%	0%	0%	0%	25%	50%	75%	100%	100%
(+)	Conservation of Lake Sevan	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%

8-2 Estimated Project Costs

The Project cost by the option is already derived in the cost estimation. In order to carry out the economic analysis, the cost has to be divided into two partition: foreign currency and domestic currency. For the sake of applying appropriate specific conversion factors, domestic currency partition should be divided into material costs, skilled labor costs, unskilled labor costs, and equipment costs.

Table 8-2.1 to Table 8-2.4 show the Project costs by foreign currency and domestic currency. The economic project cost which has been applied in the economic analysis is shown in red color.

Table 8-2.1 Financial and Economic Costs (Bentonite Sheet)

Component	Cost Estimation	Financial Cost			Economic Cost			
		FC	LC	Total	FC	Conversion Factor	LC	Total
Material (a)	6.0	3.0	3.0	6.0	3.0	0.9	2.7	5.7
Labor (b = c + d)	41.5	2.1	39.4	41.5	2.1	-	34.5	36.6
c. Skilled Labor	24.1	1.2	22.9	24.1	1.2	1.0	22.9	24.1
d. Unskilled Labor	17.4	0.9	16.6	17.4	0.9	0.7	11.6	12.5
Equipment (e)	73.1	36.5	36.5	73.1	36.5	0.9	32.9	69.4
Direct Cost Total (A = a + b + e)	120.6	41.6	79.0	120.6	41.6	-	70.1	111.7
Indirect Expenses (B)	37.2	18.6	18.6	37.2	18.6	0.9	16.7	35.3
Construction Cost Total (C = A + B)	157.8	60.2	97.6	157.8	60.2	-	86.8	147.0
Consultant Service (D)	9.5	7.4	2.1	9.5	7.4	1.0	2.1	9.5
Base Cost (E = C + D)	167.3	67.6	99.7	167.3	67.6	-	88.9	156.5
Physical Contingency (F)	8.4	3.4	5	8.4	3.4	-	4.4	7.8
Economic Cost Components (G = E + F)	175.7	71.0	104.7	175.7	71.0	-	93.3	**164.3**
Price Contingency (J)	17.1	6.9	10.2	17.1	6.9	-	9.1	16.0
VAT (H)	38.6	15.6	23.0	38.6	15.6	-	20.5	36.1
Grand Total with VAT (K)	231.4	93.5	137.8	231.3	93.5	-	122.8	216.4

Source) The Survey Team

Table 8-2.2 Financial and Economic Costs (Soil-cement Coverage)

Component	Cost Estimation	Financial Cost			Economic Cost			
		FC	LC	Total	FC	Conversion Factor	LC	Total
Material (a)	7.6	3.8	3.8	7.6	3.8	0.9	3.4	7.2
Labor (b = c + d)	52.2	2.6	49.6	52.2	2.6	-	43.4	46.0
c. Skilled Labor	30.3	1.5	28.8	30.3	1.5	1.0	28.8	30.3
d. Unskilled Labor	21.9	1.1	20.8	21.9	1.1	0.7	14.6	15.7
Equipment (e)	92.0	46.0	46.0	92.0	46.0	0.9	41.4	87.4
Direct Cost Total (A = a + b + e)	151.8	52.4	99.4	151.8	52.4	-	88.2	140.6
Indirect Expenses (B)	46.9	23.5	23.5	46.9	23.5	0.9	21.1	44.6
Construction Cost Total (C = A + B)	198.7	75.9	122.9	198.7	75.9	-	109.3	185.2
Consultant Service (D)	11.9	9.3	2.6	11.9	9.3	1.0	2.6	11.9
Base Cost (E = C + D)	210.6	85.1	125.5	210.6	85.1	-	111.9	197.0
Physical Contingency (F)	10.5	4.3	6.3	10.6	4.3	-	5.6	9.9
Economic Cost Components (G = E + F)	221.1	89.4	131.8	221.2	89.4	-	117.5	206.9
Price Contingency (J)	21.5	8.7	12.8	21.5	8.7	-	11.4	20.1
VAT (H)	48.5	19.6	28.9	48.5	19.6	-	25.8	45.4
Grand Total with VAT (K)	291.2	117.7	173.5	291.2	117.7	-	154.7	272.4

Source) The Survey Team

Table 8-2.3 Financial and Economic Costs (Bentonite-soil Mixture)

Component	Cost Estimation	Financial Cost			Economic Cost			
		FC	LC	Total	FC	Conversion Factor	LC	Total
Material (a)	6.2	3.1	3.1	6.2	3.1	0.9	2.8	5.9
Labor (b = c + d)	42.4	2.1	40.3	42.4	2.1	-	35.2	37.3
c. Skilled Labor	24.6	1.2	23.4	24.6	1.2	1.0	23.4	24.6
d. Unskilled Labor	17.8	0.9	16.9	17.8	0.9	0.7	11.8	12.7
Equipment (e)	74.7	37.4	37.4	74.7	37.4	0.9	33.6	71.0
Direct Cost Total (A = a + b + e)	123.3	42.6	80.7	123.3	42.6	-	71.6	114.2
Indirect Expenses (B)	38.2	19.1	19.1	38.2	19.1	0.9	17.2	36.3
Construction Cost Total (C = A + B)	161.5	61.7	99.8	161.5	61.7	-	88.8	150.5
Consultant Service (D)	9.7	7.6	2.1	9.7	7.6	1.0	2.1	9.7
Base Cost (E = C + D)	171.2	69.2	102.0	171.2	69.2	-	90.9	160.1
Physical Contingency (F)	8.6	3.5	5.1	8.6	3.5	-	4.5	8.0
Economic Cost Components (G = E + F)	179.8	72.7	107.1	179.8	72.7	-	95.4	168.1
Price Contingency (J)	17.5	7.1	10.4	17.5	7.1	-	9.3	16.3
VAT (H)	39.5	16.0	23.5	39.5	16.0	-	20.9	36.9
Grand Total with VAT (K)	236.8	95.7	141.0	236.8	95.7	-	125.6	221.4

Source) The Survey Team

Table 8-2.4 Financial and Economic Costs (Soil-cement with a Sandwiched Bentonite Sheet)

Component	Cost Estimation	Financial Cost			Economic Cost			
		FC	LC	Total	FC	Conversion Factor	LC	Total
Material (a)	5.9	3.0	3.0	5.9	3.0	0.9	2.7	5.7
Labor (b = c + d)	40.7	2.0	38.7	40.7	2.0	-	33.8	35.8
c. Skilled Labor	23.6	1.2	22.4	23.6	1.2	1.0	22.4	23.6
d. Unskilled Labor	17.1	0.9	16.2	17.1	0.9	0.7	11.4	12.3
Equipment (e)	71.7	35.8	35.8	71.7	35.8	0.9	32.3	68.1
Direct Cost Total (A = a + b + e)	118.3	40.8	77.5	118.3	40.8	-	68.8	109.6
Indirect Expenses (B)	36.5	18.3	18.3	36.5	18.3	0.9	16.4	34.7
Construction Cost Total (C = A + B)	154.8	59.1	95.7	154.8	59.1	-	85.2	144.3
Consultant Service (D)	9.3	7.3	2.1	9.3	7.3	1.0	2.1	9.4
Base Cost (E = C + D)	164.1	66.3	97.8	164.1	66.3	-	87.3	153.6
Physical Contingency (F)	8.2	3.3	4.9	8.2	3.3	-	4.4	7.7
Economic Cost Components (G = E + F)	172.3	69.6	102.7	172.3	69.6	-	91.7	161.3
Price Contingency (J)	16.7	6.8	10.0	16.7	6.8	-	8.9	15.7
VAT (H)	37.8	15.3	22.5	37.8	15.3	-	20.1	35.4
Grand Total with VAT (K)	226.9	91.7	135.2	226.9	91.7	-	120.7	212.4

Source) The Survey Team

8-3 Expected Project Benefits

In the base analysis, three (3) major benefits are considered; a) benefit from yield and area increase in crop production; b) benefit from livestock production improvement; c) benefit from O&M cost reduction by abolishing pump stations.

As reference, on the top of base case, further benefit d) benefit from conservation of Lake Sevan is also taken into consideration. The benefit is quite important as it is mentioned in national strategies of RA. However, it is not easy to estimate the economic value since the environmental benefit is non-marketed. In this respect, the benefit is calculated as reference only.

In this sub-chapter, above mentioned four (4) benefit will be identified in economic terms. Firstly, specific conversion factors for economic pricing are calculated in Sub-Chapter 8-3-1.

8-3-1 Conversion Factors Employed in the Evaluation

It should be noted that conversion factors are not standardized in Armenia. Due to data and time limitation, calculation results from similar projects is applied. Followings are the calculation basis for specific goods and services;

(a) Skilled and Unskilled Labor

For skilled labor, generally “competitive market” is assumed. It means that the specific conversion factor for skilled labor is 1.000. In contrast to this, reflecting rural unemployment, 0.700 of the specific conversion factor for unskilled labor is employed, which is widely used in project evaluation.

(b) Fuel requiring works

On the one hand, fuel for the agricultural sector is subsidized 70 AMD/liter of the market price, and the fuel price subsidized is 350AMD/liter. Then, the subsidy-adjusted market price is 420AMD/liter or 20% higher than the one subsidized. On the other hand, fuel is taxed by 2.8 % of the market price, so the unbiased market price is 17.2% higher than the actual one (20% - 2.8%).

It is unclear how much percentage out of the cost for mechanized works can be explained by fuel charge, therefore, referring to similar project, it is assumed that 30% out of them is fuel charge.

From the above mentioned calculation basis, the specific conversion factor for fuel requiring works is; $\{1+0.3\times(70/350 - 0.028)\} \fallingdotseq 1.052$.

(c) Seeds

According to the interview to MOA, some seeds are subsidized. The market price and selling price to farmers with subsidies are shown in Table 8-3-1.1. Immediately, the specific conversion factors are 1.888 for wheat, 2.532 for barley, 1.797 for alfalfa and 2.663 for maize.

Table 8-3-1.1 Calculation of Conversion Factors for Subsidized Seeds

Seeds	(AMD/kg)			Conversion Factor 1+(B)/(C)
	Market Price (A)	Selling Price to farmers with subsidies (B)	Difference (C) =(A) - (B)	
Wheat	302.0	160	142.0	1.888
Barley	329.1	130	199.1	2.532
Alfalfa	2,695.0	1,500	1,195.0	1.797
Maize	932.0	350	582.0	2.663

Source) The Survey Team, data is provided by MOA

(d) Fertilizers

Conversion factors for some fertilizers subsidized are calculated as listed in Table 8-3-1.2. The specific conversion factors are 1.536 for nitrogenous fertilizer, 1.971 for phosphoric fertilizer and 1.971 for potassic fertilizer.

Table 8-3-1.2 Calculation of Conversion Factors for Subsidized Fertilizers

Fertilizer	(AMD/kg)			Conversion Factor 1+(B)/(C)
	Market Price (A)	Selling Price to farmers with subsidies (B)	Difference (C) = (A) - (B)	
Nitrogenous	184.3	120.0	64.3	1.536
Phosphoric	276.0	140.0	136.0	1.971
Potassic	276.0	140.0	136.0	1.971

Source) The Survey Team, data is provided by MOA

(e) Water Fees

According to the WB (2013a), current averaged water cost is approximately 18.7 AMD per m^3 or 1.7 times larger than farmer's water fee 11.04 AMD per m^3. Therefore, the specific conversion factor is 1.700.

(f) Electricity

According to the WB (2013a), current electricity prices in Armenia (AMD 0.67/kw/h) are significantly lower than their real costs. Consequently, the specific conversion factor of electricity cost is 1.250.

(g) Crop pricing

Due to the data limitation, the survey team applies specific conversion factors calculated in KfW (2014). By using the result, it is estimated 1.020 for winter wheat, 0.720 for barley, 0.820 for maize, and 1.000 for other crops.

(h) Others

Standard Conversion Factor (0.90) has been applied for other economic pricing if it is necessary.

8-3-2 Increment in Cropping Income

In the existing irrigation areas (8,391ha), with the Project, the greater reliability and volume of water will enable farmers to produce crops more stably since they have been managed their irrigation water at the suitable time. In other words, the Project can mitigate the damages in yields due to extreme weather conditions such as irregular and random precipitation. Moreover, in the newly developed areas, additional irrigable areas (3,956ha) will be generated. The increment in agricultural income is the largest and most important benefit of the Project.

To estimate the benefit, valuation of costs and benefits of crop production was made by reference to the collected information in Table 8-3-2.1

Table 8-3-2.1 Information Sources for Costs and Benefits Valuation of Major Crops

Information	Main Source
1. Costs and benefits calculation basis, open field cultivation	Ministry of Agriculture, RA
2. Costs and benefits calculation basis, greenhouse cultivation	The Greenhouse Association, RA
3. Unit prices (inputs, labor, crops, etc.)	Survey result of the Survey Team
4. Productivity of crops	Community offices concerned WUA workshops
5. Farming practice of fruits and grapes	Experienced farmers

Source) The Survey Team

(1) Costs factors

a. Crop production costs

Unit production costs of major crops are shown in Table 8-3-2.2, while breakdown of the costs for each crop including conversion to economic costs is shown in Appendix-M. The crop production costs between the cases of without-project (present) and of with-project are same, as it is considered that crop management of individual farmers in the Project area will not change even after construction of the Yeghvard reservoir.

Table 8-3-2.2 Production Costs of Major Crops (per ha)

No.	Crop	Financial Costs (AMD/ha)	Economic Costs (AMD/ha)	Remarks
1	Wheat	344,000	416,394	1 crop
2	Barley	298,667	357,619	1 crop
3	Maize (grain)	468,800	523,462	1 crop
4	Alfalfa	3,783,000	3,553,503	6 years total
5	Potato	1,735,000	1,778,478	1 crop
6	Tomato, open	1,761,800	1,713,074	1 crop
7	Tomato, green-house	14,951,500	12,772,680	1 crop
	Greenhouse construction	38,000,000	38,000,000	20 years-life
8	Cucumber, open	1,533,200	1,490,021	1 crop
9	Cucumber, green-house	12,849,600	11,448,500	1 crop
	Greenhouse construction	38,000,000	38,000,000	20 years-life
10	Eggplant	1,746,600	1,708,581	1 crop
11	Sweet pepper	1,738,600	1,700,168	1 crop
12	Cabbage	1,420,200	1,404,204	1 crop
13	Water melon	1,550,000	1,596,869	1 crop
14	Grape (50 years average)	76,760,000	63,253,398	50 years total
15	Apricot (60 years average)	48,831,400	42,304,211	60 years total
16	Apple (30 years average)	38,699,200	33,968,055	30 years total

Source: The Survey Team

b. Additional initial costs for new cropping

The new cropped area is categorized into farmland in cadaster. According to the results of the field survey, a major part of the area is abandoned farmland with poor vegetation due to rather dry climate condition in the area. Most farmers will be able to start farming in the new cropped area without large-scale land reclamation works considering the present condition. Table 8-3-2.3 shows additional costs borne by individual farmers for starting farming in the new cropped area. The costs are only applicable to annual crops and alfalfa, since such costs for grapes and other fruits are included in the production costs as shown in Table 8-3-2.2.

Table 8-3-2.3 Additional Initial Costs for New Cropping

Inputs	Financial Costs (AMD/ha)	Economic Costs (AMD/ha)	Remarks
Land cleaning & stone collection	50,000	3,5000	Hired labor
Deep Tillage	70,000	73,640	Tractor
Land levelling	20,000	21,040	Tractor
Compost	80,000	80,000	10 ton/ha
Total	220,000	209,680	

Source: The Survey Team

(2) Crop farm-gate prices

Crop farm-gate prices as shown in Table 8-3-2.4 were collected through the survey and converted into economic prices using conversion factors referenced from KFW (2014).

Table 8-3-2.4 Crop Farm-gate Prices

No.	Crop	Financial Price (AMD/kg)	Economic Price (AMD/kg)	Remarks
1	Wheat	120	122	
2	Barley	-	-	Converted to livestock value
3	Maize (grain)	-	-	Converted to livestock value
4	Alfalfa	-	-	Converted to livestock value
5	Potato	110	110	
6	Tomato, open	120	120	
7	Tomato, green-house	250	250	
8	Cucumber, open	100	100	
9	Cucumber, green-house	220	220	
10	Eggplant	100	100	
11	Sweet pepper	170	170	
12	Cabbage	110	110	
13	Water melon	60	60	
14	Grape	150	150	
15	Apricot	200	200	
16	Apple	200	200	

Source) The Survey Team

It is expected that additional 3,956 ha will be irrigated with the Project. Assuming that 70% out of 3,956 ha will have started cultivation from just after the completion of Yeghvard reservoir (i.e. from 2023), and the other 20% and 10% of them will starting from 2^{nd} year (2024) and 3^{rd} year (2025) respectively.

The benefit calculation is done based on annual cash flow by each crops. Figure 8-3-2.1 shows that the annual agricultural benefit including both existing irrigable areas and newly developed areas. For more detail, see Appendix-M.

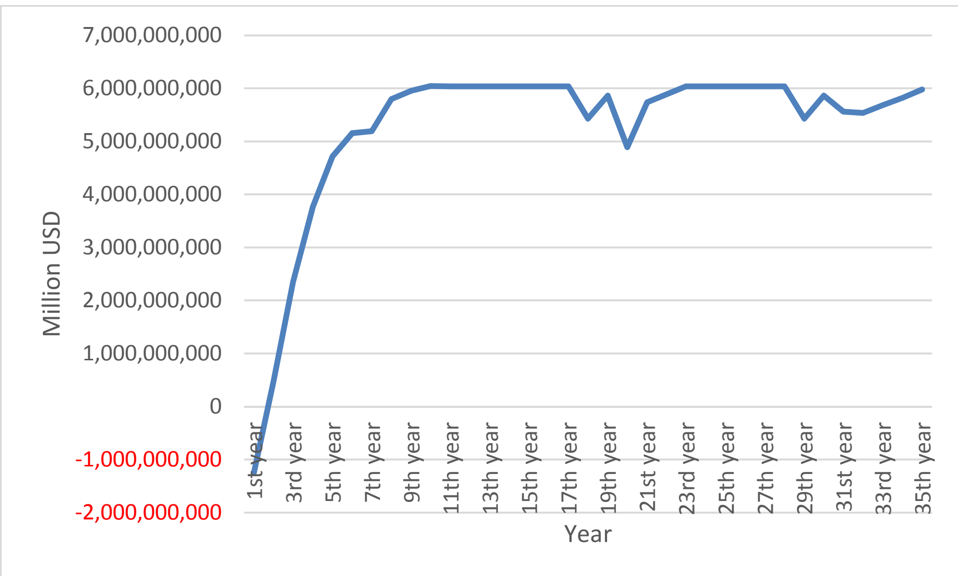


Figure 8-3-2.1 Annual Cash Flow of Agriculture Benefit (Unit: Million USD)

8-3-3 Increment in Livestock Production

It is said that fodder production is one of a bottleneck of livestock breeding. Since self-fodder production plays an important role of livestock breeding, it is expected that the increase in production of alfalfa and other fodder crops trigger the increase in number of livestock that farmers can produce.

Table 8-3-3.1 shows that the estimated number of cattle can be fed by farmer's self-produced forages in 2015 (without Project) and in 2023 (with Project). The benefit from increase in livestock production is 659,070 USD (Table 8-3-3.2).

Table8-3-3.1 Number of Cattles Fed by Produced Forages in 2015 and in 2023

Crop	Livestock Production in 2015			Livestock Production in 2023		
	Area (ha)	Yield (kg/ha)	Production (ton)	Area (ha)	Yield (kg/ha)	Production (ton)
Alfalfa	799	11.3	9.0	1,446	16.0	23.1
Other Food and Forage	433	2.5	1.1	601	2.7	1.6
Total (ton)			10.1			24.8
Forage requirement per cattle (kg)			2.4			2.4
Cattles can be fed by forages (heads)			4,213			10,316

Source) The survey Team based on interviews to livestock producers

Table8-3-3.2 Aggregated Livestock Income in 2015 and in 2023

Livestock	Without (2015)			With (2023)			With - Without
	Heads	Net Profit (USD)	Profit (USD)	Heads	Net Profit (USD)	Profit (USD)	
Cattle	4,213	108	455,040	10,316	108	1,114,110	659,070

Source) The survey Team

8-3-4 Net Saving in Pump O&M Cost

With the Project, all of deep wells and pump stations operated by WUA and WSA in the Project target areas will be converted to gravity irrigation systems. It means that O&M cost of deep wells and pumps will be zero after the completion of abolishment. The O&M cost reduction is one of the main benefit of the project.

Table 8-3-4.1 Operation and Maintenance Cost of Pump Station Operated by WSA

Name of the pump station	O&M title	Unit	Years					
			2011	2012	2013	2014	2015	Average
Ranchpar 1	Electricity	thousand kWh	2,000.4	3,063.3	7,340.7	9,281.7	8,593.8	6,056.0
		thousand AMD	45,362.9	68,767.9	223,603.2	311,327.9	333,074.0	196,427.2
	Repair and maintenance	thousand AMD	9,450.0	8,125.2	10,221.0	10,620.0	15,000.0	10,683.2
Ranchpar 2	Electricity	thousand kWh	125.3	548.5	4,480.5	6,018.0	5,138.3	3,262.1
		thousand AMD	2,458.6	10,781.6	122,936.1	179,079.7	180,838.9	99,219.0
	Repair and maintenance	thousand AMD	6,725.0	7,120.5	5,840.0	9,720.0	12,000.0	8,281.1
Aknalich	Electricity	thousand kWh	2,202.2	1,983.6	1,550.9	1,779.9	1,183.5	1,740.0
		thousand AMD	49,729.9	44,563.7	43,879.7	59,355.7	45,456.3	48,597.1
	Repair and maintenance	thousand AMD	4,950.0	6,120.0	8,346.0	4,620.0	5,000.0	5,807.2
Total	Electricity	thousand kWh	4,327.9	5,595.4	13,372.1	17,079.6	14,915.6	11,058.1
		thousand AMD	97,551.4	124,113.2	390,419.0	549,763.3	559,369.2	344,243.2
	Repair and maintenance	thousand AMD	21,125.0	21,365.7	24,407.0	24,960.0	32,000.0	24,771.5

Source) WSA

Taking average by multiple year, the current annual electricity cost of three (3) large pump stations operated by WSA is 344,243.2 thousand AMD, while the repair and maintenance cost of them is 24,771.5 thousand AMD per year (Table 8-3-4.1).

On the other hand, there are large number of deep wells and small pump stations operated by WUA. The total electricity cost of them is estimated 611,058.2 thousand AMD per year, while the total repair and maintenance cost of them is estimated 68,861.1 AMD per year (Table 8-3-4.2).

Table 8-3-4.2 Operation and Maintenance Cost of Pump Station Operated by WUA

WUA	O&M title	Unit	Years			
			2013	2014	2015	Average
Vagharshapat	Electricity	thousand AMD	240,063.3	308,097.8	353,835.7	300,665.6
	P/S and D/W Rehabilitation	thousand AMD	19,840.4	22,245.4	76,775.2	39,620.3
Khoy	Electricity	thousand AMD	278,151.9	301,995.3	351,030.4	310,392.5
	P/S and D/W Rehabilitation	thousand AMD	21,922.2	43,360.4	21,698.9	28,993.8
Ashtarak	Electricity	thousand AMD	0.0	0.0	0.0	0.0
	P/S and D/W Rehabilitation	thousand AMD	0.0	0.0	0.0	0.0
Yeghvard	Electricity	thousand AMD	0.0	0.0	0.0	0.0
	P/S and D/W Rehabilitation	thousand AMD	53.0	648.7	39.1	246.9
Total	Electricity	thousand AMD	518,215.1	610,093.2	704,866.2	611,058.2
	P/S and D/W Rehabilitation	thousand AMD	41,762.6	65,605.8	98,474.1	68,861.1

Source) WUA

Using specific conversion factors (See Sub-Chapter 8-3-1), the benefit of O&M cost reduction is estimated 2,625,097.3 USD/year in economic terms (Table 8-3-4.3).

Table 8-3-4.3 Aggregated Saving Costs for Operation and Maintenance of D/W and P/S

Operation and Maintenance		Financial O&M		Conversion Factor	Economic O&M
		(thousand AMD)	(USD)		(thousand USD)
Electricity	WSA	344,243.3	706,879.6	1.25	883,599.5
	WUA	611,058.2	1,254,765.3	1.25	1,568,456.6
Repair and Maintenance	WSA	24,771.5	50,866.5	0.90	45,779.9
	WUA	68,861.1	141,401.5	0.90	127,261.4
Total		1,048,934.1	2,153,912.9	-	2,625,097.3

Source) The Survey Team

8-3-5 Conservation of Lake Sevan (Reference)

Lake Sevan, the world's largest high-altitude lakes located in the central part of Armenia, has environmental, economic, and social significance and is an important multipurpose water reservoir for irrigation, hydropower and recreational uses. The Project target area is no exception since 50MCM/year out of irrigation water demand is now distributed from the Lake. To protect the Lake, Armenian government adapted two laws in 2001 that recognized the importance of Lake Sevan and targeted to raise the level 6 meters by 2030. From these reasons, it is essentially important to reduce the dependency of Lake Sevan in irrigation by developing another water resource within the Hrazdan river basin.

With the Project, snow melting water, which is now in no use in irrigation, will be utilized for irrigation purposes, and the water dependency from Lake Sevan is planned to be zero thanks to the Project. Since this "conservation of Lake Sevan" is consistent with Armenian national strategy, it is better to be estimated as the numerical value on the viewpoint of the national economy.

Since "water resource" is generally non-marketed goods, the benefit should be converted to monetary basis in some sort of ways. In order to do this, the benefit calculation applies the idea "alternative method" with necessary modification. The basic concept of it is that if "without the project", this conservation Lake Sevan shall be achieved by an alternative methods. In this case, additional cost is needed, for instance, construction of alternative facilities. It can be said that the cost of alternative methods are some kinds of saving cost thanks to the project.

In this analysis, three alternative methods are proposed with following conditions;

Alternative 1): without project, conservation of Lake Sevan will be achieved up to 50MCM of water per year thanks to extension of drip irrigation system somewhere outside of project areas.

Alternative 2): without project, construction of another reservoir has to be needed in order to stock same amount (50 MCM/year) of free water.

Alternative 3): without project, conservation of Lake Sevan will be achieved by constructing tunnel like Arpa-Sevan tunnel that transfers up to 50 MCM/year.

(1) The Cost of Alternative 1 (Introduce of Drip Irrigation)

Explanation: Without project, independence from Lake Sevan will be achieved by 50MCM/year of water saving thanks to extension of drip irrigation system;

1) Current irrigation water demand with furrow irrigation which *including* water loss during conveyance per ha is 12,472 m^3/ha (154 MCM/12,347 ha).

2) Current *net* irrigation water demand with furrow irrigation *not including* water loss during conveyance per ha is 5,837 m^3/ha (12,472 m^3/ha x 46.8 %).

3) Irrigation water demand with drip irrigation *including* water loss during conveyance per ha is 8,186 m^3/ha (5,837 m^3/ha / 71.3 %)

4) Taking difference, the volume of saving water by introducing drip irrigation is 4,286 m^3/ha (12,472 m^3/ha - 8,186 m^3/ha).

5) To save irrigation water up to the volume of 50 MCM, 11,666 ha of furrow irrigation system should be converted to drip irrigation (50,000,000 m^3 / 4,286 m^3/ha), which costs 13,357 million AMD or equivalent to 27.43 million USD. -------------- (A)

Note: Assume that the on-farm investment cost of introducing drip irrigation is 1,145,000AMD, referring KfW (2014).

Table 8-3-5.1 Capacity of Reservoir by Irrigation Area and Irrigation Method

Trial	Area		Irrigation Type	Conveyance Efficiency	Demand (MCM)	Yeghvard (MCM)
-	12,347		Furrow	46.8%	154	94
(i)	3,644		Furrow	46.8%	40	35
(ii)	12,347	9,949	Furrow	46.8%	146	84
		2,398	Drip	71.3%		
(iii)	12,347	8,397	Furrow	46.8%	140	79
		3,950	Drip	71.3%		

Source: This Report, Table 6-4-3.6
Note: The conveyance efficiency by furrow irrigation defines 46.8% which is calculated as 72% times 65%, and that of drip irrigation defines 71.3% which is calculated as 75% times 95%.

(2) The Cost of Alternative 2 (Reservoir Construction)

Explanation: Without project, construction of another reservoir has to be needed in order to stock 50 MCM of free water;

1) To employ the ordinal unit cost of water development in RA, WB (2015) is referred (Table 8-3-5.2).

2) The unit cost of water development is 1.82USD/m^3 (480.8 million USD/263.81 MCM).

3) To develop alternative reservoir with the volume of 50MCM, it is estimated that the cost is 91.0 million USD (1.82 USD/m^3 x 50MCM). -------------- (B)

Table8-3-5.2 Key Features of Priority Reservoirs

Reservoir name	*River basin*	*Marz (province)*	*Status*	*Total vol. (MCM)*	*Est. cost[a] (million US$)*
Kaps	Akhuryan	Shirak	Partially constructed; feasibility study is in progress for to 60 MCM reservoir option	60.00	44.0
Yegvard	Hrazdan	Kotayk	Partially constructed; feasibility study to be conducted	90.00	139.1
Vedi	Vedi	Ararat	Designed in Soviet times; feasibility study is ongoing; will be followed by preparation of final design for construction of dam	20.00	40.8
Apna	Kasakh	Aragatsotn	Partially constructed; final design was prepared in Soviet times	5.25	8.7
Karmir Guygh	Voskepar	Tavush	Partially constructed	8.50	33.0
Artik	Karkachun	Shirak	Partially constructed	1.69	3.5
Getik	Chichkhan	Lori	Partially constructed; preliminary design available	3.00	7.8
Lichk (Meghriget)	Meghriget	Syunik	New; preliminary design has been prepared by MCA	1.17	6.5
Oshakan (Kasakh)	Kasakh	Aragatsotn	New; feasibility study report is available	13.85	35.0
Argichi	Argichi	Gegharkunik	New dam; preliminary design is available, prepared by Millennium Challenge Corporation	5.50	4.2
Getikvanq	Elegis	Vayots Dzor	New; preliminary investigations have been implemented	23.00	54.0
Gegardalich 2	Yot Aghbyur	Kotayk	New; preliminary design is available	5.50	18.4
Hartavan	Gegharot	Aragatsotn	New; preliminary design is available	3.00	9.7
Khndzoreshk	Karkachun	Syunik	New; preliminary investigations have been implemented	5.20	13.0
Upper Sasnashen	Upper Sasnashen canal	Aragatsotn	New; preliminary investigations have been implemented	1.00	6.5
Elpin	Elpin	Vayots Dzor	New; final design is available	1.00	4.0
Khachik	Khachik canal	Vayots Dzor	New; preliminary investigations have been implemented	0.50	3.1
Astghhadsor	Astghhadsor	Gegharkunik	New; preliminary investigations have been implemented	1.25	2.3
Byurakan (Hamberd)	Hamberd	Aragatsotn	New; preliminary investigations have been implemented	2.70	8.7
Geghadzor	Geghadzor	Aragatsotn	New; preliminary design is available	1.50	6.5
Selav-Mastara	Selav-Mastara	Armavir	New; feasibility study was updated	10.20	32.0
Total				**263.81**	**480.8[b]**

Source: WB (2015) "Toward Integrated Water Resource Management in Armenia"

(3) The Cost of Alternative 3 (Tunnel Construction)

Explanation: To cope with the decreasing trend of the level of Lake Sevan, programs to stabilize the lake level had started in the 1980s. This includes the construction of Arpa-Sevan tunnels, which transferring up to 250 MCM. As the cost of alternative three (3), construction of another tunnel is derived from the project cost of Apra-Sevan tunnel.

1) The project cost of Arpa-Sevan Tunnel is estimated at 4.5 billion USD evaluated in the present monetary value.

2) Planted volume of water conveyance from Lake Arpa to Lake Sevan is 250MCM/year.

Therefore, the unit price of water development per m^3 is:

$$4{,}500 \text{ million USD}/250\text{MCM} = 18.0 \text{ USD}/m^3$$

The cost of similar tunnel with the water conveyance is up to 50 MCM/year is 900 million USD (18.0 USD/m^3 x 50MCM). -------------- (C)

(4) Annual Benefit Estimation

The comparison between alternative1-3 finds that the most efficient option is alternative one (1): introduce of drip irrigation. From the point of conservatism principle, alternative one (1) is applied as the saving cost of the Project.

Annual benefit is calculated as initial investment cost times discount factor (d_{in}) which is defined as following.

$$\textit{Discount Factor}\ (d_{in}) = \frac{i \times (1+i)^n}{(1+i)^n - 1}$$

i: social discount ratio (12 % is assumed), n: design service life of the facilities (80 years is assumed)

Therefore, the annual benefit of conservation of Lake Sevan is;

$$\textit{The cost of Alternative1} \times \textit{Discount Factor} = 27.43 \textit{ Million USD} \times 0.12 \fallingdotseq 3.3 \textit{ Million USD}$$

8-3-6 Opportunity Cost of the Project

(1) Opportunity Cost of HPPs Operation

Taking irrigation water from the basin may negatively influence other sectors of the region. The most concerning sector is hydropower station of Sevan-Hrazdan cascade operated by Russian company.

There are seven hydropower stations which account for 10% of the country's electricity. The annual electrical energy production of seven (7) hydropower station is 535.283 million kWh on averaging 2011-2015. The opportunity cost of HPPs is calculated as following;

1) The average current annual production by the seven Sevan-Hrazdan cascade HPPs is 535.283 million kWh on averaging 5 years (2011-2015).

2) On the other hand, the total annual water flow from Hrazdan River connected with seven HPPs is 2,089.382 MCM on averaging 2011-2015.

3) It is assumed that taking 154MCM (104MCM as for irrigation water + 50MCM as for conservation of Lake Sevan) of irrigation water from Hrazdan river reduce the productions of HPPs following the same proportion of water volume: 7.3% (154MCM/2,089.382MCM × 100).

4) According to power tariff study in Armenia, cost-recovery tariff of Sevan-Hrazdan Cascade of HPPs is 4.578AMD/kWh.

Then, the annual opportunity cost of seven HPPs is estimated as 179.4 million AMD (535.283 million kWh × 4.578 AMD/kWh × 7.3%), or equivalent to 0.37 million USD.

(2) Land Compensation and Land Acquisition

According to JICA's guideline, "land compensation and acquisition cost" have to be considered as "opportunity cost" of the project. According to chapter 5, Land compensation cost of the project is about 0.9 million USD in total.

8-4 Results of Economic Evaluation

Table 8-4.1 summarizes the economic evaluation by the options. As already mentioned, the economic Project cost consists of base cost and physical contingency. In the economic analysis, benefits and costs are standardized in economic terms using conversion factors. Three indicators have been applied: economic internal rate of return (EIRR), net present value (NPV), and benefit-cost ratio (B/C). NPV and B/C are calculated with 12.0% opportunity cost of capital.

All of the options cannot exceed 12.0% opportunity cost of capital which may reflect the little improvement in yield because the Project components consist only of irrigation systems, and not taking account any agricultural extension and/or other soft components. The Project might produce fruits more if there were other components such as agricultural extension to promote more-profitable but more water-intensive products such as vegetable and fruits.

Comparing the four (4) options, "soil-cement with bentonite sheet" marked highest on EIRR and NPV, indicating 3.68 % of EIRR with -71.9 million USD of NPV, and 0.40 of B/C in base case. Still, it is not regarded as viable even the reference case (including the benefit from conservation of Lake Sevan) as the EIRR is 5.72% against 12.0% referenced opportunity cost of capital.

Table 8-4.1 Summary of the Economic Evaluation by the Options

Indicators	Options			
	Bentonite Sheet	Bentonite-Soil mixture	Soil-Cement	Soil-cement with bentonite sheet
Project Cost calculated in Cost Estimation				
Grand Total with VAT (Million USD)	231.4	291.2	236.8	226.9
Economic Analysis				
Economic Cost (million USD)	164.3	206.9	168.1	161.3
Incremental O&M Cost (million USD)	1.6	2.1	1.7	1.6
Total Benefit (Base) (million USD)	12.6	12.6	12.6	12.6
EIRR (Base, %)	3.49%	1.60%	3.30%	3.68%
B/C (Base)	0.39	0.31	0.38	0.40
NPV (Base, Million USD)	-74.9M$	-106.6M$	-77.8M$	-71.9M$
Total Benefit (Reference) (million USD)	14.0	14.0	14.0	14.0
EIRR (Reference, %)	5.51%	3.51%	5.31%	5.72%
B/C (Reference)	0.51	0.41	0.50	0.53
NPV (Reference, Million USD)	-59.9M$	-91.5M$	-62.7M$	-56.9M$

Source) The Survey Team

8-5 Other Qualitative Benefits

For economic evaluation, benefits have to be limited only on "direct", "quantitative", and "not tentative" ones. Still, there are other important benefits originated from the Project so that it is better to be mentioned qualitatively in this sub-chapter. Following are other expected and recommended qualitative project benefits;

1) Cultivation of groundwater; In the Project target areas, there are some cases that WUAs have pumped up the groundwater and used it for irrigation purposes. The current situation of ground water levels and the volumes of collected water by drain canal for irrigation purposes become worse year by year, especially in Ararat plain area. The abolishment of pumps and deep wells may lead to ground water recharge, which will contribute to protection of the ecosystem in the area.

2) Encourage some industries around the Yeghvard area: The Project area is characterized as a leading area of vegetables and fruits production in the country. Additional agricultural productions may encourage businesses in secondary and tertiary sectors such as food processing industries, packaging industries, agricultural inputs industry, and transportation industry.

3) Creating job opportunity: Although it is a tentative benefit limited only during the construction periods, additional job opportunity will be created on the Armenian labor market.

4) Contribution for climate change mitigation: As it is mentioned in Sub-chapter 5-3-5, the estimated reduction of GHG emission thanks to the Project is 16,575.02 t CO_2/year if all of irrigation purpose pump stations and deep wells in the Project target areas would be abolished. Although it is only secondary impact, the project implementation may reduce the vulnerability of climate change as mentioned in Sub-chapter 5-3-6.

5) Contribution for tourism and leisure industries: There are many types of leisure facilities should be considered for installation nearby the reservoir such as a boating park, a fishing pond, a skating rink etc. It may encourage tourism and leisure industries within Yeghvard areas.

8-6 Proposed Indicators

Several indicators should be established in order to monitoring the Project's status. There are two kinds of indicators: operational indicator and effect indicator.

Operational indicator is an indicator measuring whether the output of the Project has been operated and utilized appropriately, while effect indicator is an indicator that aims at measuring whether the Project impact has been realized as expected.

For the usage of these indicators, several indicators are established based on the plan of 5 years after the project implementation. In the plan, the year of the completion of construction is 2022, so the proposed indicators are evaluated in 2027.

(1) Proposed indicators of irrigation systems (Irrigable area Increase)

Currently, there are 8,391 ha of existing irrigated cropping areas, and additional 3,956 ha of irrigable cropping areas will be generated after the Project implementation. Table 8-6.1 summarizes the current and planned cropping areas.

Table 8-6.1 Operational and Effect Indicators of Irrigation Systems

Crops	Existing Irrigated Area (ha)		Newly Developed Area (ha)		Total Target Area (ha)	
	Baseline Value (2015)	Proposed Indicator (2027)	Baseline Value (2015)	Proposed Indicator (2027)	Baseline Value (2017)	Proposed Indicator (2027)
Wheat	1,535	1,535	0	366	1,535	1,901
Vegetables	2,844	2,844	0	798	2,844	3,642
Grape	1,060	1,060	0	1,221	1,060	2,381
Fruits	831	831	0	788	831	1,619
Alfalfa	916	916	0	536	916	1,452
Other Food and Forage	492	492	0	109	492	601
Potatoes	713	713	0	138	713	851
Total	8,391	8,391	0	3,956	8,391	12,447
Livestock (head)	4,213	6,620	0	3,696	4,213	10,316

Source) The Survey Team

However, there are some external conditions such as transformation on land usage, especially from agricultural land to non-agricultural land, acceleration of retirements in farming due to population aging, and lacks of successors in agricultural sector.

(2) Proposed indicators of irrigation systems (Yield Increase)

Improvement in water stability benefits to farmers not only for current irrigable areas, but also new irrigable areas. However, it may take several years to get profit enough in the newly developed area, especially for plantations. Considering this, the targeted yields are set as Table 8-6.2.

Table 8-6.2 Operational and Effect Indicators of Agriculture Supporting

Crops	Existing Irrigated Area (ton/ha)		Newly Developed Area (ton/ha)	
	Baseline Value (2015)	Proposed Indicators (2027)	Baseline Value (2015)	Proposed Indicators (2027)
Wheat	3.6	3.8	-	3.6
Barley	2.7	3.0	-	2.9
Maize (grain)	2.4	2.4	-	2.3
Alfalfa	11.3	11.3	-	11.3
Potato	36.3	40.0	-	38.0
Tomato, open	47.7	48.3	-	45.9
Tomato, green-house	100.0	100.0	-	100.0
Cucumber, open	38.4	40.0	-	38.0
Cucumber, green-house	80.0	80.0	-	80.0
Eggplant	49.8	53.1	-	50.4
Sweet pepper	38.9	40.1	-	38.1
Cabbage	29.7	30.6	-	29.1
Water melon	42.7	44.4	-	42.2
Grape	11.2	12.2	-	8.70
Apricot	7.1	7.5	-	0.00*
Apple	7.7	8.9	-	7.10

Source) The Survey Team

* The proposed annual cropping plan and expected yield is shown in Appendix-M
It is difficult to cultivate any fruits within the 5 year period after planting.

(3) Proposed indicators of gravity irrigation systems (energy saving)

All pump stations and deep wells in the target areas are expected be shifted to gravity irrigation system. The plan requires that there will be no running pump station nor deep wells by 4 years after the completion of construction (i.e.2026). Table 8-6.3 indicates the proposed indicators of gravity irrigation systems.

Table 8-6.3 Operational and Effect Indicators of Gravity Irrigation Systems

Operation unit	Name of WUA/PS	Baseline Value				Proposed Indicators (2027) (kWh)
		2013 (thousand kWh)	2014 (thousand kWh)	2015 (thousand kWh)	Average 2013-2015 (kWh)	
WSA	Ranchpar 1	7,340.7	9,281.7	8,593.8	8,405.4	0
	Ranchpar 2	4,480.5	6,018.0	5,138.3	5,212.3	0
	Aknalich	1,550.9	1,779.9	1,183.5	1,504.8	0
WUA	Yegvard	0	0	0	0	0
	Ashtarak	0	0	0	0	0
	Khoy	9397.0	9070.3	9212.3	8713.1	0
	Vagharshapat	7897.5	8980.6	9048.8	8001.6	0
Total		30,666.6	35,130.5	33,176.6	31,837.1	0

Source) The Survey Team

The most important external condition is the national policy of RA. Abolishment of pump irrigation is consistent with Armenian national strategies, which makes it easier to request corporations to stakeholders. The policy must have been kept to accomplish the target.

Another important external condition is the irrigation water demand outside of the Yegvard reservoir basin. In principle, all of pumps and deep wells in the area shall be abolished, still, the plan does not exclude the possibility of complementary usage of them in the case of argent needs of water, the water insufficient within the Hrazdan river basin due to very little precipitation or extremely hot summer, for example.

(4) Proposed indicators of water conveyance from Lake Sevan (Conservation of Lake Sevan)

One of the main contribution of the Project is the conservation of Lake Sevan by reducing its burdens on irrigation water. In the plan, the irrigation water in the Yeghvard basin will be distributed without any water supply from Lake Sevan as Table 8-6.4.

Table 8-6.4 Operational and Effect Indicators of Lake Sevan

Volume of Water Conveyance from Lake Sevan at 2015 (Baseline Value, MCM)	Volume of Water conveyance from Lake Sevan at 2027 (Proposed Indicator, MCM)
50	0

Source) The Survey Team

However, it should be noted that the plan is based on normal year so it might be difficult in the case if there would be unexpected additional irrigation water demands such as water shortage in other irrigation areas somewhere in the Hrazdan river basin.

CHAPTER 9 PROCUREMENT PLAN

9-1 Condition of Procurement and Contract

Procedure of the detailed design document approved by Armenian agencies

During detailed designs stage, there is an approval process to follow making documents of detailed design effective from the governmental agencies under the Ministry of Urban Development (MUD). For the environmental assessment, MNP takes responsibility on document of ESIA.

Two (2) ways; the one is inspected by independent expertise, the other one is done by state expertise due to technical level of the project. The documents to be prepared by the selected consultant through an international bidding shall apply for the approval to the private company who has the license issued by the governmental agency.

Which processes whether inspected by private company or government agency, are described in the contract to be signed by and between an implementation agency (PIU/SCWE) and the consultant.

9-2 Procurement of Consultant

The expected consultant service is mainly divided into the detailed design (D/D) and the construction supervision (C/S) stages. In case of applying Japanese Yen Loan, the borrower shall be in accordance with the "HANDBOOK for the Procurement under Japanese ODA Loans, April 2012". In addition, the Project shall be suitable harmony with FIDIC.

(1) Detailed Design (D/D) stage

The consultant for the Project should conduct the investigation, examination and design in this stage. In addition, the consultant should prepare the tender documents for the implementation as the result of D/D. The target facilities for designing are recommended separating by areas, namely; "Target Area 1" for reservoir and "Target Area 2" for irrigation system. Therefore, it is recommended having two packages, one is for "Target Area 1" by International Competitiveness Bidding (ICB), the other is for "Target Area 2" by National Competitiveness Bidding (NCB)

In addition, related ESIA works should be conducted by ESIA consultant selected by NCB with D/D consultant. Therefore, the recommended project packages are divided into three.

Table 9-2.1 Recommended Packages of the Project

Item	Target Area 1 by ICB	Target Area 2 by NCB	ESIA consultant by NCB
Targeted components	✓ Reservoir ✓ Feeder canal 1 and 2 ✓ Outlet canal 1, 2 and 3 ✓ Rehabilitation of Arzni-Shamiram canal	✓ Rehabilitation of Arzni-Branch canal ✓ Rehabilitation of Takahan canal ✓ Rehabilitation of Shah-Aru canal ✓ Rehabilitation of Upper Aknalich canal ✓ Rehabilitation of Lower Hrazdan(part2) canal	✓ Conduct the related ESIA and RAP and its necessary survey

The necessary services for the D/D are summarized as followings;

1) Topographical and geological/hydro-geological field investigations and laboratory test (refer to table below),
2) Review of preliminary designs done during the Feasibility Study (F/S) stage,
3) D/D includes all required hydraulic, structural and hydro-geological calculations, preparation of drawings such as reservoir, feeder, outlet canals and operation manual,
4) Preparation of the pre-qualification documents for tendering,
5) Preparation of tender documents,

6) Preparation of irrigation water management manual including Target area 1 and 2,
7) Preparation of reservoir operation manual, instrumentation of observation and emergency preparedness plans, and
8) Assistance to the conduction of ESIA.

In the D/D stage, the supplemental surveys for finalizing and updating the designs should be conducted due to the changed policy and other unexpected matters. The following table shows suggestions to supplemental surveys in the D/D, in comparison with F/S and D/D stages.

Table 9-2.2 Recommended Survey in Detailed Design Stage with Comparison of F/S

Survey	F/S	D/D
1.Boring	1) Monitoring well : 5 holes x approx. 120 m 2) Core boring（include PT）: 16 holes x approx. 30m, 50m and 100m	For dike, feeder and outlet canal Core boring（include PT）: 5 holes x approx. 30m along center of new dike
2.Soil analysis	1) Site test (Test pit) : 55 pits 2) Laboratory test :34samples 3) Preventive test for Hexavalent chromium elution : 1 set 4) Lavatory. test of infiltration measures : Mixed soil with Bentonite, Soil-cement 5) Common test : Moisture ratio, wet and dry density test, permeability test at Labolatory	1) Laboratory test : 10 samples 2) Preventive test for Hexavalent chromium elution for check F/S: 1 set 3) Common test : Moisture ratio, wet and dry density test, permeability test at Lab
3.Geophysical prospecting	53sites	at intervals of 1km along alignment of each feeder and outlet canal
4.Topographic survey	1) Reservoir area survey : 1,540ha, 1/2,000, 0.5m contour 2) 2 Feeder canals and 3 Outlet canals : 216ha, 1/2,000, 0.5m contour	1) Reservoir area survey: 1,540ha, 1/2,000, 0.25m contour 2) 2 Feeder canals and 3 Outlet canals 216ha, 1/2,000, 0.5m contour 3) Profile of canal alignment : Rehabilitation of Arzni-Shamiram canal : L=2.7km (approx. PK14 and PK17, PK28 and PK32, PK64 and PK69, PK85 and PK93, PK94 and PK96. PK96 and PK97, PK101 and PK105) Rehabilitation of Arzni-Branch canal : L=2.3km (BP and PK23) : L=12.1km (PK123 and PK234) Rehabilitation of Takahan canal : L=5.7km (PK69 and PK126) Rehabilitation of Shah-Aru canal : L=6.9km (BP. and PK31 PK62 and PK70, PK82 and PK112) Rehabilitation of inner Aknalich canal : plane survey for around new pipeline Rehabilitation of Upper Aknalich canal : L=9.8km (PK6 and PK104) : plane survey for around new pipeline Lower Hrazdan canal (part2) : L=17.8km (PK10 to PK188)

(2) Construction Supervision (C/S) stage

In the C/S stage, the consultant shall assist the undertaker in Armenian government for the tender procedure by preparing invitations for pre-qualifications and prior to short listing for the prospective bidders. The consultant shall then accompany the tender procedure and participate in the evaluation of the bids. As mentioned in (1) Detailed Design (D/D) Stage, two (2) packages in construction stage is suggested, hence bidding and supervision shall be conducted to each package. The necessary services for the construction stage are summarized as followings;

[Tendering]

1) Review of designs done in D/D, if necessity,
2) Preparation of the pre-qualification and tender evaluation reports,
3) Assistance and advice to the undertaker in Armenian government for evaluation of the bidder's

offer, and

4) Assistance to obtain required certificate from JICA, in relation with pre-qualification documents and tender and contract.

[Construction]

1) Evaluation and approval of safety plan submitted by the contractor, in compliance with JICA Guideline,
2) Evaluation and approval of construction plan submitted by the contractor,
3) Supervision of quality control, site testing and material specification,
4) Issue certificate and approval to contractor on construction works in accordance with technical specifications and contract with the client,
5) Monitoring of environmental and safety issues, and
6) Submit and keep proper report during construction and arrange the project completion report.

(3) ESIA consultant

The regal regulations for ESIA are derived for a number of international conventions in Armenia is a part of and regulated in the Law on Environmental Expert Examination (Law on EEE) adopted in 1995.

The timing for the ESIA is preferably during the early D/D stage to have effective results and to be taken into account before finalizing the designs. The activities of ESIA should be conducted by the international consultant. In the C/S stage, monitoring and procedure by stipulated in ESIA can be conducted by the construction supervision consultant or by the employed external expertise.

The necessary services for the ESIA consultant are summarized as followings;

1) Data collection and investigations such as natural and social conditions

   - Review related reports on environmental issues of region,
   - Supplemental data collection, and
   - Compile baseline data of ESIA.

2) Land acquisition and resettlement activities

   - Preparation of Resettlement Action Plan (RAP),
   - Disclosure of RAP and consultation meeting on RAP, and
   - Implementation of RAP.

3) Preparation of draft ESIA report

   - Preparation of draft ESIA report,
   - Preparation of mitigation measure, recommendations for the EMP,
   - Disclosure and consultation of drat ESIA report and EMP, and
   - Finalizing the EMP and ESIA report.

4) Monitoring of the EMP implementation

   - Data collection of ecological and, hydrological and social data,
   - Preparation of quarterly monitoring reports for PIU, supervision consultant and other stakeholders, and
   - Finalizing and distribution of annual monitoring report.

9-3 Procurement of Contractor

While procedure for selection of consultant and contractor has three (3) options under Japanese yen loans, namely; option-1) Ordinal, option-2) Engineering Services (E/S) and option-3) Special Terms for Economic Partnership (STEP), as shown in Figure 9-3.1, conditions of the Project implementation do not meet applying preconditions of E/S loan (option-2) and STEP (option-3). The Project shall be proceeded by applying; 1) Ordinal loan procedure which follows International Competitive Bidding (ICB) for the selection of both consultant and construction contractor.

Japanese yen loan is the base of request from the government of Armenia. After the request for the Project implementation, JICA will send a Fact Finding (FF) mission and plural appraisal missions prior to Exchange of Note (E/N) and Loan Agreement (L/A).

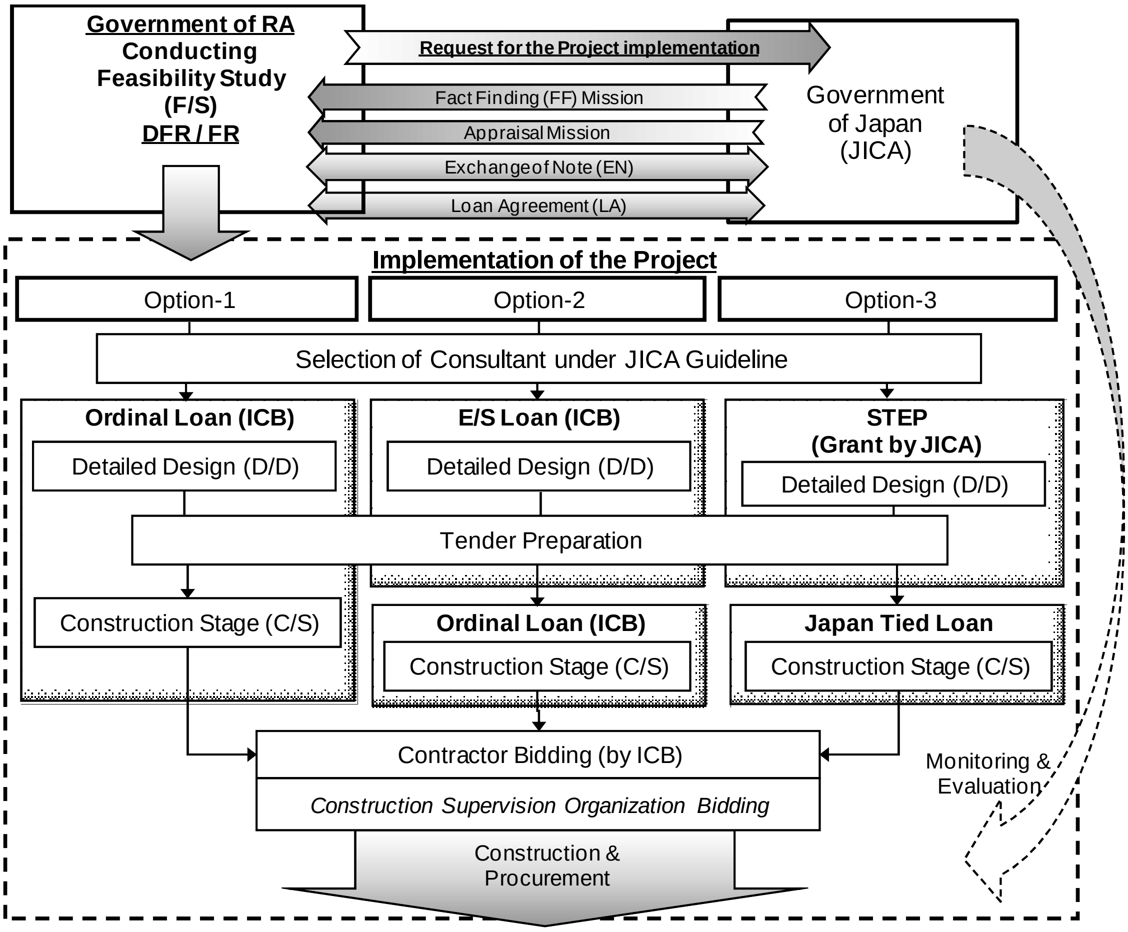


Figure 9-3.1 Options for Procedure of Japanese Yen Loan

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10-1 Viability and Necessity of the Project Implementation

Government of Armenia places this Project; that is “Yeghvard Irrigation System Improvement” as one of the important projects to fulfill the national policies which are; 1) conservation of Lake Sevan being a fundamental source of the livelihood for Armenian people as well as the environmental circumstances, and 2) shifting pump-based to gravity irrigation system prior to reducing governmental subsidies to agricultural water users due to a high rate of electricity.

While one-third (1/3) of population in Armenia is living in the capital city of Yerevan, taking accessibility and marketing into considerations, agricultural activities in the Yeghvard directly connect not to only farmers’ income generation, also food security for inhabitants of the capital because of its location within 20 km to the Yerevan.

Also, since Armenian agricultural development strategy towards promoting; 1) cooperated and competitive market-oriented and 2) export-oriented productions for international trading by shaping favorable conditions, farmers concerned in Yeghvard have much advantage to involve in opportunities obtaining agricultural training/information, extension/machinery services, credit and techniques such water saved irrigation through research institutes under MOA available in Yerevan.

Furthermore, while irrigation projects; Kaps in Shirak Marz and Vedi in Ararat Marz, assisted by KfW and AFD respectively, are under the process of detailed design and tendering stages prior to construction, government of Armenia will concur in developing infrastructural projects in relation to water resource on agriculture/irrigation sectors.

10-2 Conclusions

(1) Scale of the planned reservoir capacity

Alternatives to capacity of the Reservoir is limited since considerable factors for designing is narrowed by 1) demand of crop water requirement of agricultural land with 12,347ha, 2) availability of free water (snow melted water) from March through May in the Hrazdan River and 3) capacity of existing Arzni-Shamiram canal which is planned feeding water to the proposed Yeghvard Reservoir, while policies to the water resources made by the government of Armenia, i.e. 4) conservation of Lake Sevan and 5) shifting from pumping system to gravity irrigation. Capacity of the planned reservoir, therefore, is fixed with 94MCM from the initial stage of the Survey.

(2) Area of planned reservoir basin (900ha or 600ha)

Table 10-2.1 shows advantages and disadvantages in each case of the reservoir basin with 900ha and 600ha respectively.

Table 10-2.1 Advantage and Disadvantage by Options of Reservoir Basin Area in Cases of 900ha and 600ha

	900 ha	600 ha
1) Construction easiness	(Disadvantage) Since area of anti-infiltration work is larger than the case of 600ha, construction period of this work is longer comparatively.	**(Advantage)** Construction period of this work is shorter than the case of 900ha comparatively.
2) Environmental aspect	**(Advantage)** Swampy areas are not formed.	(Disadvantage) Enclosing southern and northern slopes by new dams might form swampy areas at those back side.
3) Acceptance of Armenian side	**(Advantage)** Both existing Dam No.1 and No.2 constructed at USSR era are reused so that past investments are fully utilized.	(Disadvantage) A part of existing Dam No.2 is not reused due to the planning of new dike construction.

While direct construction costs of planned reservoir are not much differed between options of 900ha and 600ha with area of reservoir basin, the one of 900ha is recommended adopting, because the case of 900ha has more advantages than the one of 600ha.

(3) Measure on anti-infiltration works to the reservoir basin

Given conditions geologically and hydro-geologically that the location of the proposed reservoir is located at its high permeability, the cost for anti-infiltration works is occupied approx. more than 60% of the direct construction cost, the Survey team has been conducting alternative studies carefully from the beginning of the Survey period, through investigation of drilling, its in-situ test as well as laboratory soil test, etc. in consideration with results of investigation done in USSR era. Also, simulation for water leakage rate estimation from the reservoir bottom was carried out prior to identifying the most cost-efficiency of necessity area for anti-infiltration works.

Table 10-2.2 summaries outline of the Project evaluation by examined options done during the Survey. Case by using soil-cement with a sandwiched bentonite sheet for anti-infiltration works is the most economical option, with 900ha of reservoir basin and capacity of reservoir with 94MCM.

Table 10-2.2 Outline of the Project Evaluation by Options

(Reservoir basin: 900ha)	Bentonite sheet with 2 layers	Bentonite soil mixture	Soil-cement	Soil-cement with a sandwiched bentonite sheet
Project cost with VAT (million USD)	231.4	291.2	236.8	226.9
EIRR (including Conservation of Lake Sevan)	3.49% (5.51%)	1.60% (3.51%)	3.30% (5.31%)	3.68% (5.72)%

10-3 Recommendations

10-3-1 Trial Construction for Anti-Infiltration Works

Although soil-cement with a sandwiched bentonite sheet is the best option for anti-infiltration works, some risks of leakage more than design value still remain. Additionally, there are no reservoirs having this structure as anti-infiltration works. Therefore trial construction to find appropriate measures to mitigate hazards of leakage risks and to identify difficult/important points to note on the construction shall be carried out before/during Detail Design stage.

10-3-2 Abolish of Existing Pump Stations

In accordance with national policy in Armenia, i.e. “shifting pump system to gravity irrigation”, the capacity of reservoir is designed in the Project including proposed new connection canals (by pipelines) and rehabilitation of existing main/secondary canals. While current irrigation system in some areas, however, is dependent on pumping, it is recommended that delays and/or gradual abolishing existing pump facilities with considering the effect of gravity irrigation, especially of deep tube wells should be allowed.

10-3-3 Pilot Farms for Water Saved Irrigation

Two (2) communities are recommended for pilot farms for water saved irrigation, one for fruit and the other one for vegetable cultivation. Water saved irrigation is not adopted in order to reduce water demand in the Project, however, they are recommended for new technology such as reducing an amount of fertilizer and chemical for decreasing expenditure of the agricultural inputs by sprinkler and/or drip as well as the climate changes in future as agricultural supporting projects.

10-3-4 Measures on Influences to Other Utilizations of Free Water (Snow Melted Water) at the Downstream of Hrazdan River

Even though it is evaluated that influences by taking free water with a volume of 103MCM including losses (canal conveyance and evaporation/infiltration from Yeghvard reservoir, etc. with 94MCM) through Arzni-Shamiram canal from March to May annually with the Project, would not be anticipated, by following findings, the Survey Team recommended that;

Since the Project is expected to contribute the conservation of Lake Sevan by reducing water use of approx. 50MCM annually, a part of water volume from the 50MCM is released to Hrazdan river in March to May annually as the substitution of diverting free water to the Project by taking consideration into the influences on the current ecology in the downstream of Hrazdan River.

<Findings why taking free water with 103 MCM does not influence to the downstream of Hrazdan River>

(1) Influence on hydro-power generation located along with Hrazdan River

Average annual hydro-power generation in Hrazdan river at the downstream of Arzni-Shamiram canal intake point is approx. 500 million kWh in during the last year while 1,875MCM of Hrazdan river flow in 2013 was used for power generation. Given that it is planned to take free water with 103MCM in Hrazdan river for the Project, an amount of power generation in Hrazdan river will be decreased by approx. 27.5 million kWh (500 million kWh x 103/1,875MCM) due to the Project. While the river flow of Hrazdan with decreasing ratio 5.5% after the implementation of the Project, simply calculated by 27.5/500 million kWh and also 27.5 million kWh is occupied only 0.35% calculated by 27.5/7,800 million kWh of which is total power generation in Armenia annually, are negligible. In the meanwhile, priority to utilizing for both waters from Lake Sevan as well as free water is given to agriculture, not hydro-power generation in the national law.

(2) Influence on current ecological conditions

Three (3) kinds of rare species at the downstream of Lake Yerevan are observed. Decrease of free water with a volume of 104MCM annually in March to May, however, would not change the inflow pattern of Lake Yerevan and the current ecological conditions there, while natural flow in the river of Hrazdan is dependant on Hydro-power station through artificial canals.

(3) Water right of Arzni-Shamiram Canal

Since Arzni-Shamiram Canal had been constructed in 1957, it continually has a water right of 320MCM for agricultural use in annual permitted of Ministry of Nature Protection (MNP) in Armenia through a document till now. Currently, a volume of approx. 160 MCM as actual is taken from Hrazdan river so that the Project can take an additional volume of water with 104MCM in official. In addition, as for volume of 160MCM and 104MCM, simply sum of them is within the water right of 320MCM, accordingly, the Project does not affect on present water allocation.

10-3-5 Emergency Discharge Facility

The Survey team suggests setting up an awareness program for emergency during the detailed design of the Project whenever the natural calamity occur such a large earthquake by establishing a structure of committee.

10-3-6 Compensation for Communities (RAP)

It is recommended that correspondence to compensation for communities of Yeghvard City and Nor-Yerznka Village for the land within the planned Reservoir should be discussed before the Loan Agreement (L/A) signed, while lands for the Project to be requisitioned by the government are currently belonging to those communities.

ATTACHMENT

Attachment-1: List of Parties Concerned in Armenia

Organization			Position	Name
Armenian Government Office				
Ministry of Agriculture			Minister	Sergo Karapetyan
			Deputy Minister	Armen Harutyunyan
	Department of Land Use and Amelioration		Head	Artur Baghdassaryan
	Department of Foreign Relations		Head	Andranik Petrosyan
	Department of Horticulture crop production and Plant protection		Head	Ashot Harutyunyan
			Head of Horticulture Development and Plant Protection Division	Karine Esayan
	Agricultural Support Centre Coordination Department		Head	Edgar Hakobiyan
	Department of Agricultural Development Programs		Head of Agricultural Planning Division	Artur Petrosyan
			Head of Infrastructure Development and Food Security Division	Armenak Aghajanyan
	Department of Agro Processing Development		Head	Gevorg Ghazaryan
	State Inspection of Agricultural Machinery		Head	Ghushchyan Vardan
	Agricultural Projects Implementation Unit		Director	Gagik Khachatryan
	Division of Agricultural Cooperative Support		Head	Marianna Khachatryan
	Division of Research and Coordination of Agriculture Support Centers		Chief Specialist	Hasmik Mkrtchyan
	State Service for Food Safet		Head of Phytosanitary Division	Artur Nikoyan
	State Committee of Water Economy (SCWE)		Chairman	Aram Harutyunyan
			Deputy Chairman	Volodya Narimanyan
			Deputy Chairman	Hakob Matilyan
			Adviser to the Chairman	Viktor Martirosyan
			Head of the Staff	Garik Saroyan
			Head of Economic Division	Anna Margaryan
			Head of the External Relations Division	Tigranuhi Baghdasaryan
			Head of Irrigation collector-drainage System Department	Karen Daghbashyan
			Head of Internal Audit	Garik Saroyan
			Head of Legal and Inspection Department	Harutyun Khachatryan
			Head of Mobilization Department	Artak Harutyunyan
		Sevan-Hrazdanyan Jrar Closed Joint Stock Company	Director	Samvel Hovhannisyan
			Head of Reservoir Exploitation Division	Rubik Andreasyan
			Chief engineer	Gagik Vardanyan
		Project Implementation Unit (PIU)	Director	Flelix Melikyan
			Deputy Director	Karen Grigoryan
			Engineer	Marzpet Tonoyan
			Engineer	Tigran Ishkhanyan
			Engineer	Khoren Tsarukyan
			Engineer	Varazdat Mkrtchyan
			Engineer	Zhora Tomrazyan
			Environmental Specialist	Martiros Nalbandyan
			Sociologist	Marine Vardanyan
Ministry of Finance			Minister	Gagik Khachatryan
Ministry of Urban Development			Minister	Narek Sargsyan

Organization			Position	Name
Ministry of Foreign Affairs			Deputy Minister	Sergey Manassaryan
			Second Secretary	Elina Mkrtchyan
Ministry of Nature Protection	Environmental Impact Expertize Center, State Non-Commercial Organization (SNCO)		Director	Vardan Sahakyan
			Deputy Director	Seyran Pahlevanyan
			Environmental Expert	Azganush Drnoyan
	Environmental Impact Monitoring Centre, SNCO		Director	Sasun Sahakyan
			Deputy Director	Gayane Shahnazaryan
	Climate Change Information Center		UNFCCC National Focal Point	Aam Gabrielyan
	Hydrogeological Monitoring Center, SNCO		Director	Karlen Hakobyan
			Chief Engineer	Hovik Aghinyan
	National Park “SEVAN”, SNCO		Deputy Director in Science	Vahe Gulanyan
	Water Resources Management Agency		Director	Vahan Davtyan
Ministry of Territorial Administration and Development	Department of Foreign Relations		Leading specialist	Ruben Khamoyan
	Department of the Local Self-Governme nt		Head	Ashot Giloyan
		Division of the Local Self-Government Affairs	Head	Karen Bakoyan
Ministry of Emergency Situations	Seismic Protection Service		Head	Hrachya Petrosyan
			Deputy Head	Ashkhen Tovmasyan
		Observation and Information Analysis Division	Head	Valery Arzumanyan
		Division on Seismic Resistance of Buildings and Construction	Head	Armen Antonyan
			Specialist	Anna Gevorgyan
WUAs				
WUAs	Ashtarak		Director	Arsen.Khachatryan
	Khoy		Director	Seyran Sargsyan
			Deputy Director	Hovhannes Sargsyan
			Engineer	Mamikon Avetisyan
			Engineer	Tigran Khevondyan
	Yeghvard		Director	MIhran Hovhannisyan
	Vagharshapat		Director	Surik Sedrakyan
			Deputy Director	Karapet Ter-Khachatryan
			Local Electric Specialist	Manaser Harutyunyan
			Local Head	Artash Asatryan
	Parpi		Director	Hovik Gevorgyan
	Nairi		Director	Armen Karapetyan
Cities				
Ashtarak			Mayor	Armen Antonyan
Yeghvard			Deputy Mayor	Karen.Harutyunyan
Yerevan			Chief Engineer Water Structures CJSC, Yerevan City	Vagharshak Vagharshkyan
Communities				
Armavir Marz	Aghavnatun		Deputy Head	Valeri Zohrabyan
	Aknalich		Deputy Head	Fezdinant Fidanyan
	Amberd		Head	Manvel Babayan
	Aratashen		Head	Vahzam Harutyunyan
			Deputy Head	Hovakim Nazaryan
	Aragats		Head	Ashot Kamavosyan
			Chief Specialist	Aram Hakobyan
			Representative	Aspet Movsesyan
	Arshaluys		Deputy Head	Gagik Shahgaldyan
	Artimet		Deputy Head	Manvel Sahakyan

Organization		Position	Name
Armavir Marz	Baghramyan	Head	Babken Shahbazyan
	Doghs	Chief Financial Specialist	Sveta Adamyan
	Ferik	Head	Norik Hayrapetyan
	Geghakert	Deputy Head of Community	Jahavir Amirkhanyan
		Chief Accountant Specialist	Susanna Galstyan
		Assistant Accountant Specialist	Kaline Movsesyan
	Griboyedov	Human Resources Specialist	Anahit Keshish Ghukasyan
		Jr. Specialist	Suzen Grigozyan
	Haytagh	Deputy Head	Meruzhan Muradyan
	Hovtamej	Head	Armen Sargsyan
	Khoronk	Head	Sargis Nahapetyan
		Deputy Head	Grisha Asatryan
	Lermamerdz	Deputy Head	Sahak Mirzoyan
	Mrgastan	Head	Rafik Khachatryan
		Human Resources Specialist	Susanna Gharibyan
		Financial Specialist	Gayane Yeghiazaryan
	Merdzavan	Deputy Head	Azevik Yesayan
		Director of Education & Science	Vemir Khurshudyan
	Norakert	Head	Shahen Karapeytan
		Chief Specialist/Accountant	Ashot Dovlatyan
	Taronik	Chief Accountant Specialist	Susanna Tsaghoyan
	Tsaghkalanj	Head	Manvel Mkrtehyan
		Senior Financial Specialist	Ashot Baghdasaryan
	Tsaghkunk	Deputy Head	Rafik Sargsyan
	Tsiatsan	Deputy Head	Khachik Gevorgyan
Aragatsotn Marz	Sasunik	Head	Arman Margaryan
		Representative	Vahagn Mkhitaryan
Kotayk Marz	Kasakh	Head	Sedrak Khachatryan
	Proshyan	Head	Arthuz Muradyan
		Jr. Specialist	Yurik Rzgoyan
	Zovuni	Deputy Head of Community	Suren Baghdasaryan
		Jr. Specialist	Yerjanik
	Nor-Yerznka	Head	Alina Harutyunyan
Related Organizations			
Aarhus Center of Yeghvard City		Coordinator	Ruzanna Manyan
		Coordinator	Anush Beybutyan
Institutions			
Institute of Geophysics and Engineering Seismology After A.NAZAROV, National Academy of Science of Armenia		Director	Jon Karapetyan
		Head of Department of Seismic Stable Construction	Sevada Hovhannisyan
		Head of seismic hazard assessment division	Styopa Karapetyan
		Scientific Secretary	Gohar Mkrtchyan
Institute of Water Problems and Hydraulic Engineering		Leading scientific engineer	Sergei Mkrtchyan
		Senior scientific engineer	Garnik Hovasapyan
Other Donors			
Asian Development Bank (ADB)		Associate Finance and Administration Officer	Zara Solakhyan
KFW		Local Representative	Zara Chatiyan
		Project Manager	Diniela Base

Organization	Position	Name
KFW	Principal Engineer	Thomas Wolf
UNDP	Component Manager	Baken BABAYAN
	Proect Manager	Vahan AMIRKHANYAN
UNIDO (United Nations Industrial Development Organization)	Results Manager	Margarita Gasparyan
WB	Operation Officer	Arusyak Alaverdyan
Private Companies		
ARGUMEMT Consulting Bureau LLC	Director	Vardan Aghbalyan
ATMS Solutions LLC	Ecological Specialist	Artak Ter – Torosyan
	Socialist	Suren Gyurjinyan
Ararat Cement	Director	Manuk A. Arakelyan
Armenian Mining Company CJSC	Duputy Director	Karen Simonyan
Artezia Scientific CJSC	Director	Hovik Mizakhanyan
FDA Lab	Staff and Constomer Service Manager	Elen Lopoyan
	Quality Manager	Anna Hakobyan
Georisk CJSSRC	Director	Hektor Babayan
	Translator	Yelena Abgaryan
GRP Systems CJSC	Director	Arkadi Gabrielyan
Hayjrnakhagits Institute CJSC	Director	Yuri Javadyan
Hidrogeosin LLC	President	A. Julkhakyan
Hydrogenergetica	President	Grigor Gabayan
“HYDRA TNT” LLC	Director	Tigran Tamrazyan
HYDROSCOPE	Head	Robert Minasyan
IKO Machinery LLC	Executive Director	Hayk Martirosyan
	Head of Sales Department	David Karamyants
	Account Specialist	Lilit Avagyan
ISOLUX CORSAN	Project Manager	Daniel Domingo Tabuena
Ijevan Bentonite Combinat	Technical Director	Anatoli Bairamyan
‘Modul 2015’ LLC	Director	Samson Gasparyan
Mtispiri Bentonite 2010	Executive Director	Sharashidze Tengiz
Ml Mining LLC	General Director	Margaryan Eduard
National University of Architecture and Construction of Armenia, Faculty of Urban Economy and Ecology, Chair of Hydraulics	Head of Chair, Professor	Albert Margaryan
Transimpex	Country Manager	Arman Ghazaryan
	Head of Logistics and Freight Forwarding Department	Rouben Gevorgyan
Non-governmental Organization		
ECOLUR (NGO for environmental conservation)	President	Inga Zarafian
JICA		
JICA Uzbekistan Office	Chief Representative	Katsutoshi Fushimi
JICA Armenia Liaison Office	Armenian Program Coordinator	Ruzan Khojikyan
Embassy		
Embassy of Japan	Ambassador	Eiji Taguchi
	Counselor	Kenichiro Sasame
	Second Secretary	Emiko Fujiyama
	Attache	Natsuko Fujii

Attachment-2: Aide-Memoire (Kick-off Meeting, dated on June 16, 2015)

Japan International Cooperation Agency

Date: July 3, 2015
Ref. No.: R3CAC/F2015- 31

Mr. Sergey Manassarian
Deputy Minister
Ministry of Foreign Affairs of Republic of Armenia

Re: the Preparatory Survey for Yeghvard Irrigation System Improvement Project in Armenia

Dear Mr. Manassarian ,

First of all, we would like to express our sincere gratitude for your continued cooperation on JICA projects in Armenia.

Regarding the Yeghvard Irrigation System Improvement Project (hereinafter referred to as "the Project"), we are pleased to inform you that we held a Kick-Off meeting of the preparatory survey on June 16, 2015 with you and/or other relevant ministries and organizations.

In this regard, I hereby send you an aide-memoire for our precise understanding and I would appreciate it .if you could share this with Ministry of Agriculture and State Committed of Water Economy of Ministry of Agriculture.

In case of inquiries, I would appreciate it if you could contact Ms. Khojikyan Ruzan, JICA coordinator in Armenia.

Address: JICA Armenia Liaison Office
25/14－4 Nalbandyan str. 0001 Yerevan, Armenia
Tel: + 374 10 568805 Mobile: + 374 77 710 760
Email: jica.arm.r@gmail.com

Your cooperation and assistance would be highly appreciated.

Sincerely yours,

Akihito NAGATA
Director,
Central Asia and the Caucasus Division
East and Central Asia and the Caucasus Dept.

Cc:
Ministry of Finance, Ministry of Economy, Ministry of Nature Protection of RA, State Committee of Water Economy of the RA Ministry of Agriculture
Dr. Grant Pogosyan, Ambassador Extraordinary and Plenipotentiary
Ms. Khojikyan Ruzan, JICA Coordinator in Armenia
JICA Uzbekistan Office

(End)

AIDE-MEMOIRE

on

Kick-off Meeting related to Inception Report (ICR) of the Preparatory Survey for Yeghvard Irrigation Improvement Project in the Republic of Armenia (RA)

Yerevan, June 16, 2015

The Japan International Cooperation Agency (JICA) sent a mission headed by Akiko WAKUI, Assistant Director of Central Asia and the Caucasus Division, East and Central Asia and the Caucasus Department (hereinafter referred to as "the Mission"), incorporated with a consultant team headed by Kazumitsu TSUMURA (hereinafter referred to as "the Survey Team") to Yerevan from June 9 through 19, 2015 for the Preparatory Survey (hereinafter referred to as "the Survey") for Yeghvard Irrigation System Improvement Project (hereinafter referred to as "the Project") in accordance with following backgrounds;

1. Backgrounds of dispatching the Mission and the Survey Team

1) After the request for Official Development Assistance (ODA) loan to the government of Japan was made by the Government of RA in June 2012, JICA had executed to gather information related to the construction of Yeghvard Reservoir by sending the contact missions as well as sending questionnaire in order to formulate the Project.
2) Based on the information that JICA obtained through the above 1), JICA proposed two-phased studies; a) Data Collection Survey on Agriculture and Irrigation Sectors in relation to the Project (Pre-feasibility Study: Pre-F/S) and b) Full-scaled Feasibility Study (F/S), and the Government of RA agreed the above mentioned proposal.
3) JICA dispatched a consultant team as place of the above a) Pre-F/S in June 2014. Then, the consultant team conducted a field survey including of data/information collection and had a series of discussions with related agencies in the RA from June through August 2014, and analyzed the collected information prior to prepare a draft final report (DFR) of the Pre-F/S in Japan during September to October 2014.
4) JICA sent a mission to Yerevan from November 2 through 6, 2014 for the purpose of explanatory discussion for the DFR of the Pre-F/S of the Project. Then, the government of RA accepted it.
5) JICA decided to dispatch a consultant team for the F/S of the Project and prepared its TOR and requested the Government of RA to confirm and provide comments and/or requests if there were any.

JICA sent the Inception Report (ICR) of the F/S of the Project to the government of RA prior to the dispatch of the consultant team; the consultant team was sent to conduct the F/S of the Project.

2. Results of the Kick-off Meeting of Full-scaled F/S

The Mission and the Survey Team have explained contents of Inception Report (ICR) to officials of the Government of RA, listed in the attachment. The Armenian officials have understood the approaches and methodologies as well as the schedule of the Survey shown in the ICR and in principle accepted the contents of it.

Main items discussed and agreed by the Armenian officials during the explanation of ICR are described as follows;

2-1. Environmental and Social Impact Assessment (ESIA)

The Mission and the Survey Team explained the timing of completion and process of information disclosure for the ESIA as below;

1) SCWE shall support the Survey Team for his preparation of the draft of ESIA by introducing environmental experts/companies prior to completion of the ESIA.
2) The Survey Team will prepare the draft of ESIA in cooperation with SCWE.
3) SCWE shall finalize the draft of ESIA in cooperation with the Survey Team.
4) SCWE shall, within its competency and functions, take all necessary procedures to obtain approval for the ESIA from Ministry of Nature Protection (MONP) in Armenia prior to information disclosure of the ESIA to be done on JICA's website for the necessary next step.
5) The ESIA shall be completed at the timing of finalization of this Preparatory Survey (Full-scaled F/S).

2-2. Issues to be confirmed during the Survey (Full-scaled F/S)

The Survey Team rose following issues to be confirmed during the Full-scaled F/S.

1) Latest strategy for Yeghvard irrigation area of Ministry of Agriculture (MOA) in consideration with food security, export-oriented, saving irrigation, etc. prior to estimation of water demand for the Project.
2) Means of decision making due to "Law of Lake Sevan" for confirming water utilization of Lake Sevan which would affect the design capacity of the proposed Yeghvard Reservoir.
3) Actual water utilization from Hrazdan and Kasakh Rives for other irrigation schemes other than the Project.
4) Alternatives if the scale of the Project is to be made smaller due to high construction cost for reservoir basin, based on the result of geological / hydro-geological surveys.
5) Necessity of emergency water release system from the proposed Yeghvard Reservoir.
6) Preparation of corrective action plan for those who had already been resettled and expropriated due to the construction of Yeghvard reservoir under the Government of Soviet Union, if necessary.

End

(Attachment) List of participants

涌井 明子

Ms. Akiko WAKUI
Assistant Director
Central Asia and Caucasus Division
East and Central Asia Department

Attachment-3: Memorandum of Understandings (Role and Responsibility)

Memorandum of Understandings
for
The Preparatory Survey for Yeghvard Irrigation System Improvement Project in the Republic of Armenia

Yerevan, October 02, 2015

Regarding Environmental and Social Consideration (ESIA) of the Preparatory Survey for Yeghvard Irrigation System Improvement Project (hereinafter referred to as "the Project"), State Committee of Water Economy of the Ministry of Agriculture (hereinafter referred to as "the SCWE") and the consultant team dispatched by Japan International Cooperation Agency since June 2015 (hereinafter referred to as "the Survey Team") discussed roles and responsibilities of the SCWE and the Survey Team. Mainly, they agreed that the SCWE should be the "Undertaker" for the ESIA report preparation while the Survey Team supports the SCWE. Detail contents are described in the following table:

Table Roles and Responsibilities of the SCWE and Survey Team for the ESIA Report Preparation

Contents	The SCWE	The Survey Team
1. Application form preparation of the Project	Making comments on the application form	Preparation of application form of the Project
2. Stakeholder meeting (before application form submission and ESIA report submission)		
2.1 Stakeholder analysis	Both sides analyze stakeholders of the Project.	
2.2 Public notice of the stakeholder meeting	Preparation of public notice Public notice in name of SCWE	Support SCWE to prepare public notice
2.3 Preparation of materials for the stakeholder meeting	Making comments on the materials prepared by the Survey Team	Preparation of draft materials for the stakeholder meeting
2.4 Arrangement of the stakeholder meeting	Arrangement of the stakeholder meeting such as venue reservation including securing of funds.	Support SCWE to organize stakeholder meetings.
2.5 Presentation of the Project outline and expected environmental impacts	Presentation of the project outline and summary of expected environmental impacts based on the materials Answer to questions from the participants	- Support of the presentation by the SCWE - Support SCWE for answering to questions from the participants
2.6 Preparation of minutes and participant list	Check of the minutes prepared by the Survey Team	Preparation of minutes and participant list
2.7 Shooting of the stakeholder meeting by using a video camera	None	Arrangement of necessary staff and equipment, and provision of financial support for shooting of the stakeholder meeting
3. Initial assessment application form submission of the Project to the Environmental Impact Expertise Center (EIEC) State Non Commercial Organization of the Ministry of Nature Protection	- Submission of the initial assessment application form to the EIEC in name of SCWE - Payment of application fee of the project to the EIEC	- Preparation for the initial assessment application form and support of the submission of the application form

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Contents	The SCWE	The Survey Team
4. ESIA report preparation and submission, and acquisition of positive conclusion on the ESIA report from the EIEC		
4.1 Preparation of draft ESIA report	None	- Preparation of draft ESIA report - Provision of financial and technical support for the ESIA report preparation
4.2 Submission of the draft ESIA report to the SCWE	None	Submission of the draft ESIA report to the SCWE
4.3 Comment on the draft ESIA report by SCWE and modification based on the comments	Review of draft ESIA and making comments on the draft ESIA report	Modification of the draft ESIA report based on the comments from SCWE
4.4 Draft ESIA report submission to the EIEC	Submission of the draft ESIA report to the EIEC in name of SCWE	None
4.5 Modification of the draft ESIA report based on comments from the EIEC	Review of revised draft ESIA report	Modification of the draft ESIA report based on comments from the EIEC
4.6 Submission of the final ESIA report to the EIEC	Submission of the final ESIA report to the EIEC in name of SCWE	None
4.7 Acquisition of positive conclusion on the ESIA report from the EIEC	Acquisition of positive conclusion on the ESIA report from the EIEC	None

End

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Kazumitsu TSUMURA
Team Leader,
JICA Survey Team,
Sanyu Consultants Inc. (SCI)

Aram HARUTYUNYAN
Chairman,
State Committee of Water Economy,
Ministry of Agriculture of the Republic of Armenia

5.10.2015

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Attachment-4: Memorandum of Discussions (Interim Report Explanatory Meeting)

Memorandum of Discussions for Interim Report (ITR) Explanatory Meeting of the Preparatory Survey for Yeghvard Irrigation System Improvement Project in the Republic of Armenia (RA)

Yerevan, 4th of December 2015

Based on the letter, that JICA headquarters sent to Ministry of Foreign Affairs of RA dated on 17th of March 2015 regarding on "Consultant's TOR" for the Preparatory Survey on Yeghvard Irrigation System Improvement Project (hereinafter referred to as "the Survey"), and also the Minutes of Meetings for the Survey on Yeghvard Irrigation System Improvement Project (hereinafter referred to as "the Project") sighed by and among Ministry of Agriculture (MOA), State Committee of Water Economy (SCWE) and Japan International Cooperation Agency (JICA) dated on 30th of October 2015, a consultant team headed by Kazumitsu Tsumura (hereinafter referred to as "the Survey team") sent by JICA by scheduling June 2015 through May 2016, completed Interim Report (ITR) of the Survey. An explanatory meeting of the ITR has been held on 4th of December 2015.

1. Submission of the ITR

The Survey team submitted the following ITR to officials of the Government related to the Survey. And Armenian side received them;

1) 40 copies of Armenian version of the ITR, and
2) 10 copies of English version of the ITR

2. Explanatory meeting

The Survey team explained contents of the ITR to officials of the Government of RA, listed in the attachment by using power point materials. Main items explained and pointed out by the Armenian officials at the question and answer session are as follows;

2-1. Main items explained by the Survey team

Main contents explained by the Survey team are summarizes below;

Agriculture

1) Planed cropping calendar is made according to the cropping strategy of Sustainable Agriculture Development Strategy (SADS, 2010-2020), trends of last 5 years' changes and the results of interview survey at the project sites.

Water resources and utilization / Irrigation planning

2) A capacity of planed reservoir is designed 94 MCM and it is explained the possibility to reduce it by applying saved water irrigation and by depending on other water sources such as existing pump stations and Lake Sevan.

3) Some sections of existing irrigation canal should be rehabilitated due to shortage of their existing capacities and conditions to deterioration.

4) Partly, new canal extensions are required for connecting to irrigation areas in the case of abolishing existing pump stations and also further study is needed for their finalization.

Hydro-geology / Reservoir planning

5) 600 ha of a planned area for reservoir bottom is more economical rather than 900 ha of it with constructing new dikes to be connected the Dikes No.1 and No.2 in consideration with the area of anti-infiltration works.

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6) Reducing planned area for anti-infiltration works is expected based on the results of in-situ permeability test of which additional investigation could be scheduled at next stage.

7) Reducing thickness and/or percentage such as bentonite sheet/powder mixture and soil cement for the anti-infiltration works is expected based on further considerations which are still on-going.

Project cost and evaluation

8) Project cost is estimated around 450 million USD including of contingencies and VAT with applying anti-infiltration works for reservoir bottom by either bentonote sheets or soil mixture at the level of interim stage.

9) Reducing of the project cost is expected by the further investigations and considerations shown in the above 6) and 7), and also phasing out of the Project with components, namely; a) reservoir and b) other facilities such irrigation system improvement, that will be reduced by 200 million USD approximately.

10) Since factor calculated from conservation of Lake Sevan of 50 MCM/year water usages at present level is occupied 45% to the total Project benefit, reducing project cost by minimizing capacity of the planned reservoir affects to the financial aspects.

Emergency discharge facilities

11) It was explained as the basic conditions, that seismic design for dam construction would be applied avoiding any damages by earthquake and other risks.

12) A concept of emergency discharge facilities under Japanese standard was introduced, which could not be made decision by the Survey team and it was suggested establishing a committee for further discussion among Armenian officials.

Environmental and social considerations

13) The 1st public hearing was held on 20th October 2015 by the name (undertaker) of SCWE, and the 2nd one is scheduled on March 2016 at the end of the Survey.

2-2. Main items pointed out by the Armenian officials

Followings are main items pointed out by the Armenian officials;

1) Planned area of the reservoir bottom either 900ha or 600ha should be examined in consideration with further studies in the Survey.

2) In case of 600ha for reservoir bottom, measures for back spaces between existing dikes and planned new dikes should be considered for not becoming swamp.

3) It was suggested considering active fault for dam design.

4) Risk assessment on dam safety by seismic design should be considered.

5) Armenian officials agreed to consider establishing a committee for discussing among agencies related to the emergency discharge facilities for the Project.

2-3. Comments on the ITR, added by PIU towards preparing Draft Final Report (DFR)

1) The official data, received from the Hydro-meteorological and State Monitoring Service of Armenia, should be presented as Appendixes in the DFR.
2) The information of field works, carried out by local subcontractors (geological, hydro-geological, topographic surveys, laboratory tests, etc.), should be presented as Appendixes in the DFR.
3) The economic efficiency by decreasing the area of the reservoir bottom, should be presented in detail in the DFR.
4) Options of anti-infiltration materials, particularly, bentonite sheet and bentonit-soil mixture should be presented in detail in the DFR.
5) Graphs, plans, sections, etc. shown in main report of the ITR, should be presented as Appendix by A3 size in the DFR.
6) It would be suggested that benefits with 15 million USD/year from conservation of Lake Sevan, not be included in the project benefits for the calculation of IRR, in case of 94 MCM of the reservoir capacity.
7) Since detailed cost estimation including rehabilitation of the irrigation systems is not mentioned in the ITR, it should be presented as Appendixes in the DFR.

2-4. Others

The Survey team requested to Armenian officials to give more comments on ITR towards preparing draft final report (DFR).

End

(Attachment) List of participants and memorandums

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Kazumitsu TSUMURA
Team Leader,
JICA Survey Team,
Sanyu Consultants Inc. (SCI)

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Attachment: List of participants and memorandums

List of participants

No.	Name	Position
1	Aram Harutyunyan	Chairman, State Committee of Water Economy (SCWE), Ministry of Agriculture (MOA)
2	Volodya Narimanyan	Deputy Chairman, SCWE, MOA
3	Hakob Matilyan	Deputy Chairman, SCWE, MOA
4	Artak Harutyunyan	Head of Mobilization Department, SCWE, MOA
5	Karen Daghbashyan	Head of Irrigation collector-drainage Systems Department, SCWE, MOA
6	Araksya Harutyunyan (Ms)	Chief Specialist of Foreign Relations, SCWE, MOA
7	Sona Hayrapetyan (Ms)	Chief Specialist of Irrigation collector-drainage Systems Department, SCWE, MOA
8	Garik Saroyan	Chief of Staff, SCWE, MOA
9	Kamo Sargsyan	Head of Internal Audit, SCWE, MOA
10	Lilia Khzmalyan (Ms)	Project Administrator, SCWE, MOA
11	Nune Davtyan (Ms)	IT Coordinator, SCWE, MOA
12	Anna Margaryan (Ms)	Head of Economic Division, SCWE, MOA
13	Samvel Karapetyan	SCWE, MOA
14	Karen Dadoyan	SCWE, MOA
15	Naira Manukyan (Ms)	Chief Specialist of Secretariat, SCWE, MOA
16	Armen Balayan	Department of Water Supply and Sanitation Systems, SCWE, MOA
17	Artavazd Badalyan	Legal Division, SCWE, MOA
18	Elmira Papyan (Ms)	SCWE, MOA
19	Marzpet Tonoyan	Project Implementation Unit (PIU), SCWE, MOA
20	Varazdat Mkrtchyan	Engineer, PIU, SCWE, MOA
21	Khoren Tsarukyan	Engineer, PIU, SCWE, MOA
22	Arthur Baghdasaryan	Head of the Department of Land Use and Melioration, MOA
23	Larisa Harutyunyan (Ms)	Ministry of Finances (MOF)
24	Askhen Tovmasyan (Ms)	Deputy Head of SSP, Ministry of Territorial Administration and Emergency Situations (MTAES)
25	Karo Karapetyan	Head of division, Rescue Service (RS), MTAES
26	Valeri Arzumanyan	Head of Division, Service for Seismic Protection (SSP), MTAES
27	Arkadi Cherchinyan	Chief Specialist, MTAES
28	Hripsime Babayan (Ms)	Chief Specialist, Department of Local self-government, MTAES
29	David Mejlumyan	Leading Specialist of Water Cadastre and Monitoring Division, Water Resources Management Agency (WRMA), Ministry of Nature Protection (MNP)
30	Nazik Khzmalyan (Ms)	MNP
31	Arthur Avagyan	Head of Hrazdan Territorial Basin Management Division, WRMA, MNP
32	Sevak Matilyan	Deputy Head of the Division of Basing Planning Management, WRMA, MNP
33	Mihran Hovhannisyan	Head of Yeghvard WUA
34	Gagik Ghazaryan	Chief engineer, ArmWaterProject Institute CJSC
35	Aleksey Tarverdyan	ArmWaterProject Institute CJSC
36	Varujan Titizyan	ArmWaterProject Institute CJSC
37	Kenichiro Sasame	Counselor Embassy
38	Emiko Fujiyama (Ms)	Second Secretary Embassy
39	Elina Sahakyan (Ms)	Political and Economic Officer Embassy
40	Gayane Manukyan	Diplomat
41	Akiko Wakui (Ms)	Assistant Director, JICA Survey Team
42	Shotaro Ono	Assistant Director, JICA Survey Team
43	Ruzan Khojikyan (Ms)	JICA Armenia Liaison Officer
44	Kazumitsu Tsumura	Team Leader/ Irrigation Planning, JICA Survey Team
45	Kazuma Akiyoshi	Co-Team Leader/ Irrigation Planning, JICA Survey Team
46	Fusataka Arakawa	Irrigation Planning, JICA Survey Team
47	Haruo Hiki	Reservoir Planning, JICA Survey Team
48	Mamoru Hatano	Marketing/ Agricultural Organization
49	Shohei Natsuda	Economy and Financial Analysis/ Social Consideration, JICA Survey Team
50	Gevorg Gevorgyan	Assistant / interpreter, JICA Survey Team
51	Tamara Mirzoyan (Ms)	Assistant / interpreter, JICA Survey Team
52	Tatevik Minasyan (Ms)	Assistant / interpreter, JICA Survey Team
53	Christine Goroyan (Ms)	Assistant / interpreter, JICA Survey Team
54	Luiza Ohanyan (Ms)	Assistant / interpreter, JICA Survey Team
55	Haykuhi Asatryan (Ms)	Armenia TV
56	Karen Arzumanyan	Business Express newspaper

Memorandums during the question and answer session

1. Opening Remarks

(Tsumura/ JICA Survey team leader): Today is the interim report presentation day. I am sorry for such a small space in the meeting room. We didn't expect that we would have so many participants. And now Mr. Harutyunyan will make the opening remarks.

(Harutyunyan/ Chairman, SCWE): Ladies and gentlemen, the construction of reservoirs is very important for Armenia. Currently, we have 90 reservoirs in this country. The most important issue for us is the conservation of Lake Sevan. Its conservation measures should result in reduction of dependency on the lake. One of the main goals of the Project is the conservation of water resources of the lake. In addition, thanks to the Project, we will be able to save electricity through introducing gravity irrigation. We have other similar ongoing projects. The first one is Vedi reservoir – 29 MCM. Then, the second one is Kaps reservoir – 25 MCM in the first phase and 60 MCM in the second phase. They are followed by Selav-Mastara – 60 MCM and then this Yeghvard. We should ensure sustainable management of surface water; namely, usage of melted snow. Construction of Yeghvard reservoir will allow us to store the water resource. Only through Yeghvard reservoir, we will be able to save energy of 25 million kWh.

The target Project area is located in three (3) marzes and includes 27 communities. I am familiar with the works that have been carried out by the Survey team and want to thank them for comprehensive investigations. Now is the stage of feasibility study but it is very important for passing to the next stage. I also want to express my gratitude to JICA and the Japanese Government. Yeghvard reservoir was just a small throwback to the history. It was a more ambitious project during the USSR (Union of Soviet Socialist Republics) times. But the current format will ensure the most efficient use of water. From environmental point of view, reduction of dependency on Lake Sevan is very important. The first reservoir constructed after the independence was Marmarik reservoir – 24 MCM. The next positive outcome of the Yeghvard reservoir project will be abolishing the operation of a few dozens of pump stations and deep wells. The cost of agricultural products will decrease because of the abolishment.

Your opinions and remarks will be highly appreciated, as they are very important for the future course of the Project. All opinions and remarks will be considered in the planning. We should examine the peculiarity of our region, particularly the seismic activity. Our first meeting with the Japanese consultants lasted quite long and was very productive. After this preliminary stage, we will proceed to the main stage. And, after design works with expertise, construction will start.

Again this is a very important project. Thank you!

(Tsumura/ JICA Survey team leader): Thank you, Mr. Chairman. My name is Kazumitsu Tsumura, I am the JICA Survey team leader. Now we will start the presentation of the ITR.

2. Presentation of Interim Report

Refer to presentation materials

3. Question &Answer Session

Q1 **(Artur Baghdasaryan/ Ministry of Agriculture):** Is the Survey team planning to construct both of the feeder canals that you presented or just one of them?

A1 **(Akiyoshi/ Survey team):** We plan the construction of both of them.

Q2 **(Karo Karapetyan/ MTAES):** When we say high radioactivity, how much do you mean, how many micro-roentgen/hour?

A2 **(Hiki/ Survey team)**: It exceeds the environmental radioactivity by three (3) times, which is not harmful to people's health.

Q3 **(Karo Karapetyan/ MTAES)**: Has the Survey team calculated the project cost?

A3 **(Tsumura/ Survey team)**: We have done some calculations but we still need to do more detailed recalculations.

Q4 **(Gagik Ghazaryan/ ArmVodProject)**: What is reservoir volume for three (3) different project costs, i.e., Bentonite sheet (1 layer), Soil cement, Bentonite soil mixture shown in slide #76, correspond to the same volume?

A4 **(Tsumura/ Survey team)**: Yes, they are corresponded to the same volume 94MCM.

Q5 **(Gagik Ghazaryan/ ArmVodProject)**: In case of a smaller area of reservoir bottom (600ha), are the existing embankments or will new ones be constructed?

A5 **(Tsumura/ Survey team)**: We design new embankments.

Q6 **(Gagik Ghazaryan/ ArmVodProject)**: Then, what about the existing embankments?

A6 **(Tsumura/ Survey team)**: We will use them and just make the space smaller. We will combine the existing and the new embankments.

Q7 **(Gagik Ghazaryan/ ArmVodProject)**: Won't these new dikes increase the project cost?

A7 **(Tsumura/ Survey team)**: We have compared the cases of 900ha and 600ha in consideration with area of anti-infiltration works and construction cost of new dikes. You can see the project cost for each of them.

Q8 **(Gagik Ghazaryan/ ArmVodProject)**: But you just said that the anti-filtration works will be reduced by 500ha (slide #74) due to anisotropy. Won't it affect the project cost?

A8 **(Tsumura/ Survey team)**: Allow us to make more detailed investigations.

Q9 **(Gagik Ghazaryan/ ArmVodProject)**: If you cover the slopes with soil-bentonite mixture, won't there be danger of this layer washed down by water during the decrease of water level?

A9 **(Tsumura/ Survey team)**: We plan to use soil-cement for the slopes.

Q10 **(Gagik Ghazaryan/ ArmVodProject)**: But you didn't introduce breakdown of project cost of bentonite and soil mixture for the bottom, and soil-cement for the slopes.

A10 **(Tsumura/ Survey team)**: We have done such calculations but allow us to make more detailed investigations and discuss the issue later.

Q11 **(Gagik Ghazaryan/ ArmVodProject)**: If we completely close the reservoir with embankments, don't you think that there may cause swamps on the other side of the dam? Because the different water head between inside and outside of reservoir, could make the swamp. Don't you think this might cause damage to the dam?

A11 **(Tsumura/ Survey team)**: We will make the design with consideration of such issues.

Q12 **(Gagik Ghazaryan/ ArmVodProject)**: If you completely surround the reservoir by embankments, how will it be used for recreational purposes?

A12 **(Tsumura/ Survey team)**: This is an agricultural and irrigation project and we have not considered issues related to recreation.

Q13 **(Gagik Ghazaryan/ ArmVodProject)**: Resettlement and land acquisition are mentioned as negative factors. But the lands in the reservoir community are possessed by community lands. Hence, we do not have resettlement and land acquisition issues.

A13 **(Tsumura/ Survey team)**: We have to follow not only by the Armenian legislation but also by the JICA guideline as well.

Comment (Karo Karapetyan/ MTAES): We would kindly ask you to involve us in these works. We have a lot of information.

Q14 (Valeri Arzumanyan/ MTAES): You have drilled 30m boreholes. At what depth can the basalt be found? And besides, are you going to strengthen the dam body or are you going to leave it as it is?

A14 (Hiki/ Survey team): In the center, the reservoir bottom is covered by 120m-thick sandy loam. Towards the slopes, it changes to basalt. That is why we plan to carry out anti-infiltration measures instead of strengthening the embankments.

Q15 (Gagik Ghazaryan/ ArmVodProject): How do you design anti-infiltration measures on the embankment?

A15 (Mr. Hiki/ Survey team): These are the same measures that were planned during the Soviet period.

Q16 (Volodya Narimanyan/ SCWE): There are certain norms for filling and drawdown of reservoirs. In case of quick drawdown of the reservoir, what is the risk of damage of the dam body?

A16 (Tsumura/ Survey team): As the basic conditions, we plan to make the design to avoid any damage by earthquake and other risk. However, if the design should be followed by Japanese legislation, it will result in sharp increase of the project cost, because of huge emergency facility. We should discuss it with SCWE and related agencies.

Q17 (Volodya Narimanyan/ SCWE): What justification of anti-infiltration did you use for planning three (3) layers of bentonite sheets and one sheet only? The same condition applies to soil and bentonite mixture? How did you justify between three (3) and one (1) layer as applied layer? Besides, if you exclude the irrigation system from the Project, the reservoir will become a meaningless structure.

A17 (Tsumura/ Survey team): Regarding the first question, laboratory tests showed lower permeability results than was expected by us. However, we have not finalized result yet, we still need to continue the detailed investigations. Regarding the bentonite sheet, the bentonite factory suggested a higher permeability coefficient than the data provided by the PIU. That is why it may be possible to use one layer. Regarding excluding the irrigation system from the project cost, the productivity will be decreased, if this components will not be included. We suggest demarcating the project components between Reservoir project and other project in order to reduce project size and cost. We don't know how the Government will try to find funds. Dividing the project into two (2) phases maybe more convenient for the Government.

Q18 (Ashkhen Tovmasyan/ MTAES): What impact on the seismic activity of the area does a big reservoir have? The investigations are testified that there may be relatively strong earthquakes due to the big reservoirs. The 2008 earthquake in China was occurred by a big reservoir. They had forgotten that there is an active fault nearby.

A18 (Hiki/ Survey team): In my experience, there is one related public report about an earthquake that occurred in 1950s due to the construction of a big reservoir (Mihoro dam). I heard about another one in Thailand, where I was engaged as a member of design team. According to the Japanese norms, if there is an active fault, it is allowed to construct a reservoir with keeping at least at a 300m distance from the fault. Several clear faults have been found around and near the reservoir area but they are judged not to be active faults because of their not cutting our targeted geological layers. We assume that the construction of the reservoir will not result in fault activity.

Comment (Ashkhen Tovmasyan/ MTAES): I want to draw your attention on the fact that the Armenian norms require constructing a reservoir 10km away from the fault. There is no map of active faults but there is a reference to it in the norms. There are two representative maps in this report, but they just give a general picture.

Q19 (Gagik Ghazaryan/ ArmVodProject): What norms have you used for calculating the construction cost? Each country has its own prices. What criteria have you used for calculation?

A19 (Tsumura/ Survey team): These are preliminary calculations, RA norms have been considered. An Armenian specialist was also involved in the cost estimation. But these are all preliminary estimates. Allow us to continue. Of course the cost estimation should be in line with the Armenian norms.

Q20 (Volodya Narimanyan/ SCWE): I want to summarize our meeting as it is not possible to understand so much information in three hours and to organize a comprehensive discussion. I suggest that Armenian side openly submit your comments and remarks in written form. We will discuss them with the consultants.

I just have one remark. It would be more appropriate to change the word "Russian" for "USSR" when you speak about the investigations.

A20 (Tsumura/ Survey Team): We are still in Armenia and we can discuss any kind of remark. We have already replaced the word "Russian" in the slides, but we didn't have time to make this change in the report. We will revised all of words in DFR.

4. Closing Remark (Volodya Narimanyan/ Deputy Chairman, SCWE):

I want to thank the Japanese consultants for such detailed and serious studies. I also want to thank JICA and all the participants.

End