6.4 Basic Plan for Storm Water Harvesting

Storm water harvesting is an initial attempt in Palestine. In addition, there are limitations on the availability of hydrological, geological and topographic data and information. Thus, for the time being, it is recognized that the measure of water resources development by means of storm water harvesting is uncertain, as compared to the rehabilitation of agricultural wells and improvement of spring water conveyance system. Taking into consideration the present water deficit condition in the Study Area, storm water harvesting is a highly potential water source which could contribute in alleviating the water shortage.

In consideration of the aforesaid data ability and present situation of the Study Area, the Basic Plan for storm water harvesting is formulated at a preliminary level in this section. Related detailed information is described in Annex 3.

The target wadis for this Basic Plan are Wadi Far'a, Wadi Auja and Wadi Qilt.

6.4.1 Basic Concept for Formulation of Basic Plan for Storm Water Harvesting

Taken into consideration the present situation of water resources in the Study Area and the lack of hydrological record, four basic concepts was set to formulate the Basic Plan for the development of storm water harvesting. These are summarized in the following table.

Table 6.4.1 Basic Concept for Storm Water Harvesting

Issues for planning	Basic Concept	Actions Taken	Subsection
Deficit of water resources	Maximization of possibility for realization of water harvesting	Listing up of potential plans	6.4.2 (2)
		No rejection without convincing proof based on limited information	6.4.2 (3)
Limited available data for the Feasibility Study	Pre-feasibility Study based on limited information	Preparation of draft drawings and cost estimates based on the limited information	6.4.4
		Planning of the pilot project	6.4.7
	Long term vision for realization of storm water harvesting	Preparation of further investigation schedule with list of information required	6.4.5
		Planning of installation of hydrological station	6.4.6
		Preparation of draft TOR for future feasibility study	6.4.8
High evaporation rate and much suspended load	Consideration of measures against evaporation and suspended load	Preparation of recommended measures for evaporation and suspended load	6.4.3

Source: JICA Study Team

(1) Maximization of Possibility for Realization of Water Harvesting

Groundwater resource in the Study Area has deteriorated due to over-pumping, especially in Jericho area. On the other hand, some portion of the water especially those for domestic use, depends on the Israeli water supply. In consideration of water and food security in Palestine, self-sufficient rate of water supply should be increased. Considerable measures include improvement of efficiency of water use and development of new water resources.

In this Study, storm water harvesting is regarded as a high potential water resource, although further efforts are still required in collecting information in order to assess its feasibility.

Based on this concept, most possible potential water harvesting plans were listed. In the selection of prospective plans among the potential ones, only those which are clear and with convincing justifications were considered even if important information remains insufficient to realize its acceptability.

(2) Pre-feasibility Study based on Limited Information

To conduct Feasibility Study on storm water harvesting, wadis' discharge record including its quantity and quality within a certain period are required. However, this critical information was insufficient. In addition, geological and topographic data was also limited.

On the other hand, storm water harvesting has a high potential as a new water resource in Palestine, as mentioned above. Under this situation, Pre-feasibility Study for development of storm water harvesting, which includes draft drawings and cost estimates, was prepared based on the limited information available. In addition, a pilot project was initiated to collect the information required and to evaluate the possibility of storm water harvesting.

(3) Long-Term Vision for Realization of Storm Water Harvesting

Due to the above reasons, the Feasibility Study could not be conducted in this component. However, realization of the prospective plans on storm water harvesting is vital for the Palestinians. Therefore, from the long-term point of view, the following issues were described in the Basic Plan as alternatives to conducting the Feasibility Study:

- (i) Preparation of further investigation schedule with a list of information required in order to evaluate the feasibility of the prospective plans;
- (ii) Installation plan of hydrological station; and
- (iii) Preparation of draft Terms of References (TOR) for the future feasibility study on the prospective plans.

(4) Consideration of Measures against Evaporation and Suspended Load

High evaporation rate and suspended load in the turbid flood is to be considered in the Study Area. Without any measures devised to prevent these issues, sustainability and efficiency of the storm water harvesting facilities could not be secured.

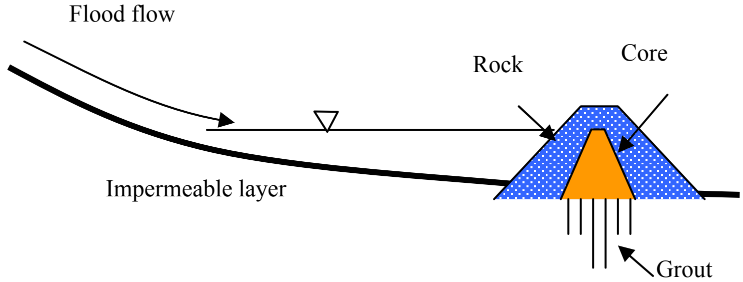
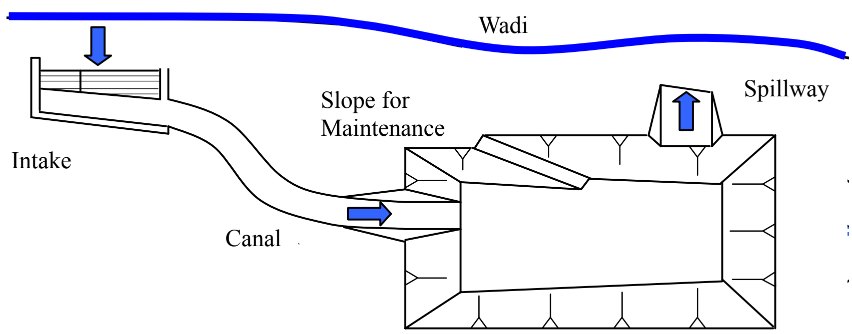
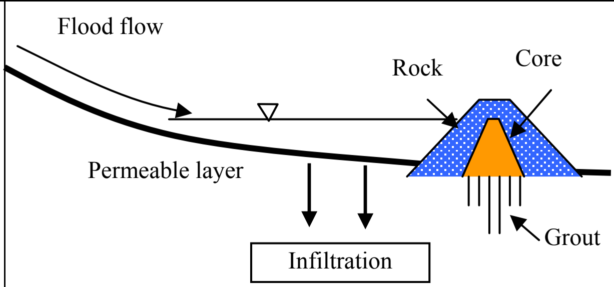
Therefore, measures against evaporation and suspended load were considered as the fourth basic concept. Based on this concept, recommended measures for evaporation and suspended load were prepared in the Basic Plan. The measures were also applied in the related draft drawings and cost estimates of the prospective plans.

6.4.2 Selection of Prospective Storm Water Harvesting Plans

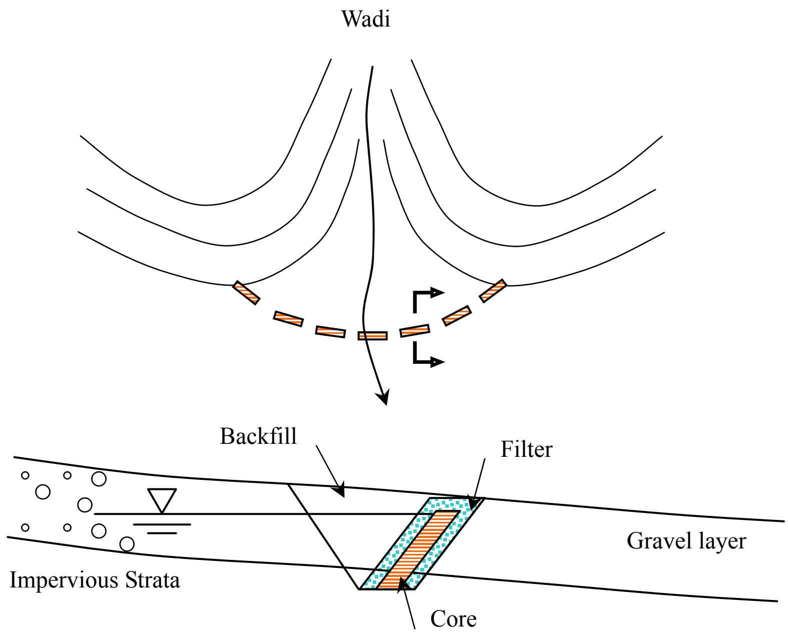
(1) Conceivable Types of Storm Water Harvesting Facilities

The storm water harvesting facilities conceived in the Study Area are classified mainly into the following four types:

Table 6.4.2 Conceivable Types of Storm Water Harvesting Facilities

<table>
<tr><td colspan="2">1) Storage type dam on wadi</td></tr>
<tr><td>Objectives</td><td>• To store flood flow in the dam reservoir
• To use water in the storage throughout a year</td></tr>
<tr><td>Issued to be considered</td><td>i) Dam security control aspect such as safety against probable maximum flood, foundation of the dam, seepage from the dam and sedimentation of the reservoir
ii) Dam operation and maintenance aspect such as total amount of flood discharge, sedimentation and infiltration rate of the reservoir
iii) Natural and social environmental aspects including land acquisition and/or resettlement</td></tr>
<tr><td>Schematic drawing</td><td>
</td></tr>
<tr><td colspan="2">2) Reservoir (or pond) for turbid wadi water</td></tr>
<tr><td>Objectives</td><td>• To store the wadi flood water and excessive spring water</td></tr>
<tr><td>Issued to be considered</td><td>i) Volume of flood discharge on wadi
ii) Suspended sediment load concentration
iii) Foundation of the intake facilities and infiltration rate of the reservoir
iv) Land availability (land acquisition, resettlement)</td></tr>
<tr><td>Schematic drawing</td><td>
</td></tr>
<tr><td colspan="2">3) Retention dam and recharge basin</td></tr>
<tr><td>Objectives</td><td>• To retard the flood flow on the wadi
• To accelerate infiltration of the wadi water into the groundwater</td></tr>
<tr><td>Issued to be considered</td><td>i) Existence of highly permeable layers in the bed of the reservoir
ii) Sedimentation in the reservoir area</td></tr>
<tr><td>Schematic drawing</td><td>

*Difference from storage type dam on wadi is the objective of recharge basic. This type is aimed to recharge underground the stored through the highly permeable layers under the recharge basin.</td></tr>
</table>

4) Underground dam	
Objectives	• To stop the subsurface flow • To store water under the ground
Issued to be considered	i) Existence of highly permeable alluvial fan as surface layer to store the wadi water and impervious base layer ii) Slope and porosity of alluvial fan
Schematic drawing	

Source: JICA Study Team

(2) Identification and Preliminary Assessment of Potential Storm Water Harvesting Plans

While the hydrological and other data are not sufficiently available for formulating the storm water harvesting plans, the potential plans were preliminarily identified, taking into account the following conditions:

(i) Land availability based on existing land use map,
(ii) Topographic condition based on existing topographic maps, and
(iii) Geological condition based on existing geological maps.

The potential plans of storm water harvesting in each stretch of the three major wadis are identified, as shown in Table 6.4.3 below based on the aforesaid conditions:

Table 6.4.3 Identified Storm Water Harvesting Plans in Three Major Wadi Basins

Location		Land availability [1)] Area A	Area B	Area C	Land use Nature reserve	Land use Farmland	Land use Residential area	Land use Unused	Topography	Geology Riverbed	Geology Subsurface	Possible type of storm water harvesting
Wadi Far'a	Upper		*	**	*	**	*	*	Mountainous area with deep and narrow gorge	High permeability (Limestone)	High permeability (Limestone)	Retention dam
	Lower			***		**	*	*	Flat plain with narrow wadi	High permeability (Sandy alluvial fan)	Very low permeability (Marl)	Reservoir for turbid flood
Wadi Auja	Upper			***	***			*	Mountainous area with deep and narrow gorge	High permeability (Limestone)	Unknown	Less possibility for storm water harvesting
	Lower	***				**	*	*	Flat plain with wide wadi and wide subsurface flow	High permeability (Sandy alluvial fan)	Very low permeability (Chalk)	Underground dam
Wadi Qilt	Upper	*		**	**	*	*	*	Mountainous area with deep and narrow gorge	High permeability (Limestone)	Very low permeability (Marl)	Dam on wadi
	Middle	**		*	*	*	*	**	End of mountainous area	High permeability (Sandy alluvial fan)	Unknown (Marl or alluvial fan)	Retention dam in case of alluvial fan, Underground dam in case Marl
	Lower	***				**	*	*	Flat plain with narrow wadi	High permeability (Sandy alluvial fan)	Very low permeability (Marl)	Reservoir for turbid flood

Notes 1) Data availability:;: partly covered, **; mainly covered, ***; completely covered*

2) +: geological investigation including core drilling needs to be performed to clarify the existence of the highly permeable alluvial fans

Source: JICA Study Team

Location map of the potential storm water harvesting plan and topographic map along each wadi are shown in Figure 6.4.1 to Figure 6.4.3. The potential water harvesting plans are explained below from the technical viewpoints:

1) Wadi Qilt

- Storage type dam on the wadi Qilt at the foot of mountain
- Retention basin or underground dam at the nearby location of the existing partial flume on the Wadi Qilt
- Storage facility of the storm water on the left bank of the Wadi Qilt at downstream site of the existing garbage damping site

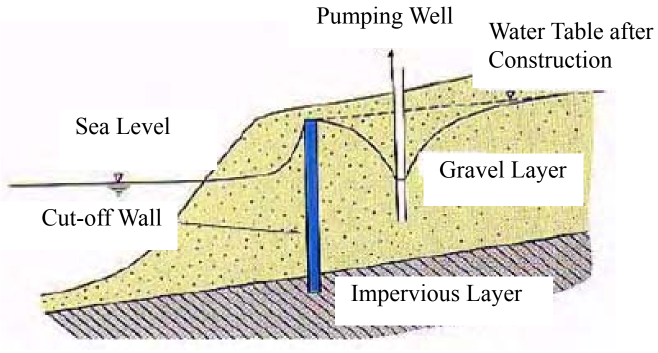


Image of Underground Dam

2) Wadi Auja

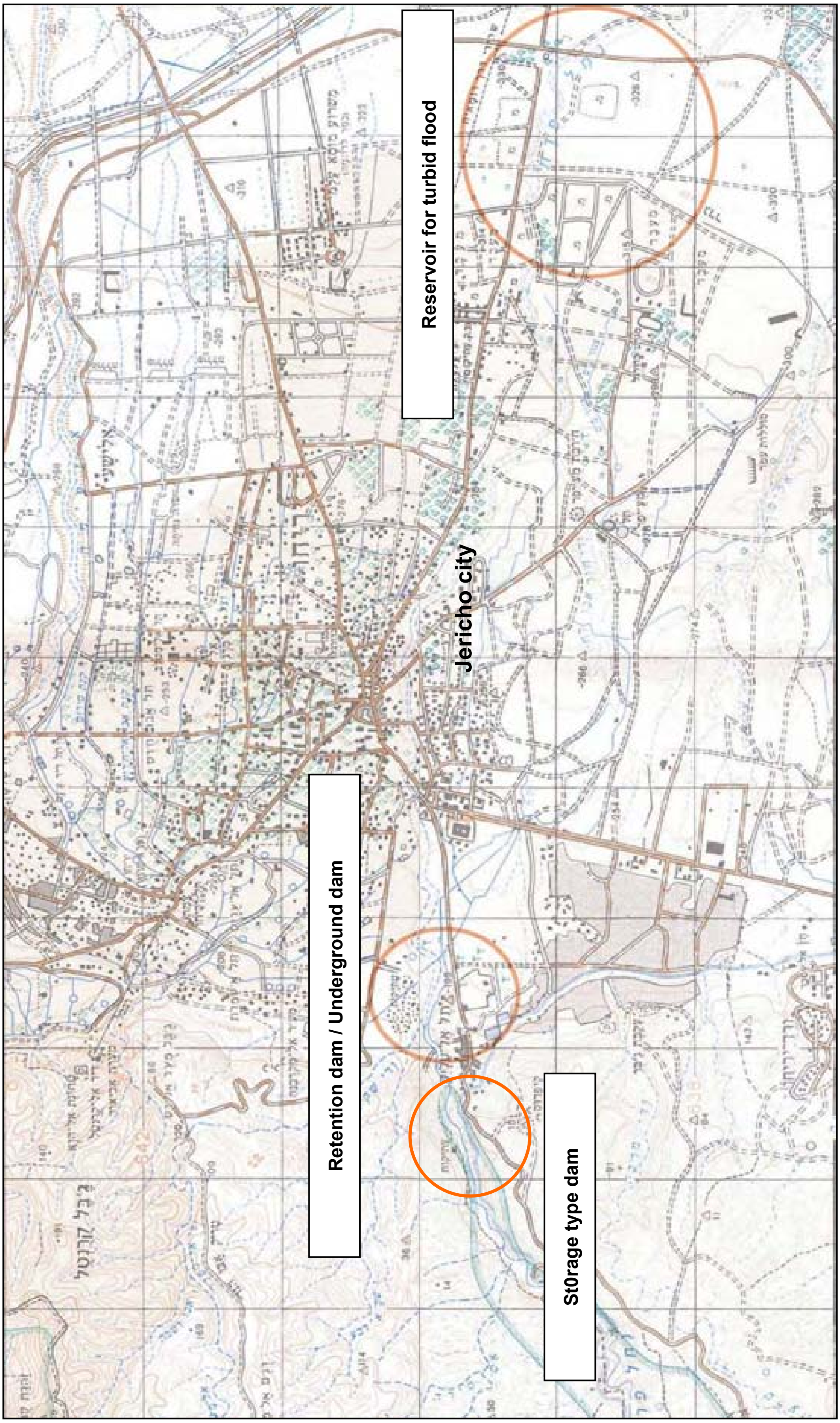
- Recharge basin or underground dam at the downstream end of the alluvial fan
- Regulating reservoir for storing surplus spring water and realizing the systematic water supply utilizing the headrace channel in the wide/flat plain area

3) Wadi Far'a

- Storage type dam on the Wadi Far'a mainstream at the confluence of Al Far'a and Al Baden (tributaries of the Wadi Far'a), and storage type dam on each of these tributaries
- Retention dam and/or terracing facilities that will be proposed under the on-going study on the EU-Najah University joint project (EXACT)

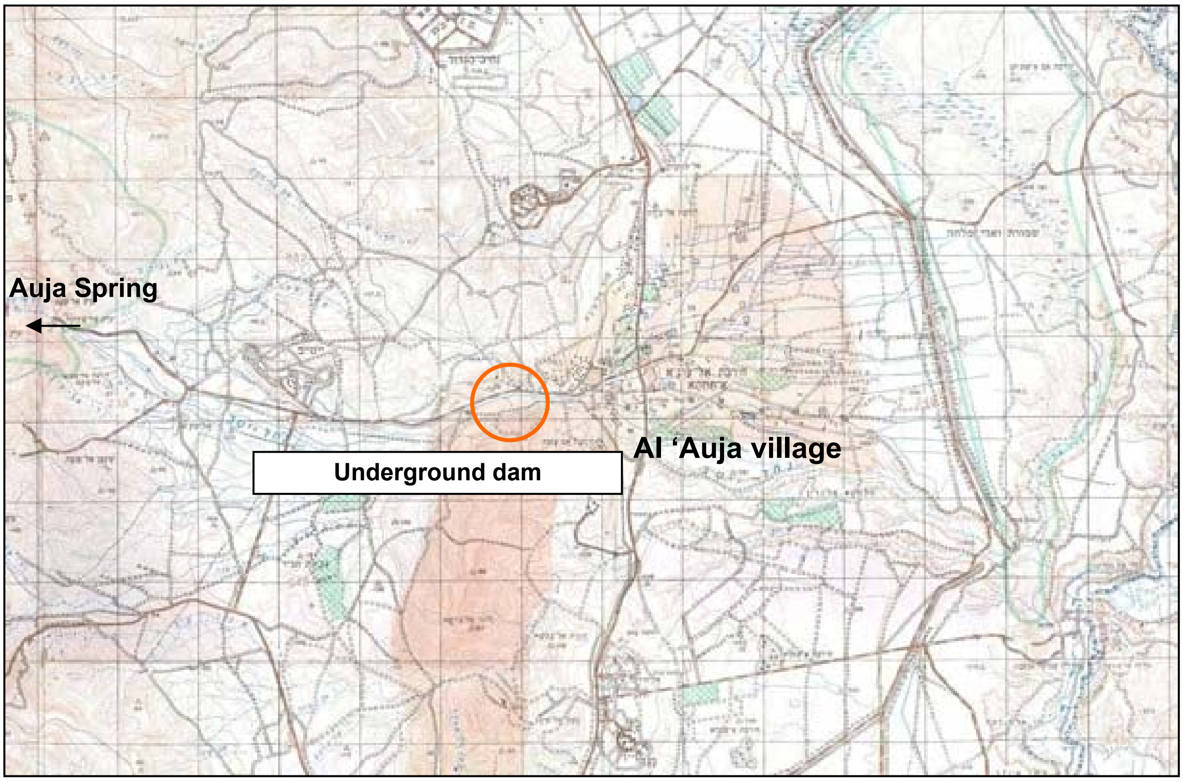
It is recommended that the following technical aspects are deeply examined in planning and design the storm water harvesting facilities:

(i) Regional specific design conditions of storm water harvesting facilities;
(ii) Availability and soil mechanical characteristics of embankment materials;
(iii) Countermeasures against high evaporation; and
(iv) Countermeasure against turbid flood water of wadi and siltation, especially for flood flow of the Wadi Qilt.



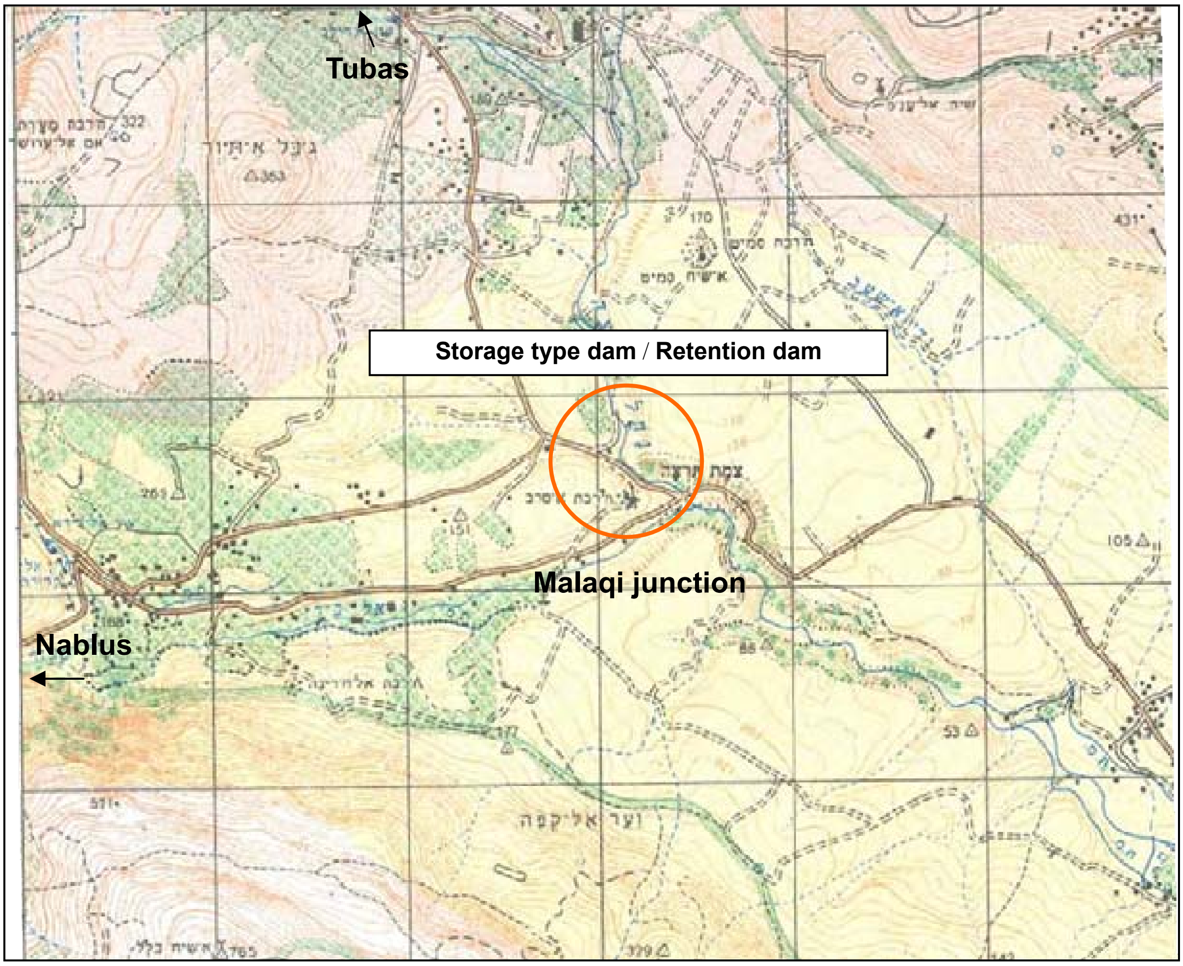
Source: JICA Study Team

Figure 6.4.1 Potential Storm Water Harvesting Plan on Wadi Qilt



Source: JICA Study Team

Figure 6.4.2 Potential Storm Water Harvesting Plan on Wadi Auja



Source: JICA Study Team

Figure 6.4.3 Potential Storm Water Harvesting Plan on Wadi Far'a

(3) Selection of Prospective Water Harvesting Plans

To further ascertain the possibility of realization of the potential storm water harvesting plans, field reconnaissance was intensively carried out in the Study (Refer to Annex 3.1). Consequently, the following three potential plans were discarded from the above list.

1) Storage type dam on Wadi Qilt

A potential site for storage type dam on Wadi Qilt is located at the foot of the mountain.

Upstream area of Wadi Qilt is characterized by a very steep slope of the wadi bed, with a slope of more than 1/50. Besides, the flood flows, which were observed in the field work periods, were very turbid, containing a large quantity of suspended loads with very high concentration.

According to the dam design criteria in Japan, the reservoir storage volume must have sediment inflow into the reservoir for 100 years, unless the facilities, which can flush sediments in the reservoir effectively, are provided. The sediment inflow volume into the reservoir for 100 years was estimated for the Wadi Qilt, applying a denudation rate of 0.75 mm/year as shown in Subsection 4.2.8. Consequently, the estimated sediment volume in 100 years is about 7.7 million m^3.

$$V_s = 103.1(km^2) \times 0.75(mm/year) \times 100\ (years)/10^3 = 7.7\ (million\ m^3)$$

The above estimate led to an engineering judgment that a significantly high dam needs to be constructed in order to secure the necessary reservoir volume for sediment. Evidently, this is difficult to implement considering the topographical aspect. Besides, the foundation rock has neither sufficient strength to support such high dam, nor low permeability to allow its construction. Hence, the storage type dam plan on the Wadi Qilt was discarded from the prospective water harvesting plans.

2) Storage type dam on Wadi Far'a

Potential dam sites were preliminarily selected on the existing topographic maps in order that larger storage volumes could be secured with the smaller embankment volume for the storage type. Three storage type dam sites on the mainstream of the Wadi Far'a, and its two tributaries, namely Al Far'a and Al Badan, are listed below:

i) Site A; Al Far'a (Tubas area)

ii) Site B, C; Mainstream of Wadi Far'a, located downstream of confluence of Al Far'a and Al Badan

iii) Site D; Al Badan (Nablus area)

As tabulated below, the appropriate dam height at each of the above sites, and its gross storage capacity were calculated based on the existing topographic maps:

	A	B	C	D
Dam Height m	20	15	20	10
Storage m^3	586,000	255,000	456,000	40,000

Note: Storage was calculated by CAD using existing topographic maps (Refer to Annex 3.2).
Source: JICA Study Team

The base rocks of these dam sites consist of limestone. Limestone has lots of cracks and has small to large-scale caves mainly due to the weathering process of the water. Therefore, permeability of the limestone was assumed to be extremely high, especially near the ground surface, due to weathering.

In case a storage type dam is constructed at the above sites, foundation is generally improved by grouting to prevent leakage. However, this is determined difficult to implement from a dam engineering viewpoint. Besides, the appurtenant structures such as spillway and intake structures would also require a large scale improvement of foundations.

In addition, another issue is the sediment accumulation in the reservoir created by the storage type dams. Applying a denudation rate of 0.625 mm/year in a catchment area of 74.2 km^2, the sediment inflow volume at the Site-B in 100 years is estimated to be 4.6 million m^3, which is by far larger than that shown in the table above.

$$V_s = 74.2(km^2) \times 0.625(mm/year) \times 100\ (years)/10^3 = 4.6\ (million\ m^3)$$

From the above evaluations, it was realized that construction of a storage type dam in the Wadi Far'a basin is not feasible.

In the site reconnaissance conducted in June 2007, it was found out that the streamflow of on the Al Baden constantly flows down, the tributary of Wadi Far'a upstream of confluence of Al Far'a and Al Baden, while there is no streamflow on the Al Far'a. The local inhabitants informed the Study Team that the constant flow of the Al Baden is wastewater coming from Nablus, having the most serious adverse influence on the water resources in the Wadi Far'a basin. According to the information from PWA, a sewerage plan for Nablus municipality has been prepared with the aid of Germany, awaiting the approval of the concerned organization. As the first step to manage and develop the water resources in the Wadi Far'a is to install the sewerage system for Nablus and other upstream municipalities in the Wadi Far'a basin.

At present, the EXACT, which is the EU-Najah University cooperative project under PWA, is carrying out a study on Small Scale Water Treatment and Artificial Recharge Project in the Wadi Far'a basin. Recently, the study suggests alternative sites of retention dams and terracing facilities on the Al Far'a and Al Baden, as well as the mainstream of the Wadi Far'a downstream of confluence of the both tributaries, in order to develop the groundwater recharge. Annex 1: Hydrology presents the interim proposal of the on-going study in the Wadi Far'a basin.

PWA is awaiting the outcomes of the study and implementation of the project proposed under the on-going study. Taking the situation into consideration and as a result of the consultation with PWA, it is determined that the selection of the Basic Plan in the Wadi Far'a basin is entrusted to the on-going study and that no further examination be carried out under this Study.

3) Reservoir for Flood at Lower Wadi Far'a

Lower Wadi Far'a area has a possibility of storm water harvesting as same as lower Wadi Qilt. However, potential sites of the lower Wadi Far'a area were completely located in Area C. In parallel with the field reconnaissance, interview survey at the community of Al Jiftlik around the potential sites, was carried to confirm the land availability. Through the land availability, it was found that any type of construction work has not been approved. Although the community has planned to construct a village council building under JICA support more than a year ago, it has not been approved yet.

Considering the above fact, this potential plan was discarded from among prospective plans although the plan has a high potential in realizing storm water harvesting.

6.4.3 Consideration of Measures against Evaporation and Suspended Load

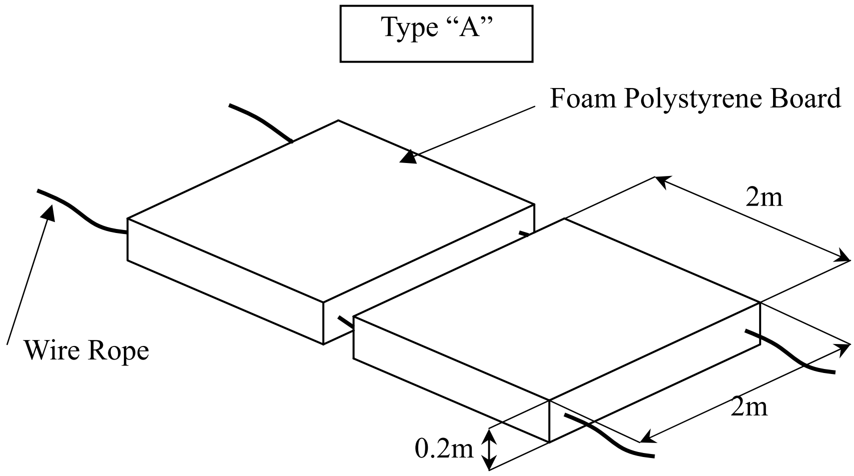
Sites and types of the prospective plans were selected in Subsection 6.4.2. However, the following issues must be also considered as part of the technical aspects in order to make the effective and sustainable plans:

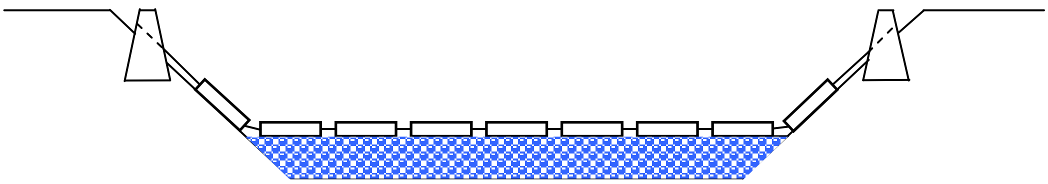
(1) Treatment for evaporation

Considering the intensive sunshine, high temperature and low humidity in the Study Area, evaporation loss from reservoirs or ponds is significant. Some ideas in preventing evaporation are illustrated as follows, which is still subject to further discussion in view of its possibility or economical aspects.

1) Type A

As shown in the sketch below, Foam Polystyrene Boards connected by wire ropes, are placed on the surface of the reservoir to prevent evaporation.





2) Type B

On the other hand, Cobble and Boulder, which has almost of same size and shape, are backfilled into the excavated reservoir. Water is stored in the void between cobbles and boulders. Finally, surface of the reservoir is covered with a soil of about 2 m thick. High effect for preventing evaporation will be expected in this type.

Porosity (void ratio between cobbles and boulders) should be determined through laboratory test. Porosity of 20% is assumed to be the Study so far (Refer to Annex 3.3).

(2) Treatment for turbidity

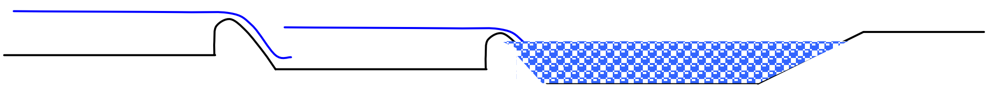
Treatment for turbidity is an important subject similar to the treatment for evaporation. Method/principle to obtain clean water from turbid water is shown as follow.

- Utilization of chemical act
- Silt/Sand basin (Type-A)
- Percolation using filter (Type-B)

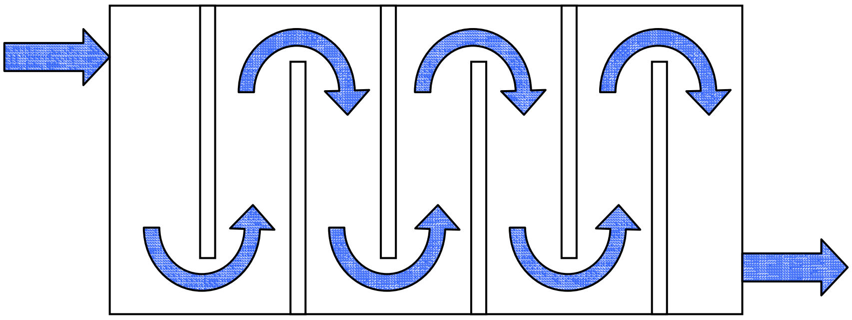
Among these methods, utilization of chemical act is not suitable to treat a huge volume of turbid water. Another two methods are discussed below. Further discussion such as its possibility and economical conditions shall be initiated in the design stage.

1) Type-A

Schematic profile as one of examples is shown below.



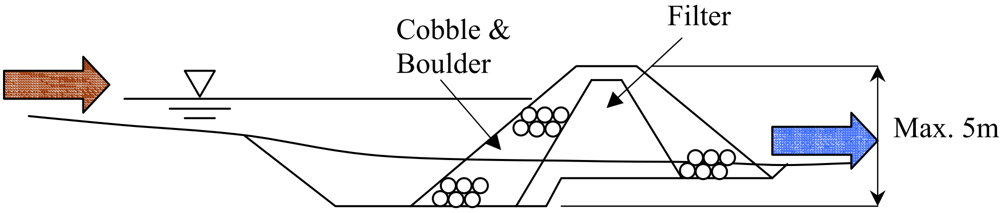
Schematic plan view as another example is shown below. This includes several separator walls to keep the velocity low, and to accelerate siltation.



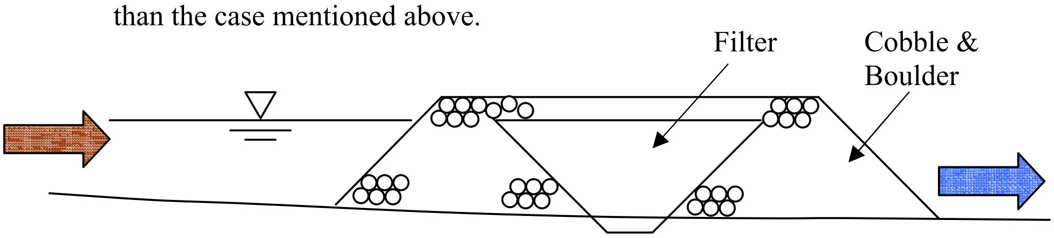
In both cases, siltation should be removed periodically.

2) Type-B

Clean water is obtained from turbid water after passing through the filter dam, which is constructed from filter and rock materials.



From view point of maintenance, the filter dam with a shape shown below could be advantageous, since excavation of filter part and refill of filter material is easier than the case mentioned above.



6.4.4 Pre-feasibility Study for Storm Water Harvesting

As discussed previously, the storm water harvesting plans of storage type dam in the Wadi Qilt and Wadi Far'a basins, and reservoir for flood at lower Wadi Far'a have been excluded from the Pre-feasibility Study.

(1) Downstream Area of Wadi Qilt (Alternative-1)

The following conditions are taken into consideration to formulate the Basic Plan for storm water harvesting:

(i) Contour maps that have been written out automatically based upon the aerial photographs are employed for the preliminary design. Consequently, some part of the actual topographic conditions, such as position or elevation regarding wadis, might not be reflected precisely in the maps;

(ii) There are no reliable hydrologic data, such as incidence, hydrograph, and turbidity of the flood water running through the wadi. Therefore, the following presumptions are undertaken: i) the peak flood discharge is assumed at $Qpeak = 100m^3/sec$; ii) Turbid water emerged at the initial flood stage will not be taken into the reservoir. The water intake commenced when the flow speed is stabilized and the turbidity is lessened;

(iii) Geographic condition allows constructing an over-flow weir for an intake;

(iv) The capacity of over-flow weir is assumed as $Qintak = 10m^3/sec$;

(v) A filter dam is constructed to filtrate the water, assuming that it will function effectively. As clogging information is required, a related test (Refer to Annex 3.4) will be conducted during the pilot project; and

(vi) It is expected that the flood flows very rapidly since the wadi riverbed is so steep, with a slope of nearly 1/50. In order to prevent erosion and to facilitate effective intake, stabilizing the water flow along the intake facility is essential. Therefore, widening the river channel (to 20m wide) and stabilizing the riverbed slope (to 1/500) are necessary for the construction of storm water harvesting facility.

A storm water harvesting facility consisting of an intake weir and a reservoir located outside of the wadi riverbed is recommended in the downstream area of Wadi Qilt, as described in the foregoing paragraph. The diverted flood water is led to the primary reservoir by a headrace. Turbid water in the primary reservoir shall be filtrated to obtain clean water after passing through the filter system. Subsequently, the clean water will be stored in the secondary reservoir.

The process of storing the flood water is conducted by means of gravity. From the topographical view point, it is advantageous to reduce excavation volume by providing the longest distance possible between the diversion point and the secondary reservoir.

Subsequent to preliminary hydraulic calculations (Refer to Annex 3.5), the following three layout plans were studied as shown in Figure 6.4.4. Plan “A” is located at just south of the garbage damping site under construction, with less land use observed around this site. Plan “B” and Plan “C” sites meanwhile are located within the defined “Area C.” However, both plans have topographic advantage against plan “A”.

Preliminary quantity calculation and storage capacity of each of the plan are tabulated in Table 6.4.4. Considering various aspects, the Plan “A” is tentatively selected, since it is located at the defined “Area A”.

Table 6.4.4 Summary of Quantity Calculation

		Plan "A"	Plan "B"	Plan "C"	Remarks
Earth Works					
Excavation	m^3	399,500	570,200	733,700	Common Soil
Embankment	m^3	---	800	---	Common Soil
Spoil	m^3	399,500	569,400	733,700	
Rock	m^3	14,500	23,800	20,300	
Filter	m^3	5,600	9,700	8,000	
Slope protection	m^3	20,600	28,500	28,300	t=1m
Intake Facility					Including Headrace
Excavation	m^3	4,600	4,700	4,500	
Backfill	m^3	1,800	1,800	1,700	
Concrete	m^3	950	970	930	21N-8-25 RC
Weir Structure					
Concrete	m^3		582		21N-8-25 RC
Excavation	m^3		9,200		
Backfill	m^3		1,000		
Protection	m^3		2,350		Gabion
Gate	Nos.		4		B4m*H2m
Storage					
Primary	m^3	22,700	43,600	47,700	Turbid Water
Secondary	m^3	51,300	107,800	126,900	Clean Water
Construction Cost					
	USD	6,640,000	8,820,000	9,680,000	

Source: JICA Study Team (Refer to Annex 3.6)

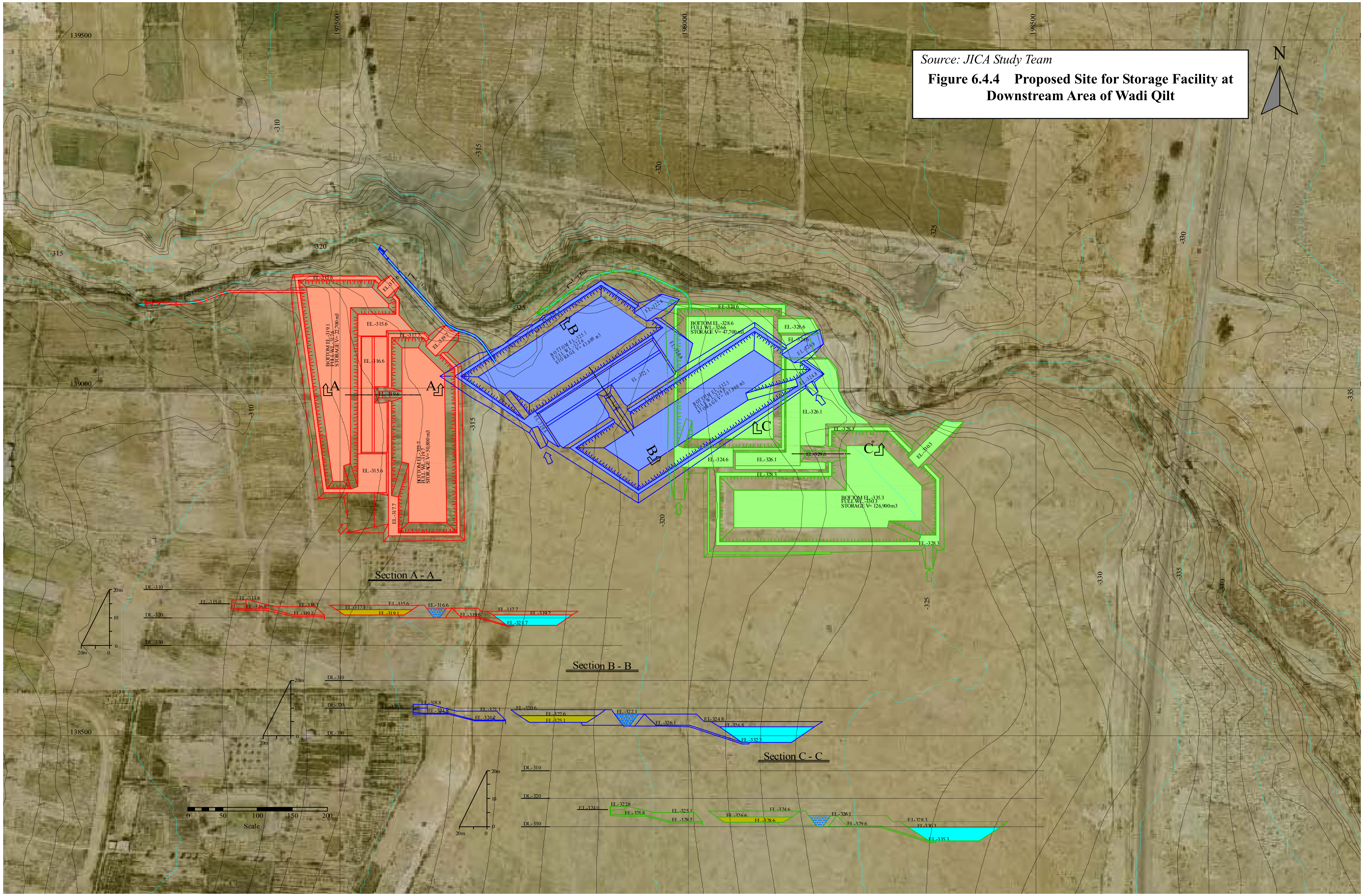
Method of taking flood water running along the wadi is an issue considered for the reservoir outside the river channel. An over-flow weir considered in the Basic Plan is required to safely divert the water downstream, whose flow volume is greater than its intake capacity (*Q= 10*m^3*/sec*). On the other hand, the weir is also required to store the water even during a minimal flow occurring at the termination stage of the flood.

It is also proposed to construct a concrete weir with gate on the river channel in order to regulate flood flow and divert excessive flow downstream. Figure 6.4.5 indicates the location of the respective facilities, which include a reservoir, an over-flow weir, an intake canal and a concrete weir with gate constructed on the river channel. In addition, Figure 6.4.6 shows an image of the concrete weir with gate. The turbid water at the initial flood stage will be diverted downstream through the gate. When the level of flow and turbidity becomes suitable, the gate will be closed to secure the water at a depth of 1 - 1.5 m. Simultaneously, the flow volume is also diverted by controlling a stop logs installed at the top of the over-flow weir.

Use of pumping cars is also a possible alternative method in constructing the concrete side weir. Specification and price information of a typical pumping car is as follows:

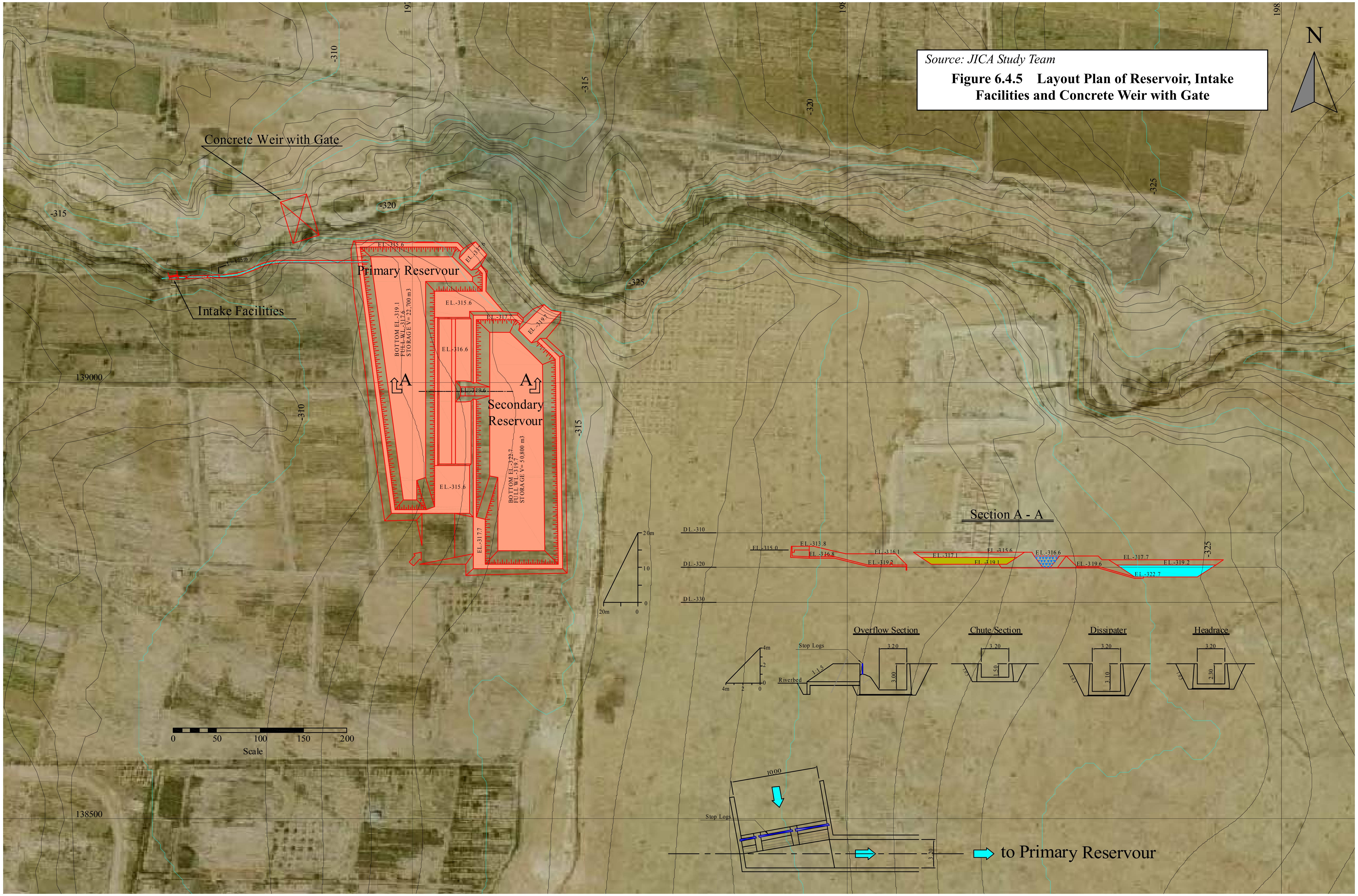
- Pumping capacity *Q=1*m^3*/sec (60*m^3*/min)*
- Price USD509,000

(Refer to Annex 3.7)



Source: JICA Study Team

Figure 6.4.4 Proposed Site for Storage Facility at Downstream Area of Wadi Qilt

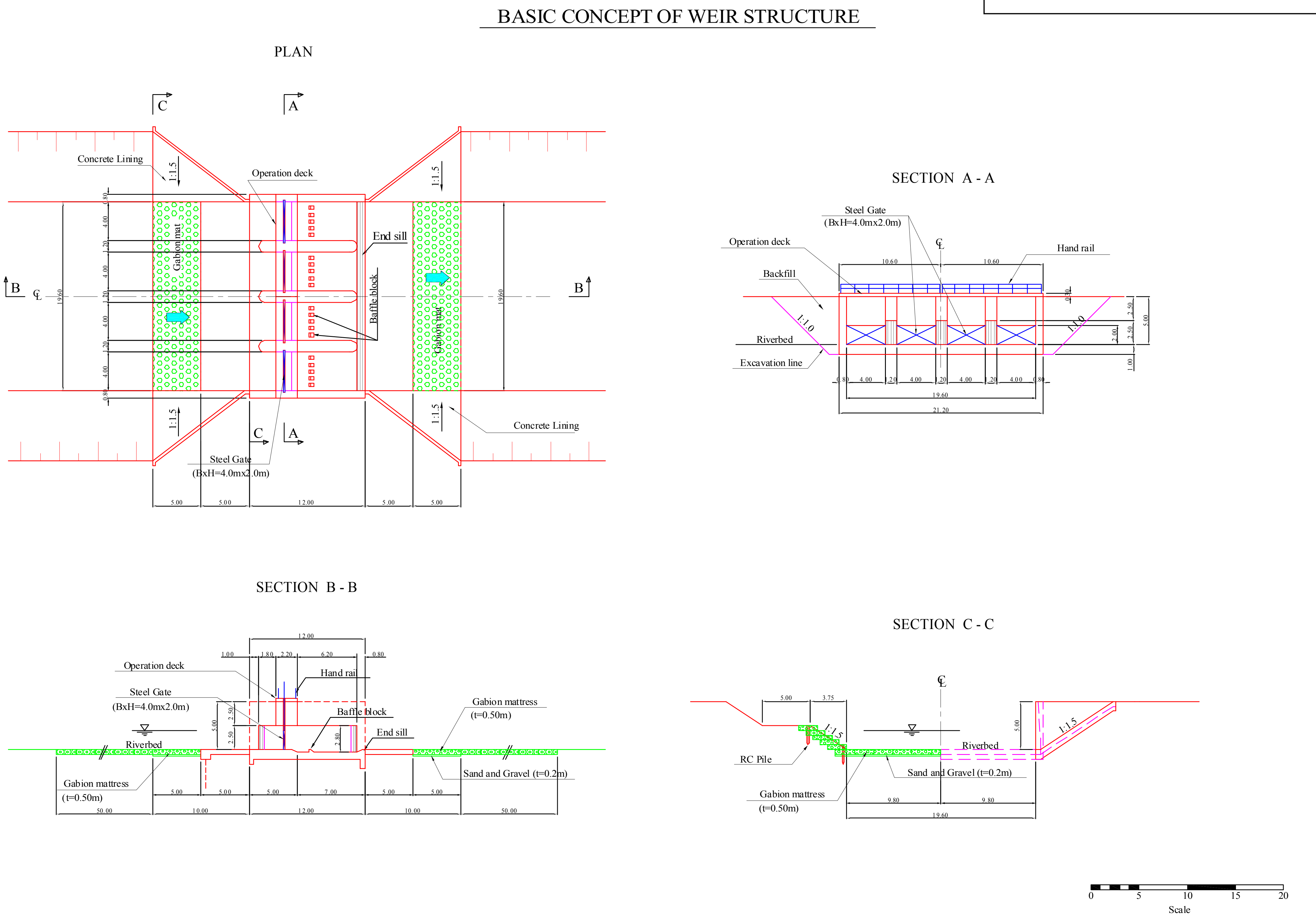


Source: JICA Study Team

Figure 6.4.5 Layout Plan of Reservoir, Intake Facilities and Concrete Weir with Gate

Source: JICA Study Team

Figure 6.4.6 Basic Concept of Concrete Weir with Gate

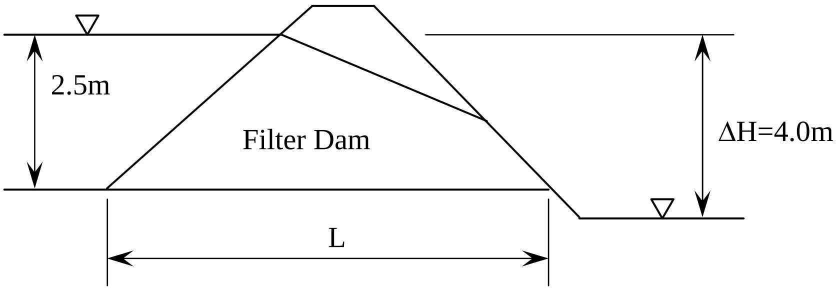


[Issues to be solved for the plan]

The following issues should be resolved for the preparation of the proper plan.

1) Filtration Ability of Filter

Filtration ability of the filter is studied under several assumptions.



$i = \Delta h/L$ | $k = 5*10^{-3}$ *cm/s (assumption)*

$v = k*i$ ⇨ $= 5*0.864$ *m/day* ⇨ $Q = 1{,}080\ m^3/day$

$Q = v*A$ | $L = 4\ m,\ \Delta H = 4\ m$

$A = 2.5\ m^2$

$\ell = 100\ m$ *(longitudinal length)*

As shown in the calculation result above, it takes time to extremely filtrate turbid water against the flood discharge of $Q=10m^3/sec$ *(Max).*

2) Frequency of Maintaining the Filter

This is the most uncertain issue, which should be necessarily confirmed from laboratory tests (Refer to Annex 3.4).

3) Treatment for Evaporation

The foam polystyrene board is placed on the surface of the secondary reservoir as a means of treatment for evaporation.

(2) Upstream Area of Wadi Qilt (Alternative-2)

Conceivable types of storm water harvesting facility in this area are i) the underground dam at the alluvial fan or ii) the recharge facility for the aquifer (gravel layer below “Marl”).

Figure 6.4.7 shows the geological condition around the end of the mountainous area of Wadi Qilt, to the Jericho town. Proposed site for the underground dam or the recharge facility is located around the existing partial flume. As shown in the figure, a complex geological characteristic is observed within this area, especially near the fault.

When the underground dam method is adopted, it is necessary to construct the cut-off wall to reach the impervious clay layer, or the “Kumi layer (Chalk)”, as shown in the figure above. On the other hand, determining the permeability and continuity of the “Oli (Marl) layer” is necessary to assess the possibility of a recharge facility. Therefore, although boring test at two points was planed to determine the geographic condition (refer to Figure 6.4.7), this has not been conducted due procedural issue.

It is required that a retarding basin is constructed at an elevation equal to the flood water surface if groundwater recharge system is adopted. However, construction of the retarding basin is not suitable for this area because: i) the difference in elevation between wadi riverbed and original ground surface around the existing partial flume is more than 20 m, ii) the whole area of right and left bank of the wadi have already been cultivated for cropping. Therefore, construction of the underground dam is more suitable based on the current geographic and topographic conditions.

The extent of the underground dam initially assumed is as follows.

Length of the cut-off wall	680 m
Storage area	61,000 m^2 (estimated using CAD software.)
Storage volume	*61,000* $m^2 \times 20\ m \times 0.1 = 122{,}000\ m^3$
	（20m: water depth in the gravel layer）
	（0.1: porosity of the gravel layer）

A storage volume of the reservoir calculated as 122,000 m^3, would take 70 days to fill based on the following calculation. The calculation has taken into consideration the recharge rate from the wadi riverbed to the underground dam. Therefore, the additional reservoir for water recharge should be considered to improve the percolation efficiency.

Dimension	*240 m (length) x 15 m (width) = 3,600* m^2
Infiltration volume from wadi	*3,600* m^2 *x 0.5 m/day* = 1,800* m^3*/day*
	*0.5 m/day: infiltration capacity[1]
Required period	*122,000* m^3 */ 1,800* m^3*/day = 70 days*

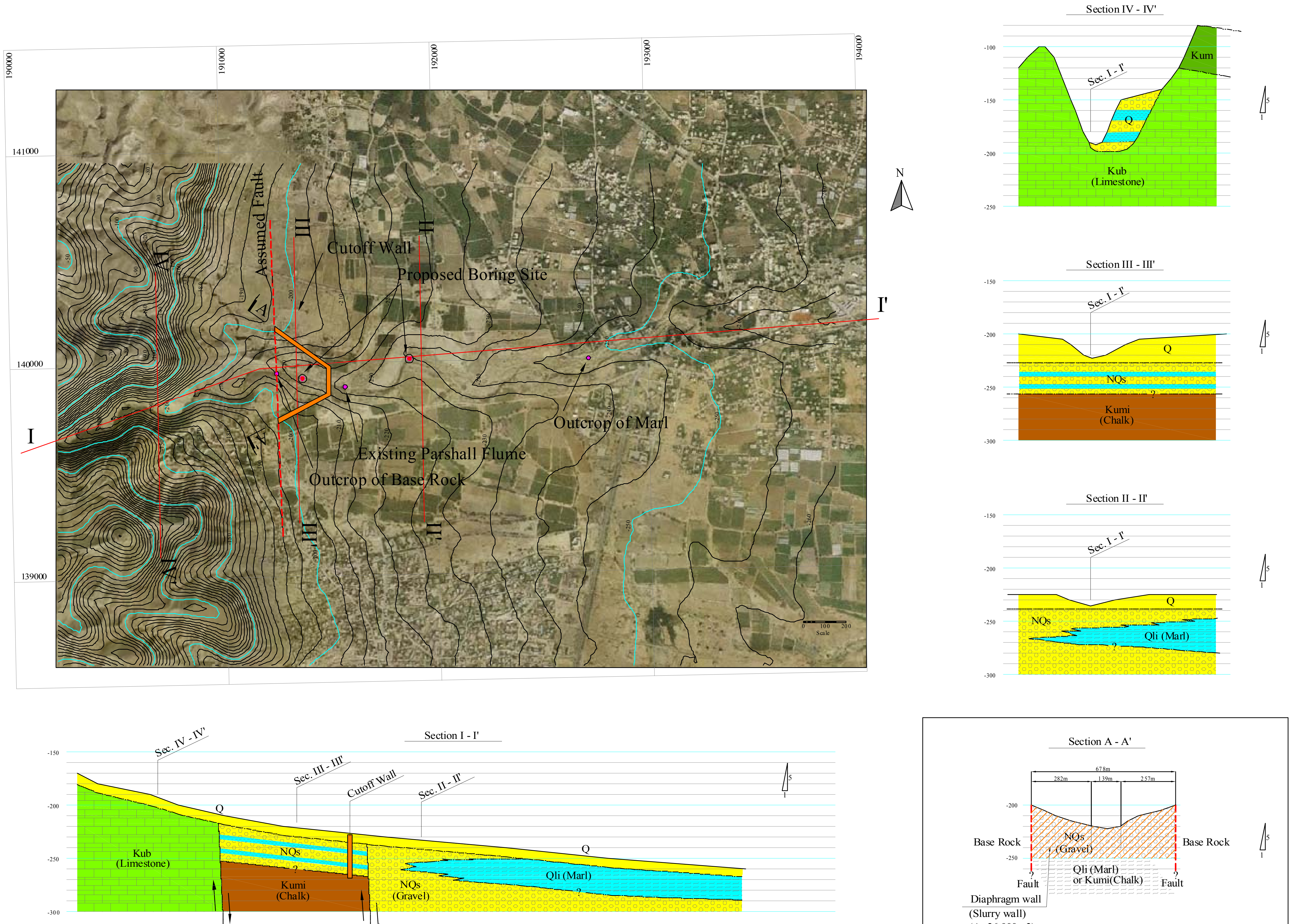
On the other hand, an open cut mining method from the ground surface is eliminated, since the maximum depth of the cut-off wall reaches 50 m. A slurry wall method is more preferred than a grouting method since the underground dam would be constructed

[1] Todd,D.K. 1980. *Groundwater Hydology: Second edition.* John Wiley & Sons, New York

within the gravel layer. Construction costs using the slurry wall method are calculated as follows.

Dimension of construction	26,000 m^2 (estimated by CAD software.)
Unit price per 1 m^2	USD600/ m^2 (Based on the Japan's price)
Preliminary construction costs	*26,000 m^2 x USD600/ m^2 = USD15,600,000*

From the above discussions, construction of the underground dam at the upper stream of the Wadi Qilt seems not economically viable. In addition, space for construction of the required recharging basin around the prospective site is expected insufficient, however, it is to be confirmed through geological survey to verify its effectiveness in the future feasibility study stage. PWA expressed its strong intention in alleviating the deterioration of groundwater by the recharge basin of storm water harvesting.



Source: JICA Study Team

Figure 6.4.7 Proposed Site for Recharge Facility at Upstream Area of Wadi Qilt

(3) Wadi Auja (Alternative-3)

Wadi Auja has been formed as a wide alluvial fan after it flows in the mountain area, as shown in the geological map (Figure 6.4.8). This runs in a narrow space between the hills just before the Al ‘Auja village, finally flowing into Jordan River. Lisan Formation (Qli: Marl) is spread in the eastern area of the alluvial fan similar to the Wadi Qilt. However, in the wide alluvial fan, a gravel layer (Q2: Gravel) with thickness of more than 20 meters lies above the impervious “Kumi (Chalk) layer”

The storm water harvesting facilities of the underground dam which has cut-off wall around the narrow gorge is recommended, in consideration of the topographical and geological conditions. Recommended construction site of the underground dam is shown in Figure 6.4.9. Storage volume is calculated with the following assumptions.

Water depth	10 m
Longitudinal gradient of ground surface	i = 1/50
Longitudinal gradient of groundwater surface	i = 1/100

(Groundwater is assumed in running condition.)

(In the case inactive, groundwater surface is flat.)

Porosity of gravel layer	n = 0.1

Calculation result of the storage is as follow.

Plan “A” V = 300,000m^3

Plan “B” V = 750,000m^3

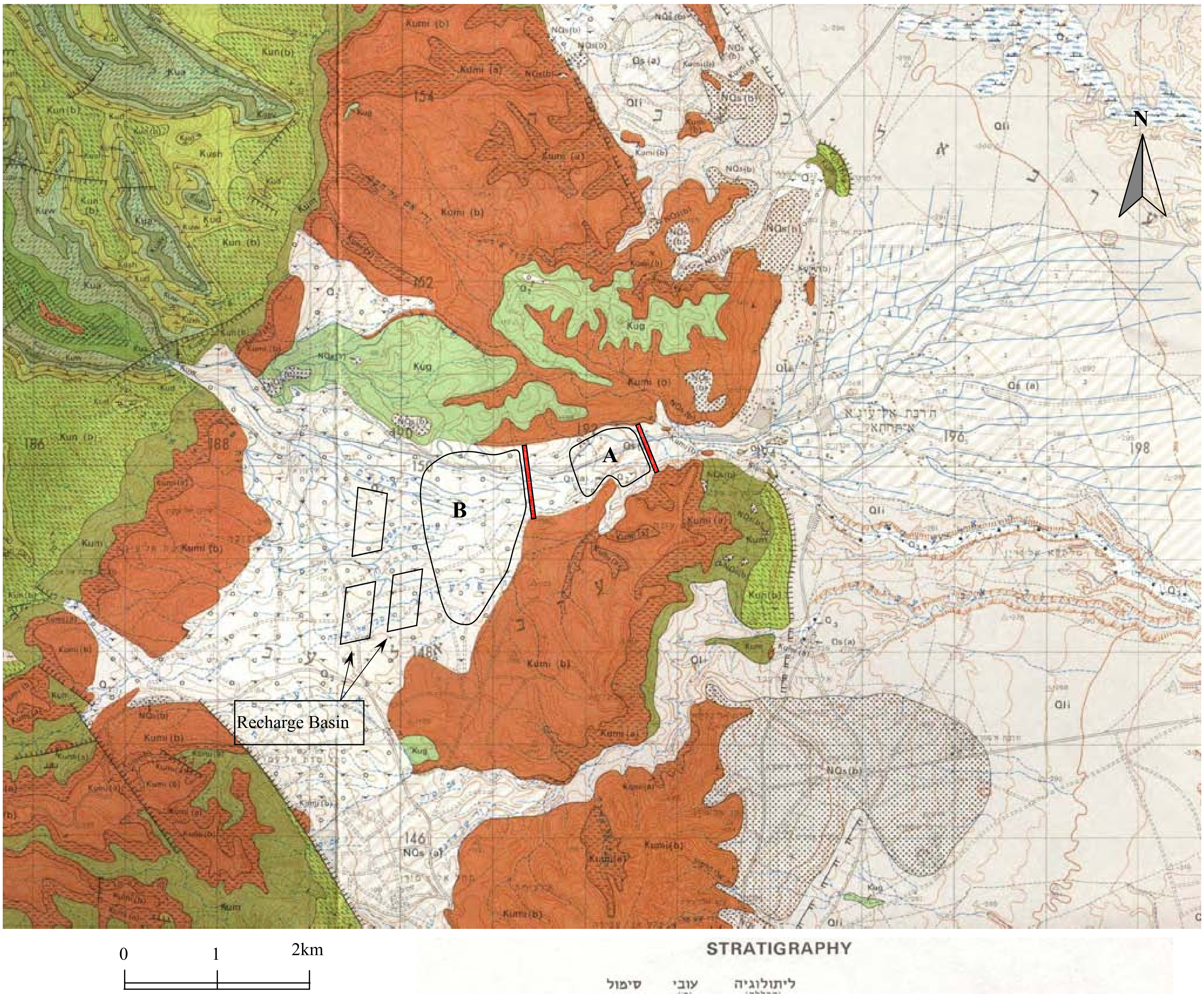
Preliminary quantity calculation and storage capacity of each of the plan are tabulated in Table 6.4.5.

Table 6.4.5 Summary of Quantity Calculation for Storm Water Harvesting Facility at Wadi Auja

【Underground Dam with Recharge Basin】					
Item		**Quantity**	**Unit Cost (USD)**	**Cost (USD)**	**Remarks**
Underground Dam					
Cut-off Wall (Plan "A")	m^2	10,500	600	6,300,000	Japanese cost is converted into USD
Recharge Basin					
Excavation	m^3	240,000	6.0	1,440,000	200m*200m*Z2m*3Nos. =240,000m^3
Total Cost	USD			7,740,000	**Storage** 300,000 m^3
【Regulating Reservoir】					
Item		**Quantity**	**Unit Cost (USD)**	**Cost (USD)**	**Remarks**
Earth Works					
Excavation	m^3	590,000	6.0	3,540,000	Common Soil
Embankment	m^3				
Slope protection	m^3	36,300	91.8	3,333,000	t=1m
Countermeasure for evaporation					
Porystyrene-boad	m^2	59,000	12.4	732,000	Target covering area 80% (73,643*0.8)
Total Cost	USD			7,605,000	**Storage** 500,000 m^3

Note: *All of the cost shown above means "Direct Cost".*
All of the cost has researched in Ramallah except the fuel.
In the case Jericho, an additional cost for transportation or accommodation fee for labor, etc, should be necessary.

Source: *JICA Study Team (Refer to Annex 3.6)*



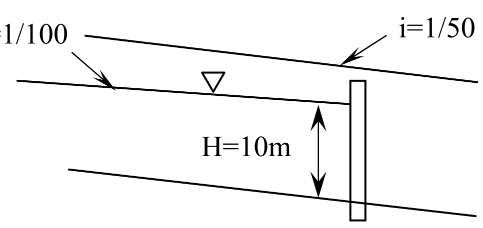
	"A"	"B"
Cutoff Wall : L(m)	550	800
Reservoir Area : A(km2)	0.7	1.5
Storage : V(m3)	300,000	750,000

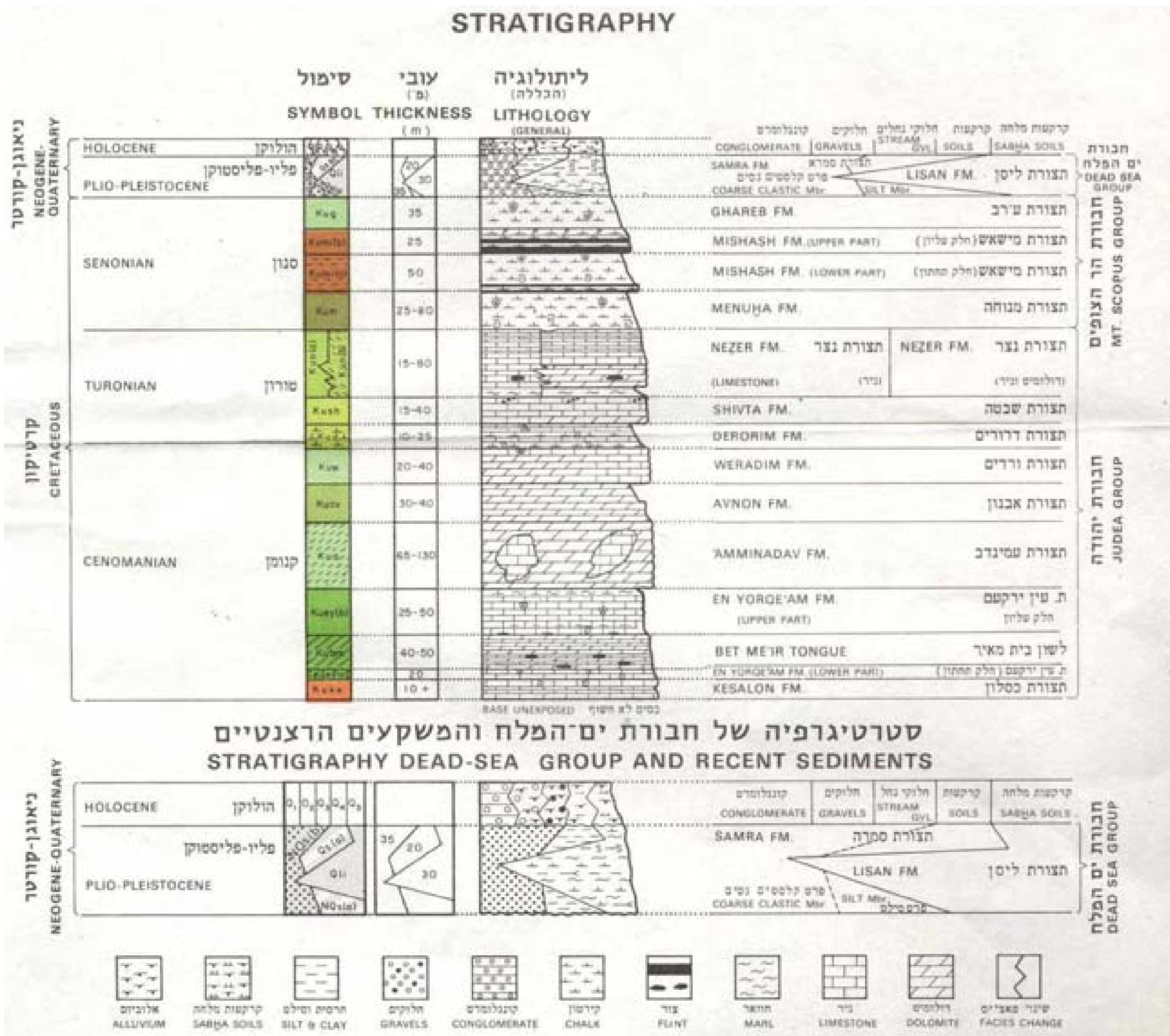
Note : Storage is calculated under following assumptions.

V=A･H･n･(1/2)

n=0.1 (Void Ratio)

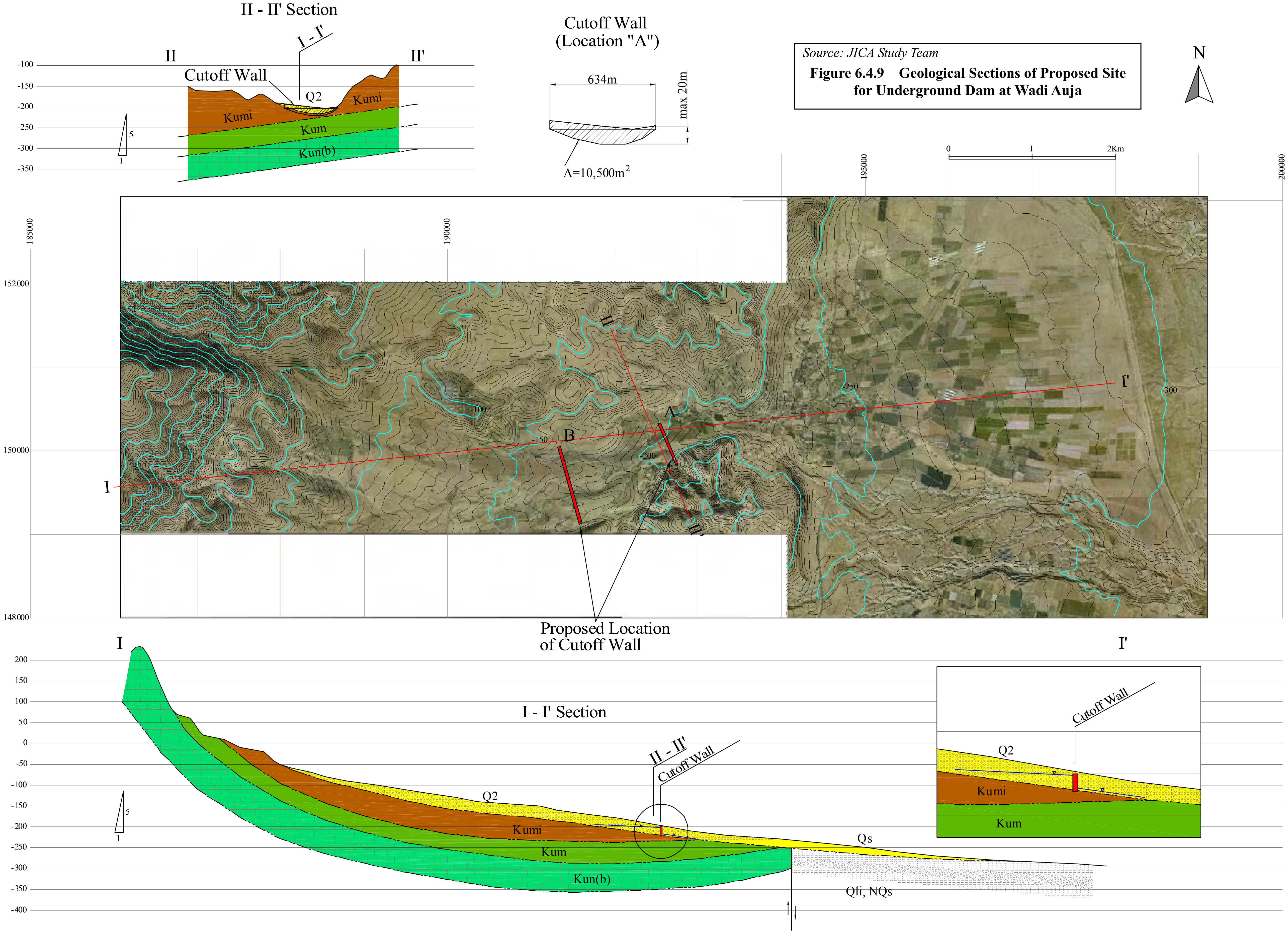
H=10m (Maximum Water Depth)





Source: JICA Study Team

Figure 6.4.8 Geology of Proposed Site for Underground Dam at Wadi Auja



Source: JICA Study Team

Figure 6.4.9 Geological Sections of Proposed Site for Underground Dam at Wadi Auja

As described in the previous subsection, the recharging basin shall be constructed inside the alluvial fan to promote percolation of the storm water into the gravel layer. The large- scale retarding basin could provide a better effect. On the other hand, the accumulated suspending load such as silt and clay in the flood water should be removed periodically.

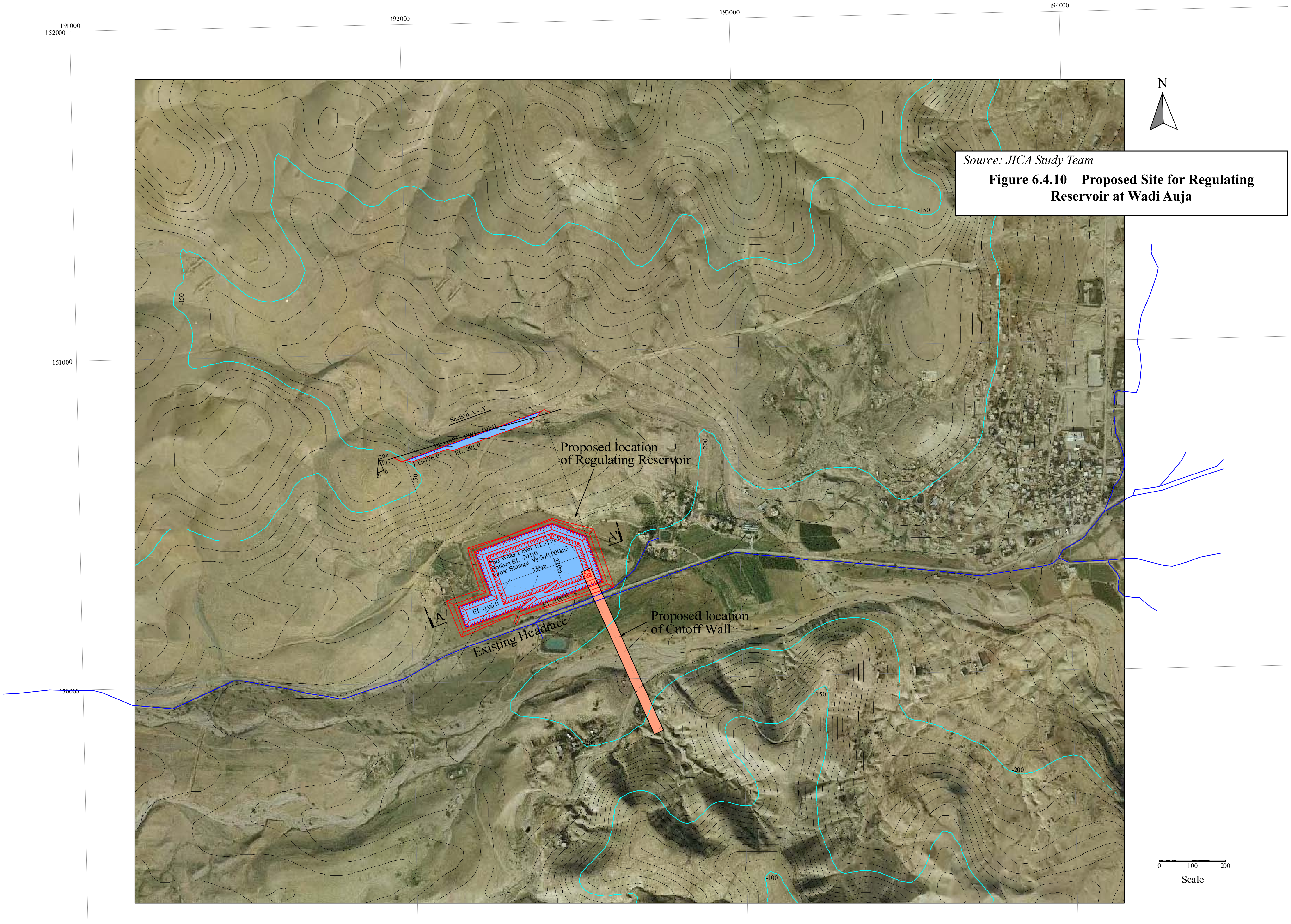
The cut-off wall of Plan “A” and Plan “B” is located in “Area A.” However, there is no space allowed for the retarding basin in “Area A,” unlike at “Area C”. Proposed area for the retarding basin is also shown in the figure.

The underground water of the eastern area of the Al ‘Auja village is supplied from the mountainous area as shown in Figure 6.4.9 (geologic cross section) through Kun (b) layer (Limestone). It seems that there is no harmful effect to the downstream area with the installation of the underground dam.

The annual amount of the spring water of Wadi Auja in average is estimated at 9.55 MCM. On the other hand, it has been reported that insufficient volume of water is estimated at around 0.43 MCM from August to November, from the view point of water demand. The spring water trough the headrace has been utilized through the small-scale pond which has a capacity of several hundreds cubic meters. If it is possible to operate water effectively as a total managing system of water, this would contribute in decreasing the volume of waste water.

It is recommended to construct a medium-scale regulating reservoir (about V = 500,000 m^3) in order to unify the water managing system in the entire district.

Figure 6.4.10 shows the proposed site for the regulating reservoir. This area belongs to Area “A”, and is located about 1.5 km west of the Al ‘Auja village. It is suitable to construct a middle-scale regulating reservoir in this location, because no land use as of now is being developed in this wide and flat area. In addition, the proposed site is located just beside the proposed underground dam site (Plan “A”) as mentioned above. Therefore, it is convenient to collect water pumped up from the underground dam.



Source: JICA Study Team

Figure 6.4.10 Proposed Site for Regulating Reservoir at Wadi Auja

(4) Tentative Evaluation of the Prospective Plans

Based on the above Pre-feasibility Study, the prospective plans were tentatively evaluated. Taking into consideration the project cost and storage volume, Alternative-3 exhibited the highest potential of storm water harvesting. From the viewpoint of possibility of artificial recharge into groundwater, Alternative-2 was recommended.

However, readiness of implementing both prospective plans, is relatively lower than Alternative-1. Moreover, required working items for Alternative-1 are simple and generally adopted in construction.

Therefore, Alternative-1 was finally recommended and subjected to subsequent feasibility study. Draft TOR for the feasibility study is described in Subsection 6.4.8.

Table 6.4.6 Summary of Tentative Evaluation Result of the Prospective Plans

	Alternative-1	Alternative-2	Alternative-3
(1) Location	Downstream Area of Wadi Qilt	Upstream Area of Wadi Qilt	Wadi Auja
(2) Storage volume (m^3)	74,000 in total	122,000	800,000
(3) Project cost (USD)	6,640,000	15,600,000+ α *	15,345,000
(4) = (3)/(2) (USD/m^3)	90	128+ β *	19
(5) Area	A	A&C	A&C
(6) Land availability	• Mainly Waqf land	• Land acquisition is difficult from topographic aspect. • Nature reserve area	• Private land
(7) Beneficiary	• Jericho municipality	• Jericho municipality	• Auja village
(8) Needs	• High	• High	Low
(9) Remarks	• The proposed site is located near from agricultural lands. • Required working items are simple and generally used in construction works.	• High possibility of groundwater recharge is expected. • PWA expressed strong intention for realization. • Readiness is lower because distribution of impervious strata and aquifer are unknown. • Highly skilled construction methodology such as for "slurry wall" is required.	• Huge capacity of water storage and the lowest construction price per unit volume of water are expected. • Readiness is lower because distribution of impervious strata and aquifer are unknown. • The estimated capacity is uncertain until a significant number of boring tests is conducted. • Highly skilled construction methodology such as for "slurry wall" is required.
(10) Evaluation	• Highest possibility of realization among the prospective plans	• Low priority because of land availability and low readiness	• High potential is expected but collection of further information is a prerequisite to commence the Feasibility Study.

** Construction cost of reservoir and other required facilities to be added*
Source: JICA Study Team

6.4.5 Further Investigation Schedule with List of Information Required

As mentioned in the foregoing sub-sections, further information is required to confirm the feasibility of the prospective plans. To realize these, further investigation schedule to collect the information required are recommended as follows:

(1) Required Investigation Works

Following table shows required field survey and investigation works to confirm the feasibility.

Table 6.4.7 Main Field Survey and Investigation Works for the Storm Water Harvesting

Item of Survey and Investigation	Main Purpose
1) Hydrological observation for flood flow of wadi at the proposed stream gauges	Refer to Subsection 6.4.6 ・ To derive the accurate shape of flood hydrographs at the proposed diversion point ・ To assure the frequency of flood flow in relation to daily rainfall amounts at rainfall gauges located adjacent to upper watershed of the wadi basin ・ To estimate annual water volumes of possible off-take (or diverted) storm water volumes based on the observed flood hydrographs
2) Suspended sediment analysis for the wadi water samples	・ To measure the concentration of suspended loads contained in the wadi water ・ To draw a discharge-suspended load rating curve ・ To estimate the annual sediment volumes transported by the wadi
3) Longitudinal and cross section survey of the wadi	・ To estimate the flow capacity of each wadi stretch through the non-uniform analysis applying the river cross sections surveyed at about 100 m intervals ・ To estimate the volume of erosion of riverbed
4) Topographic survey for producing 1:2,000 scale topographic maps	・ To prepare the preliminary design of main structures for storm water harvesting
5) Geo-technical Investigation	
i) Boring test including permeability test and standard penetration test (SPT)	・ To clarify the subsurface conditions at the following sites, which include derivation of permeability coefficients: - Diversion points on the wadi - Aquifer recharge basins - Regulating ponds
ii) Soil engineering test for soil samples got through the aforesaid boring test	・ To derive the basic physical and engineering properties of subsurface soils including particle size distribution, specific gravities, etc.
6) Data on land use and land ownership in the sites of the prospective plans	・ To confirm the possibility of land acquisition
7) Laboratory test for filter and embankment materials	Refer to Annex 3.4 ・ To confirm the ability of the filter to get clean water from turbid water in the laboratory
8) Implementation of pilot project	Refer to Subsection 6.4.7
9) Feasibility study on the prospective plans	Refer to Subsection 6.4.8

Source: JICA Study Team

(2) Investigation Schedule

The investigation schedule for the construction of the storm water harvesting facilities is drafted as shown in Figure 6.4.11

Item of Survey and Investigation	2009	2010-2012			2013-2015			2016
1) Hydrological observation for flood flow of wadi at the proposed stream gauges	▬	▬	▬	▬	▬	▬	▬	▬
2) Suspended sediment analysis for the wadi water samples	▬	▬	▬	▬	▬	▬	▬	▬
3) Longitudinal and cross section survey of the wadi***		▬						●●●
4) Topographic survey for producing 1:2,000 scale topographic maps***								●●●
5) Geo-technical Investigation								
i) Boring test including permeability test and standard penetration test (SPT)***								●●●
ii) Soil engineering test for soil samples got through the aforesaid boring test***								●●●
6) Data on land use and land ownership in Jericho plain***								●●●
7) Laboratory test for filter test and embankment materials***								●●●
8) Implementation of pilot project*		●●●	●●●	●●●	●●●	●●●	●●●	
9) Feasibility study on the prospective plans**								●●●

* *Period of the pilot project is expected to be 6 years including 3 years monitoring.*
** *Feasibility Study is expected to be started after the pilot project is monitored three years or more.*
*** *These survey and investigation are scheduled to be conducted in the Feasibility Study.*
Source: JICA Study Team

Figure 6.4.11 Investigation Schedule for Construction of Storm Water Harvesting Facilities

6.4.6 Installation Plan of Hydrological Station

One of the key issues in planning the storm water harvesting is the limited data available on hydrological measurements of wadi streamflow. This subsection describes the following aspects in connection with the installation of new streamflow gauging stations in the Study Area, mainly for the purpose of promoting the development of storm water harvesting:

- (i) Necessity of the new streamflow gauging stations;
- (ii) Main features of new streamflow gauging stations to be installed;
- (iii) Requirement of hydrological measurements on the new streamflow gauging stations;
- (iv) Utilization of hydrological data observed at the new streamflow gauging stations to formulation of storm water harvesting; and
- (v) Recommendations on hydrological observation and monitoring system.

(1) Necessity of Installation of Stream Gauge

PWA intends to install a streamflow gauging station on each of the major wadis to measure the flood runoff and to obtain data for the purpose of planning the water and storm water harvesting. Since early 1960s, PWA has performed current metering once a month for the spring flow, so as to measure the instantaneous discharge. At present, staff gauge required to observe the continuous spring flow on a daily basis is not installed, except for a very limited number of sites on spring streamflow. As a result, water level recording of spring streamflow is not continuously conducted. Ultimately, hence, staff gauges and/or new water level recorder should be installed at each of the discharge measurement sites.

As discussed in the foregoing subsections of this chapter, the prospective water harvesting plan is suggested in two major wadi basins, namely Wadi Qilt and Wadi Auja, while the study on storm water harvesting is on-going under the EU's technical and financial assistance in Wadi Far'a basin. It is recommended to install a new streamflow gauging station on the Wadi Qilt and Wadi Auja at the earliest opportunity, and to set up and keep on the hydrological measurement and monitoring system at the following three major wadis in the Study Area:

- (i) Wadi Qilt;
- (ii) Wadi Auja; and
- (iii) Wadi Far'a.

(2) Present Hydrological Monitoring System and Installation Plan of New Stream Gauges for Major Wadis

The present hydrological measurement and observation system and installation plan of new stream gauges for the aforesaid three major wadis are described hereunder.

1) Wadi Qilt

In 2001, the stream gauging station was rehabilitated, and a rain recorder and automatic water level sensor were installed on the Wadi Qilt at the location downstream of the entrance to its gorge, as illustrated in Figure 6.4.12. At the stream gauging station, a partial flume with steel-made cable crossing the wadi which would be used for current metering was provided. However, all the metal equipment was taken out in two months upon the completion of the stream gauge and rain gauge. Thus, all the equipment was already lost before the start of meteo-hydrological observation.

While at present, only concrete-made partial flume remains, the riverbed degradation is progressing at the location just downstream the lower end of the partial flume, with a depth of degradation at this point as approximately 2.5 m in May 2007. This problem seems to be caused by the reduction of flow width in the downstream portion of the partial flume, as well as the characteristics of riverbed soil materials that are susceptible to erosion. Hence, it is needed to rehabilitate the eroded portion by filling in with gabions and bricks.

At the existing partial flume site, it is recommended to resume the water level observation by installing a sensor into concrete wall of the partial flume, after rehabilitation of the downstream erosion. Besides, a new stream gauge is proposed to be installed slightly downstream of the existing garbage dumping site, where the flood flow of the Wadi Qilt is proposed to be diverted for storm water harvesting. At both sites, a sensor type of water level recorder and staff gauges are recommended to be installed.

2) Wadi Auja

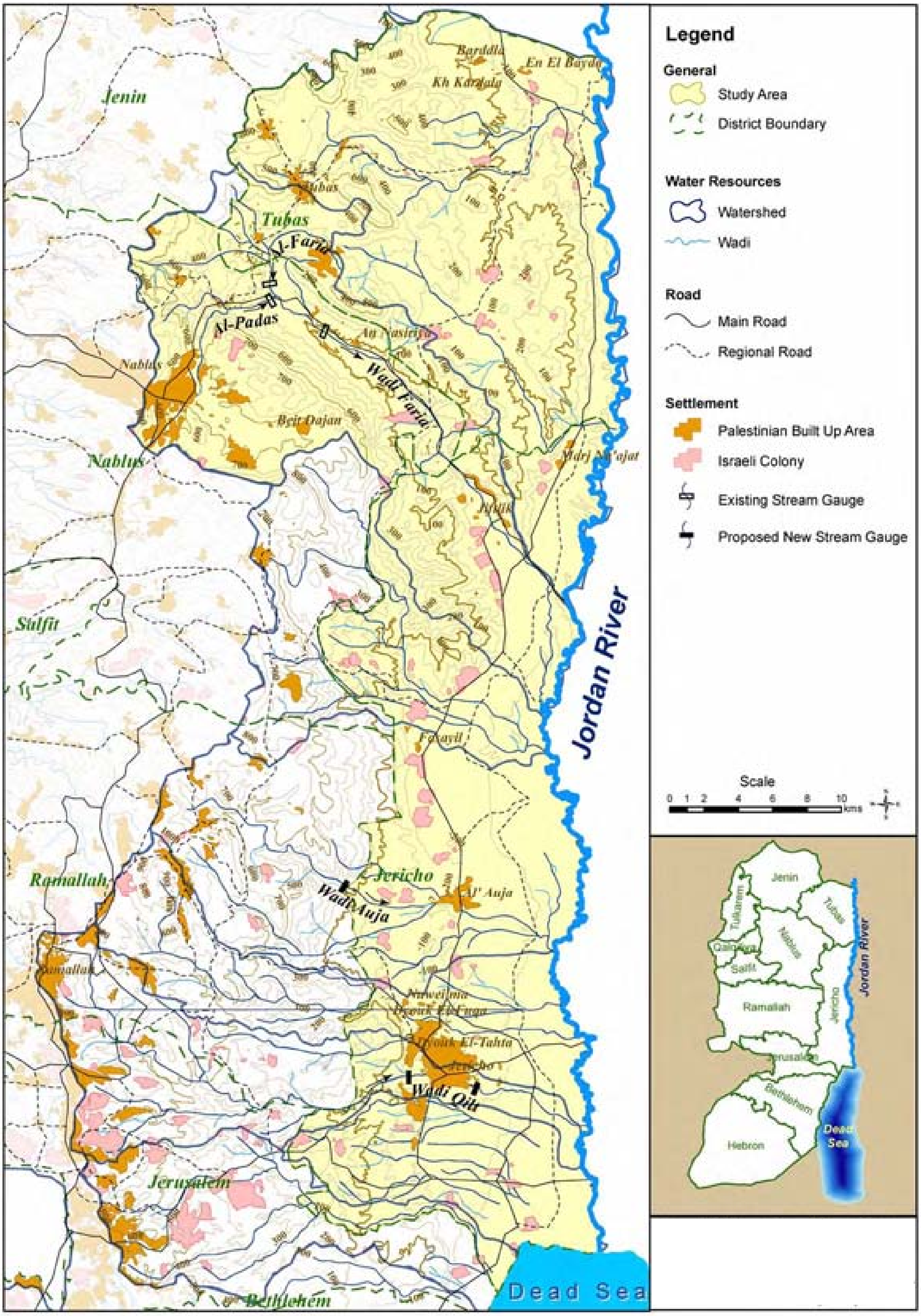
The spring water flowing down the channel of the Wadi Auja is diverted into the connecting channel at a location of about 7 km west of Al ‘Auja village. There is a fixed concrete weir on the Wadi Auja and PWA has adopted the current metering of the spring flow just upstream of the weir. According to the community of the Al ‘Auja village, the flood flow has often overtopped the weir crest in the winter season. To develop the water or storm water harvesting through utilizing the excessive flood water, a sensor type of water level recorder and staff gauges are to be installed, besides the concrete weir.

3) Wadi Far’a

As mentioned above, there are three stream gauges in the Wadi Far’a basin, each placed on Wadi Far’a mainstreams, Al Far’a and Al Baden. The stream gauge on Wadi Far’a mainstream was installed under a French aid project. PWA has also a stream gauge on the Wadi Far’a, however, they reported that this is currently out of order as of early July 2008, and needs to be rehabilitated.

The existing stream gauges at Al Far’a and Al Baden, which both constitute the uppermost sub-catchments of the Wadi Far’a basin, were installed under the EU-Najah University cooperative project.

Since there is a stream gauge on each of the major wadis in the Wadi Far’a basin, no new units need to be installed at present.



Source: JICA Study Team

Figure 6.4.12 Location of New Stream Gauges on Wadi Qilt and Wadi Auja

(3) Hydrological Monitoring Activities Practiced by PWA

In PWA, the Department of Hydrological Studies and Monitoring is responsible for the hydrological monitoring, including current metering of streamflow of wadis and springs. Usually, a hydrological monitoring team consisting of five personnel visits the sites in order to carry out the current metering and collection of water level data from a data logger at the existing sensor-type stream gauges. Presently, a team of two to three personnel goes to the sites on board a 4-wheel drive vehicle, and utilize a set of current meter device. For the field works, only the fuel cost is spent by PWA.

In carrying out the field works, the team has encountered the following issues:

- Insufficient budget for conducting field works
- Restriction on road passage, requiring prior permission
- Insufficient O&M of equipment including the current meter

Occurrence of rainstorm on the wadis is very seldom throughout the winter season. In order not to miss the opportunities of current monitoring, the hydrological monitoring team of PWA needs to go to the stream gauge sites on wadi in time when heavy rains take place in high altitude areas. Hence, a sufficient budget should be allocated for field works and for the procurement of hydrological equipment. Moreover, it is vital that free passage to roads leading to the stream gauge sites is guaranteed, through coordination with the concerned authority of Israel. Otherwise, it would not be possible to carry out satisfactory hydrological field works in time.

(4) O&M of New Stream Gauges

It was proposed as part of this Study, to install two new stream gauges at Wadi Qilt, and one at Wadi Auja. These are intended for observing the hydrological data to be utilized for future study on water and storm water harvesting. The locations of these new stream gauges at Wadi Qilt and Wadi Auja are shown in Figure 6.4.12.

The Study Team considered the possibility of installing the proposed three new stream gauges during the second field work stage that commenced in October 2007, as well as during the successive field work stages. The TOR on the installation of the stream gauges is attached as Annex 1: Hydrology. However, the Study Team could not install these new stream gauges during this Study stage since the permission could not be obtained from the concerned Israel authority. It is hoped that the new stream gauges be installed in the future as soon as the required permission is granted.

The structural characteristics of these stream gauges are summarized in the table below, together with the installation method at each site:

Table 6.4.8 Proposed New Stream Gauges on Wadi Qilt and Wadi Auja

No.	Name of Wadi	Location	Contemplated Installation Works
1.	Wadi Qilt	Upstream Site (Existing partial flume site)	• A perforated vinyl-chloride pipe accommodating a sensor is planned to be buried inside the concrete wall of existing partial flume after removing and chipping the concrete as required. The pipe surface will then be covered with concrete. • The downstream eroded riverbed portion will be filled with gabions/bricks.
2.	Wadi Qilt	Downstream Site (Slightly downstream of existing garbage dumping site)	• The left bank side will be excavated at a slope of about 1:2 to install a perforated vinyl-chloride pipe accommodating the sensor. The pipe will be encased with concrete and back-filled with excavated earth materials.
3.	Wadi Auja	Existing non-gated concrete weir	• A perforated vinyl-chloride pipe accommodating the sensor is planned to be installed at the left bank side of the existing non-gated weir on Wadi Auja.

Notes: 1.Staff gauges need to be installed at each of the above stream gauges sites.
2.The JICA Study Team could not install above stream gauges, since the permission was not obtained from the concerned Israel authority.

Source: JICA Study Team

(5) Hydrological Data to be Measured at New Stream Gauges

The new stream gauges on Wadi Qilt and Wadi Auja could not be installed in this Study stage. It is recommended that the following data be worked out through the hydrological measurements and observation:

i) Discharge data of wadi on daily and hourly basis
ii) Suspended sediment data including concentration of suspended load and physical and geotechnical properties

1) Discharge data

The current metering results will be used to construct stage-discharge rating curves at the respective stream gauge sites. To determine corresponding discharge based on the observed water level, the following stage-discharge rating curve is worked out based on the results of the current metering:

$$Q=a \cdot (H+b)^2 \text{, or}$$

$$Q=a \cdot H^b + c$$

Where, Q: Discharge (m^3/sec)

H: Stage height (m), to be read on staff gauge at the stream gauge site

a, b, c: Constants

For the water level data at the stream gauges on Wadi Qilt, the runoff data derived from the above stage-discharge rating formula will be performed on an hourly basis of each flood event.

The flood data at the stream gauge on Wadi Auja will also be determined on an hourly basis. Moreover, these will be performed on the basis of mean daily discharge data in order to estimate the annual mean runoff with accuracy.

On the basis of the observed hourly discharge hydrographs, the possible intake discharges for storm water harvesting needs to be estimated for the planned designed intake discharge.

2) Sediment data

In planning and designing the intake facilities on wadi and the storage facilities extracted from wadi for the storm water harvesting facilities, it is essential to investigate and clarify the suspended sediment volume contained in the wadi streamflow, as well as the physical and geotechnical characteristics. In order to clarify the sediment volume and physical properties of sediment materials in each wadi basin, a water sampling from the streamflow should be performed by the hydrological monitoring team of PWA, while current metering is conducted at the new stream gauge. The water samples will be analyzed in a laboratory to derive the following values of suspended sediment materials:

(i) Concentration of suspended sediment materials contained in wadi streamflow;

(ii) Physical and geotechnical values including particle size distribution and specific gravities, etc. of suspended sediment materials.

To clarify the variation of concentrations of suspended sediment materials during the occurrence of flood, it is recommended that water sampling and suspended load analysis be carried out two times a day, during the occurrence of streamflow on the wadi.

(6) Utilization of Hydrological Data for Planning of Storm Water Harvesting Facilities

1) Analysis of concentration of suspended sediment materials

Water sampling and laboratory analysis to clarify the suspended load concentration contained in wadi water should be as much as possible conducted for various magnitudes of streamflow, in order to set up a consistent discharge-suspended load rating curve mentioned below. Besides, the water sampling should be carried out to cover a wide range of discharges.

Based on the results of the laboratory tests on the suspended load concentration, a rating curve showing the relation between discharge and suspended sediment concentration should be worked out at each of the new stream gauges. The discharge-suspended load rating curve is generally expressed as follows:

$$S=a \cdot Q^b$$

Where, S: Suspended load concentration (liter/sec)

Q: Discharge (m^3/sec)

a, b: Constants

By applying the above discharge-suspended load rating curve to the hourly discharge recorded at each stream gauge, the sediment inflow for each flood event can be estimated accurately. In addition, the annual sediment yield in each basin can be derived in case the hourly water levels are continuously recorded with the stream gauge mentioned above.

The data on suspended load concentration is also essential for designing the regulating reservoirs suggested on the banks of Wadi Qilt and Wadi Auja, since the following basic design conditions will be determined accordingly:

i) <u>How is sediment volume inflowing into reservoir from wadi for the design intake discharge, when the wadi streamflow is extracted by the planned intake facility?</u>

The sediment inflow volume into reservoir will be estimated by applying the aforesaid discharge-suspended load sediment. The results of the estimate will be applied to determine the required extent of dredging works of sediments to be deposited in the reservoir bed, as part of the O&M works, executed upon the completion of the reservoir. Since it is foreseen that the O&M cost would have a significant influence on the viability of the storm water harvesting project, it is necessary to clarify the volume of sediments to be deposited in the reservoir bed, in case the wadi streamflow is extracted with the planned intake facilities.

ii) <u>When should the extraction of wadi streamflow be executed with the planned intake</u>

As a result of the observation of the Wadi Qilt streamflow that was performed during the field investigation, there seemed to be a tendency that the suspended sediment load concentration of the wadi is considerably high in the initial period after occurrence of flood, as compared with that in the latter stage. Primarily, the extraction of wadi streamflow should not be done during the period when the concentration of suspended sediment load is extremely high. It is recommended to determine the operation mode of the intake facilities based on the general tendency of variation of the suspended sediment load concentration, which is to be clarified through the aforesaid laboratory analysis on the wadi water.

2) Analysis of physical and geotechnical values of suspended sediment materials

As discussed in Subsection 6.4.4, it would take a very long time for the extracted wadi water in the primary reservoir to pass through the filter dike connecting the primary and secondary reservoirs. As an alternative measure, it is conceived that the sediments contained in wadi water be deposited in the primary reservoir bed. During the field investigation, a simple test was conducted by observing the deposition of sediments in the wadi water placed in transparent bottles. The simple test shows that most of the sediments, except for its very fine particles, have been deposited within a few days.

In designing the primary reservoir accordingly, one of the important conditions is the time to take for the sediment contained in wadi water to settle in the primary reservoir bed. To enable estimating the time, laboratory tests for analyzing particle size distribution and specific gravities, etc. of suspended sediment materials should be performed for the limited number of water samples taken from wadi.

In case the analysis of the basic data and laboratory test on precipitation of sediment materials shows the difficulty to initiate precipitation within a reasonable time, it would be necessary to place precipitants like alum in the primary reservoir.

Nevertheless, PWA does not have the equipment to carry out the laboratory analyses. Therefore, these need to be procured in order to enable the tests in the PWA's laboratory.

(6) Recommended Hydrological Observation and Monitoring System

Upon installation of the new stream gauges in the future, the hydrological monitoring team in the Department of Hydrological Studies and Monitoring of PWA will be responsible for the O&M of the stream gauges. Said team will undertake periodic inspections of the stream gauges, especially the operational condition of the sensor and retrieving of data stored in the data logger. Moreover, the team will carry out current metering and sampling of wadi water at each site during the winter season, when large-scale or long-duration rainfalls take place.

To adequately conduct the O&M of the proposed new stream gauges, it is recommended to reinforce the Department of Hydrological Studies and Monitoring of PWA with regard to the following aspects:

(i) To keep close coordination with the concerned agency of Israel in order for the field staff of PWA to timely access the stream gauge sites immediately upon occurrence of heavy rainfall in Ramallah, or to establish a regional office in Jericho municipality and Al ‘Auja village in which field staff of PWA are based during the winter season;

(ii) To increase the budget for field works and equipment including vehicle and current meter so that two parties can be organized to perform field measurements and O&M works of new stream gauges;

(iii) To secure and provide training to the field staff who will be exclusively engaged in the hydrological field works, such as current metering, water sampling, and O&M works of the new stream gauges; and

(iv) To set up a system for arranging and storing hourly discharge and sediment data in cooperation with the other PWA’s concerned departments

6.4.7 Pilot Project for Storm Water Harvesting

(1) Purpose of Pilot Project

Constructing a storage facility outside the riverbed around downstream area of Wadi Qilt is considered most suitable for the future feasibility study on storm water harvesting. The main purpose of the pilot project is to collect the necessary data as a prototype model prior to the feasibility study. The following items are to be examined through the pilot project phase:

1) Filter dam

- Filtration capacity of the filter dam (Intake capacity per day)
- Effectiveness of water purification (from turbid water to clear water)
- Durability of filtering effects (Frequency of clogged filter by turbid water and maintenance timing)

2) Reservoir

- Infiltration volume from the reservoir into underground
- Geologic conditions of the excavated surface (engineering characteristics, such as geology and permeability)

3) Wadi river channel

- Viability of the proposed protection
- Effectiveness of protection
- Flooding situations (flow velocity/ steady flow or rapid flow)

(2) Design concept

Acquiring basic profile of wadi-river flow (flood volume, turbidity, and other basic information) as well as hydrological data is generally the prerequisite to prepare a practical storm water harvesting plan. However, most of the basic information is not available in the Study Area.

Under these circumstances, the pilot project plan discussed in this section was prepared based on the assumption that i) a water harvesting plan can be prepared even if hydrological data are not available, and ii) series of items listed above will be examined practically.

1) Wadi-river channel improvement

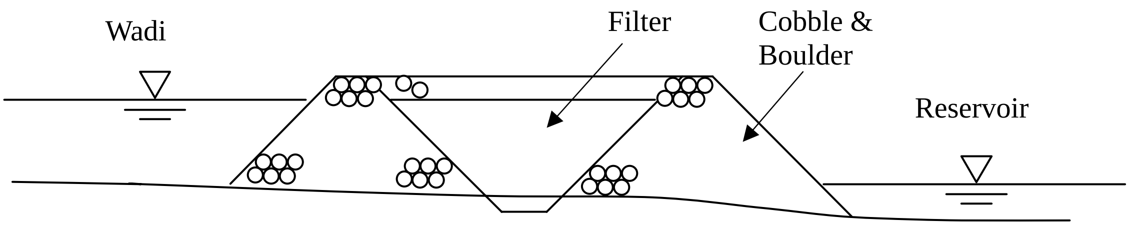
The river channel is seriously eroded due to rapid flows, as confirmed by the narrow, meandering channel with a steep gradient (of around 1/50). Therefore, a stable flow condition (slow and steady flow) is required in order to take water from Wadi-river. The following approaches are effective in stabilizing the water flow:

- Widening the Wadi-river (to the range of 20 m) from its upstream to its downstream portions, which includes the pilot project site, and placing a gabion to support the river bed and side slope
- Stabilizing the riverbed slope at around 1/500 level (recognized as "steady flow") by installing a drop structure (difference: 1 to 1.5 m) at several points.

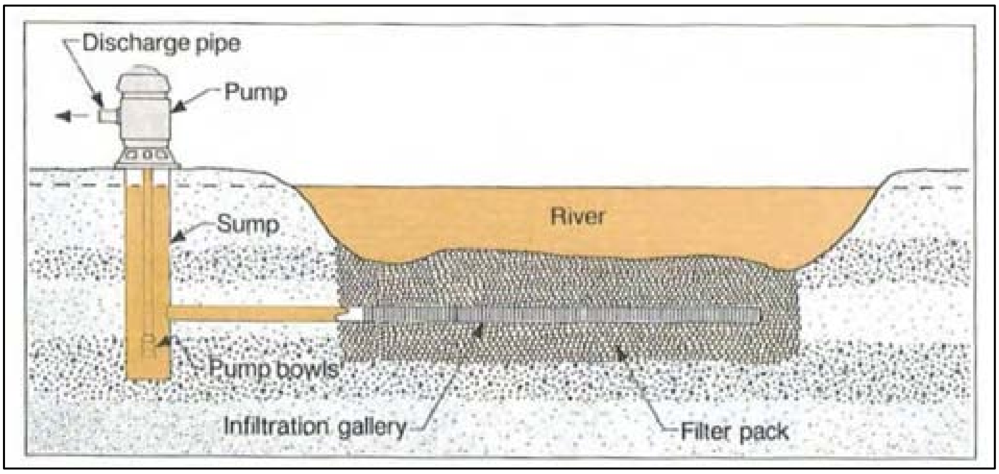
2) Water intake plan (Refer to Annex 3.8)

A preliminary design for taking water from wadi-river via filter dam and infiltration gallery was prepared. This water intake plan shall be reviewed in the future feasibility study.

- Filter dam



- Infiltration gallery



Source: Groundwater and Wells

3) Water storage plan

Reservoir should be constructed beside the intake facilities. Following matters are to be considered:

- Open-cut reservoir will be constructed, and the elevation of the reservoir bottom shall be set below the wadi-riverbed. A depth of 10 m is required to be excavated. Under these circumstances, if the open-cut reservoir were left for a long period, it would be very difficult to cope with a flooding and slope stability situation that would endanger the wadi-river and its surroundings.
- Therefore, it is planned that the water through intake facilities is impounded in the cobbles that are backfilled in the reservoir. The excavated materials shall be backfilled above the cobbles, up to the same elevation as the original ground.
- Filter dam and infiltration gallery shall be structured separately.
- Intake water volume cannot be adjusted using the proposed intake method. Therefore, it is required to construct a spillway which can safely release water beyond the reservoir's storage capacity, if unexpected volume of water flows into the reservoir.
- The stored water is pumped out by a pumping well installed inside the reservoir.

(3) Selection of Candidate Sites

Reconnaissance survey was conducted from the upstream to downstream areas of Wadi Qilt in order to find out the appropriate site for the pilot project. A suitable space for implementation with minimal issues on land ownerships are important factors in selecting an appropriate pilot project site.

According to the reconnaissance survey, four candidate sites whose locations are shown in Figure 6.4.13 were finally selected. Subsequently, a comparative study on water storage capacity of these four sites has been conducted. The study result indicated that constructing a reservoir with maximum water capacity is possible at site No.2 (PP2). Therefore, said site has been selected for the pilot project.

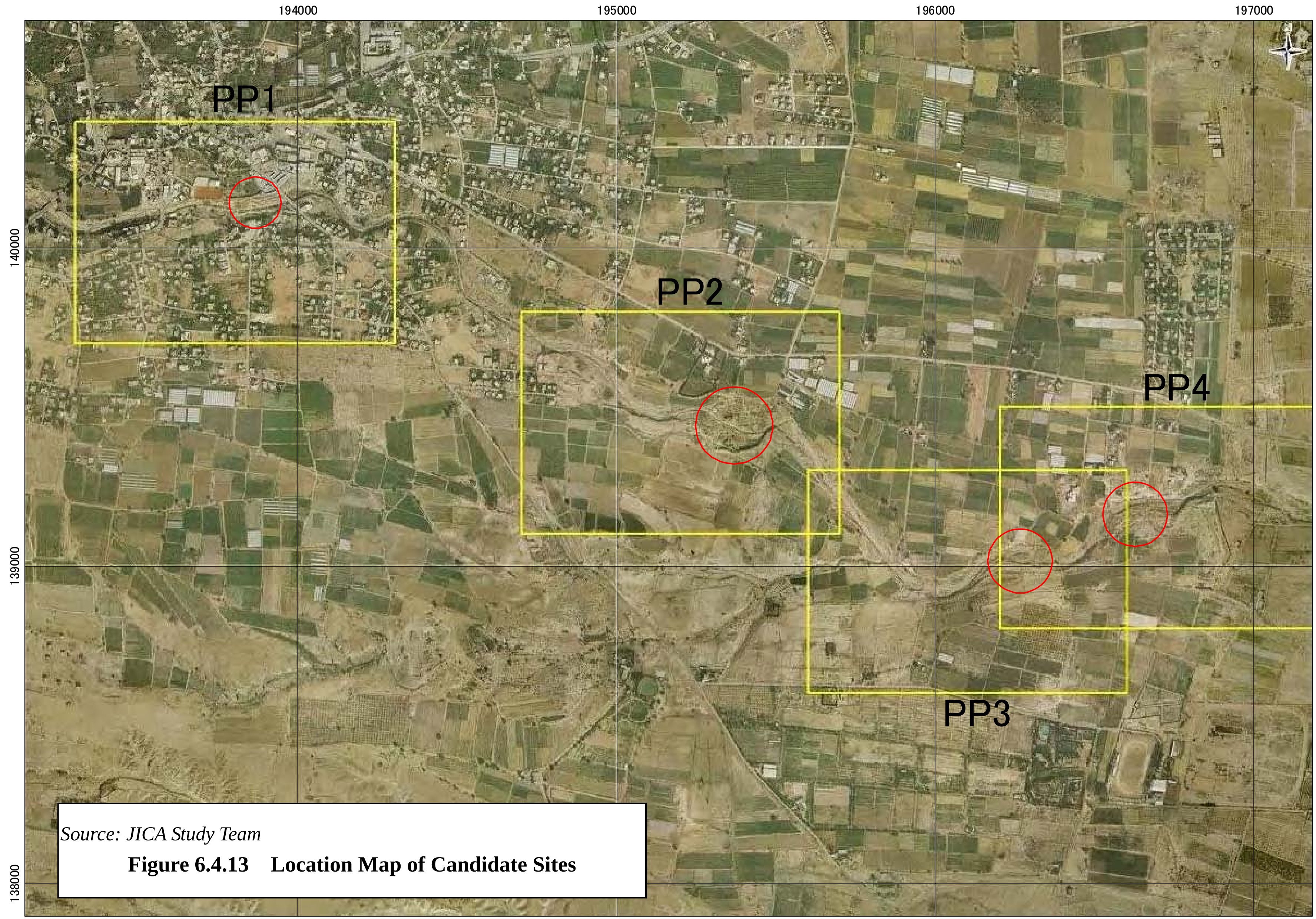
Table 6.4.9 Water Storage Capacity of Candidate Sites

	PP1	**PP2**	PP3	PP4
Storage (m3)	1,300	**6,500**	2,400	2,100

Source: JICA Study Team *Refer to Annex 3.6*

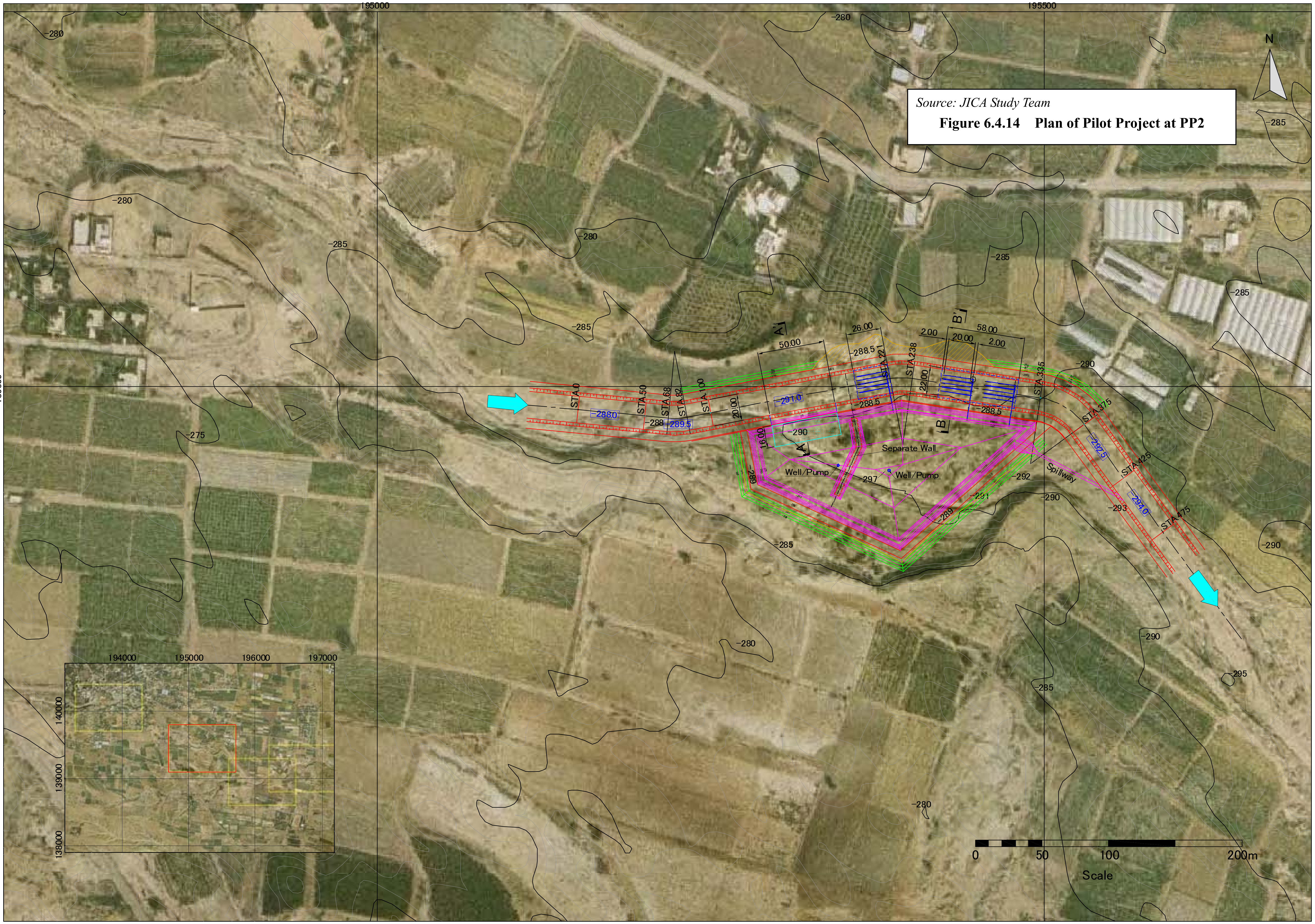
(4) Preliminary Design

Based on the foregoing discussions, a preliminary design on the pilot project at site PP2 has been undertaken. Corresponding drawings are as follows:



Source: JICA Study Team

Figure 6.4.13 Location Map of Candidate Sites

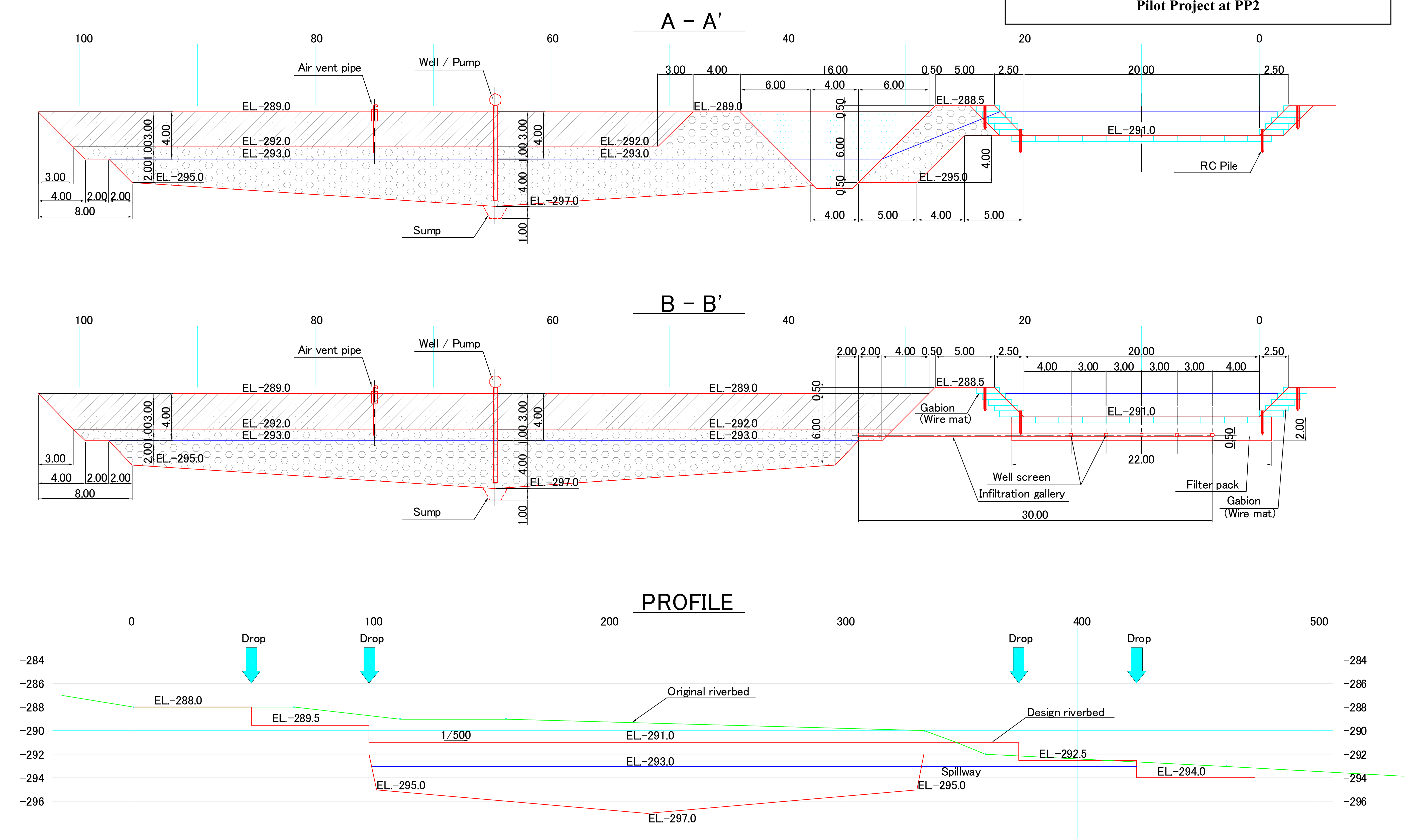


Source: JICA Study Team

Figure 6.4.14 Plan of Pilot Project at PP2

Source: JICA Study Team

Figure 6.4.15 Standard Cross-section and Profile for Pilot Project at PP2



(5) Prerequisite Studies and Examination prior to the Detailed Design

Marl appeared at the proposed project site. Although marl is generally thought as part of an impermeable layer, this may also be formed in the alternate layers made up of gravel. Hence, in order to verify the geologic condition of the project site, a boring test is required.

1) Specification of boring investigation

Wadi part	One point	Length = 10m (Totally 10m)
Inside reservoir	Two points	Length = 20m (Totally 40m)
Specification	On site permeability test Standard penetration test	

2) Investigation materials

Uniform sized cobbles are required to secure the largest space between the cobbles, considering that these are utilized to store water. Based on the size of typical cobbles found in the riverbed of the upstream area, porosity is estimated. At present, the porosity $n = 0.2$ is tentatively adopted in the preliminary plan.

A filter dam is composed of "filter-zone" and "rock-zone". The specification of both zones shall meet the standards of the Filter's Law. Accordingly, a sieve analysis is necessary to be performed using required materials procured for each zone.

3) Topographic survey

The preliminary plan is designed from the contours defined based on the aerial photographs. Preparing topographic maps by conducting topographic survey is required since contours do not precisely indicate the actual land pattern. Specification of the topographic survey is as follows:

- Scale: 1/500
- Range: $300m \times 600m = 180{,}000m^2$

(6) Monitoring System after the Implementation of the Pilot Project

Several items listed below are to be examined during the pilot project:

1) Turbidity

Infiltration effects are assessed by analyzing turbidity on each i) flood water running wadi-river, ii) storage water in the filter dam, and iii) infiltrated water that passed through the infiltration gallery.

2) Clogging

A visual inspection and a grain size test (at fine-grained fraction level) via material sampling shall be conducted by excavating a part of the filter dam, subsequent to flooding. Degree of clogging shall be evaluated by comparing results of before and after grain size tests.

3) Groundwater increment

The following methodologies are undertaken to assess the ground water recharge.

- This should be performed on a well located nearby the reservoir to observe and record the ground water level. Other hydrologic data such as water level of the reservoir, precipitation, and others are also recorded.
- Finally a qualitative analysis on ground water recharge shall be done based on the water balance record and the above mentioned records. Sample of a record note is exhibited as follows:

Table 6.4.10 Sample of a Record Note

Day/Month/ Year	Water level of Wadi-river (EL)	Water level of the Reservoir (EL)	Storage volume (m^3)	Intake Volume (m^3)	Spill out (m^3)	Remarks

Source: JICA Study Team

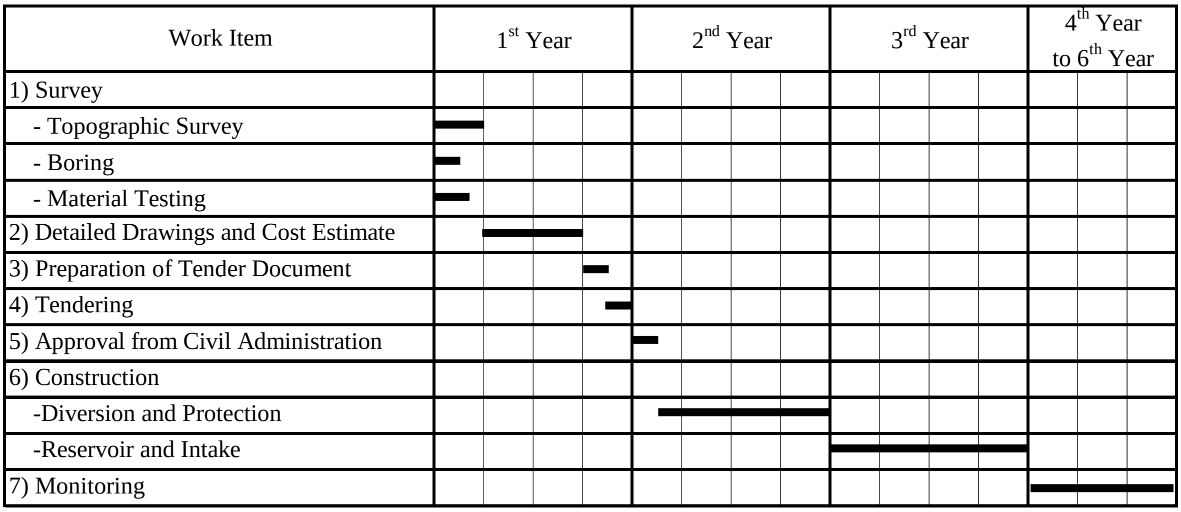
(6) Construction Cost

Preliminary construction costs for the pilot project have been estimated as below:

- Excavation: 88,500 m^3
- Cobbles: 40,500 m^3
- Gabion: 11,000 m^3
- Storage Capacity: 6,500 m^3
- Preliminary cost estimate: USD2,950,000 (Refer to Annex.3.6)

(7) Implementation Schedule

Implementation schedule for the pilot project was tentatively prepared as shown in the following figure:



Source: JICA Study Team

Figure 6.4.16 Implementation Schedule of Pilot Project

6.4.8 Draft TOR for Future Feasibility Study for Storm Water Harvesting

After completion of the pilot project on storm water harvesting, it is recommended to carry out a feasibility study on its related prospective projects in the Wadi Qilt basin, where water shortage is likely to become crucial in the near future. The draft TOR on the feasibility study is framed as follows:

(1) Prerequisite (Refer to Subsection 6.4.5)

- Continuous hydrological records with suspended sediment data are available for a minimum of five years.
- Longitudinal and cross section survey of the downstream sections of Wadi QIlt is conducted once, and corresponding data is available.
- Pilot project is implemented, and three years monitoring result is available.

(2) Objectives

- To conduct a feasibility study on priority storm water harvesting scheme in Wadi Qilt basin
- To carry out technology transfer to Palestinian counterpart personnel through on-the-job training during the course of the Study

(3) Study Area

The study area is the Wadi Qilt basin and other areas affected by the selected scheme.

(4) Scope of the Study

The study is divided into the following two phases:

- Phase 1: Selection of the priority scheme of storm water harvesting in Wadi Qilt basin through incorporation of the results of pilot project
- Phase 2: Feasibility Study on the priority scheme

The study period is scheduled to last 18 months, which will consist of ten months for Phase 1 and eight months for Phase 2. The scopes of the study in each phase are as follows:

1) Phase 1: Updating of the prospective plan of storm water harvesting in the downstream section of Wadi Qilt, through incorporation of the results of pilot project

1 Basic data and information collection, and analysis for preliminary planning

1-1 Update current situation of existing water resources and water uses in Jericho municipality and its vicinity

1-2 Clarify latest progress of water resources development projects and other development programs in Jericho municipality and its vicinity

1-3 Verify the effect of the storm water harvesting from a viewpoint of water demand and supply balance

1-4 Collect and analyze the hydrological data including analyses of suspended sediment loads, and analyze water quality of stream water in Wadi Qilt

1-5 Perform topographic survey, geological investigation and soil mechanical tests required for comparative study of alternative schemes for storm water harvesting in Wadi Qilt basin

1-6 Clarify land use and land ownerships of lands along the Wadi Qilt

1-7 Collect and analyze the seismic data in order to determine the seismic intensity to be taken into the design of the storm water harvesting facilities (Refer to Annex 3.9).

2 Preliminary planning

2-1 Formulate river bank protection plan for downstream reach of Wadi Qilt in consideration of river morphological change due to construction intake structure on Wadi Qilt

2-2 Formulate basin conservation plan for upper reach of Wadi Qilt

2-3 Formulate basic design concept of the prospective plan

2-4 Carry out an initial environmental examination (IEE) on the prospective plan of storm water harvesting

2-5 Carry out preliminary design of main components of the prospective plan

2) Phase 2: Feasibility study on the priority scheme

<u>3 Feasibility study including supplemental data collection</u>

3-1 Perform supplemental survey and investigations required for the feasibility-grade design

3-2 Carry out feasibility-grade design on the prospective plan

3-3 Estimate the project cost and annual O&M cost of the priority plan, taking into account required removal works of sediments from facilities of storm water harvesting

3-4 Prepare a implementation program of the prospective plan

3-5 Carry out environmental impact assessment (EIA) on the prospective plan

3-6 Carry out economic analysis and financial evaluation

3-7 Study and propose the organizational system of Palestine to enable sustainable O&M of components involved in the prospective plan

(5) Expected Schedule of the Future Feasibility Study

Work Item	Phase 1										Phase 2							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 Basic data and information collection and analysis for planning	━	━	━	━	━	━	━											
2 Preliminary planning								━	━	━								
3 Feasibility study including supplemental data collection											━	━	━	━	━	━	━	━

Source: JICA Study Team

Figure 6.4.17 Expected Schedule for the Future Feasibility Study

6.5 On-farm Water Management

6.5.1 Present Status of Irrigation System

Water resources from the springs and wells of the Jordan River Rift Valley are quite limited. In the Study Area, crop cultivation without irrigation system is difficult, except for those with high tolerances to dryness. Therefore, various modern irrigation systems were widely adopted in the Study Area. These irrigation systems used in the Jordan River Rift Valley area are shown in table below.

Drip irrigation system in open field

Drip irrigation system in greenhouse

Table 6.5.1 Use of Irrigation Practices in the Jordan River Rift Valley

Crop Type / Irrigation Practices		Jordan River Rift Valley (%)
Vegetables		100
	Drip Irrigation	99.4
	Furrows Irrigation	0.6
Tree orchards (Citrus and others)		100
	Drip and Sprinkler Irrigation	70
	Basins Irrigation	30
Banana		100
	Drip Irrigation	100
Field crops and forage		100
	Sprinkler Irrigation	98
	Flooding Irrigation	2

Source: Water Resources and Irrigation Agriculture in the West Bank 1998

It was found that the water-saving irrigation practices, such as the drip irrigation system and the sprinkler irrigation system have been widely adopted since 1998.

6.5.2 Efficient Water Use for Irrigation

It is evident that the limited water resources are a major constraint to the economic development, considering the agricultural livelihood, in the Study Area. In order to cope with this, and to improve productivity in the agricultural sector, it is necessary to raise efficiency in irrigation. Irrigation efficiency can be expressed as the ratio between the total quantity of irrigation water delivered, and the quantity of water effectively used for the crops.

Irrigation efficiency can be divided into water conveyance efficiency and on-farm application efficiency, as follows:

(1) Water Conveyance Efficiency

Water conveyance efficiency is defined as the ratio between the water delivered to a block of field and the water diverted from the source. The water conveyance efficiency in piped systems from wells, measured in some irrigation schemes, is around 90%[1].

In the Study Area, the water conveyance systems from springs to farms comprise of open earth and concrete canals. Hence, a large amount is wasted prior to its utilization, mainly due to leakage, evaporation and illegal extraction. According to PWA estimate, these losses are estimated to be approximately 30% of the total water discharge.


Leakage from spring water conveyance system

(2) On-farm Application Efficiency

On-farm application efficiency is defined as the part of the applied water used for plants. However, field efficiency varies largely depending on the type of irrigation techniques used and the performance of the irrigation network.

Results of a study conducted on irrigation in the West Bank in 1995 indicate that application efficiency of irrigation water is relatively high (F. Al-Juneidi and J. Issac; ARIJ). However, this can not be attributed to good management, but rather mainly due to the shortage of water in the irrigated areas. In the Study Area, however, about 97% of vegetables are irrigated using drip systems, having an application efficiency of 78%, while 2.4% is by sprinklers with an application efficiency of 85%[2]. These high efficiencies may be acceptable in many other countries, however, given the severe scarcity of water and the high population growth that require increase in water demands in the area, further realization of efficient systems are vital.

In order to raise water-use efficiency on-farm level, corresponding actions should be initiated in the Study Area, namely, i) Improvement of techniques and suitable operation and management (O&M) for water saving irrigation, ii) Replacement of old facilities for water saving irrigation and iii) Improvement of the awareness for water saving irrigation.

Considering raising the on-farm application efficiency from the present 75% to an efficiency of 85%, the following estimate is prepared.

1 I. Nofal, Water management in small groundwater irrigation schemes in Palestine, 1998.

2 MoA, LRC and PHG, Some Aspects of Irrigation Systems Performance in PALESTINE, 2004.

Table 6.5.2 Agricultural Water Demand

Area	Irrigated Area (Dunum)	Agricultural Water Demand (MCM/yr)		
		Application Efficiency (75%)	Application Efficiency (85%)	Water Savings
Jericho/Al 'Auja	26,079	29.17	25.74	3.43
Lower Al Far'a	20,289	15.26	13.47	1.79
West Tubas	5,837	4.14	3.66	0.48
North Tubas	8,772	6.05	5.33	0.72
Total	60,977	54.62	48.20	6.42

Source: Agricultural Statistics, PCBS, 2004/05, Water resources and Irrigated Agriculture, Applied Research Institute, March 1998, and JICA Study Team estimate

It was found that 6.42 MCM/yr of water could be saved by raising the on-farm application efficiency to 10%.

Water conveyance efficiency is previously discussed in Section 6.2 & 3, while constraints and countermeasures of on-farm application are described in the succeeding sections.

6.5.3 Constraints of On-farm Application Efficiency

(1) Techniques and O&M for water saving irrigation

Considering that the irrigation field is the largest user consuming more than 90% of the total available water resources in the Study Area, it has become an urgent task to increase the efficiency of water use, through recovering the functions of currently inoperable irrigation facilities. This is intended to achieve a sustainable irrigation operation.

It is confirmed that the water saving irrigation system has been widely introduced in the Study Area, based on interviews and baseline surveys. In the present situation, farmers in the Study Area are not making effective use of the existing water saving irrigation system such as the sprinkler irrigation and the drip irrigation. This is mainly due to the lack of knowledge among farmers regarding water saving irrigation.

In general, by adopting the drip irrigation system necessary amount of water can be supplied accurately and efficiently to the aimed location at any required time. Hence, the design arrangement of water supply pipes, drip pipes and emitters are determined in consideration of the crop spacing as well as the relief and gradient of the cropping field. This is adopted in order to accomplish the rate of higher yield per unit area and the improvement of the water saving irrigation. However, most farmers in the Study Area are installing the equipment based on their own empirical judgments without considering the type of crops. The improper installation of the drip irrigation facilities may result in shortage or excessive supply of water to the crops. Moreover, the O&M of the screening devices and emitters in the Study Area will not be performed properly on time. In such case, uniformity of dripping flow rate is not secured.

Constraint-1

Lack of techniques and suitable O&M for water saving irrigation, with the existing irrigation facilities

(2) Facilities for water saving irrigation

According to interviews and baseline surveys conducted with the farmers in the Study Area, most of the water saving irrigation facilities has been used for over 20 years. In general, the optimum functional capability of the drip system has a useful life span of 5 to 10 years[3]. After which, serious depreciation is expected. This capability degradation consequently causes the deterioration of on-farm application efficiency.

Constraint-2

Old water saving irrigation facilities

(3) Awareness for water saving irrigation

Farmer's awareness for water saving irrigation is an essential factor in raising the application efficiency. Distribution and management system mentioned below will adversely affect the farmer's awareness for water saving irrigation.

1) Time Charging System

In the Study Area, water distribution system from most wells and several springs are managed through time sharing system, based on hourly unit rates. Therefore, the farmer in the Study Area is obliged to supply as much irrigation water as possible to their field in a limited time. Generally, in the arid region, irrigation should be conducted with respect to the crop water requirements, in order to conserve water. Under the condition of time sharing system, farmers carry out irrigation without considering the crop's adequate water requirements. Furthermore, water supply crisis is experienced due to unstable water service equipment conditions (old pumping machine of well compounded by the fluctuation of the spring water discharge in the dry season). As a result, excessive water is irrigated in the farm.

Hence, improving water distribution system should be reconsidered in the Study Area. This means that water charging system should be changed to a per volume unit of consumption, instead of the time unit rate adopted at present. Unless conversion to the volumetric charging system is adopted, appropriate water savings in irrigation can not be realized. Thus, it should be noted that the operations of the existing water saving irrigation facilities can not be fully utilized in the Study Area.

2) Water Users Associations (WUA)

Several wells and springs exists in the Jordan River Rift Valley, and are either communally owned or without clear ownership rights. Water cost and distribution system adopted depend on the owner. To initiate the volumetric water distribution system, it is necessary to establish a WUA which will involve the well and spring owners.

It is apparent that under the existing water distribution and management condition, it is very difficult to raise the farmer's awareness on water saving irrigation.

[3] Interview survey from the Drip Irrigation Supplier in Israel.

Constraint-3

Water distribution system by time unit

Lack of WUA to serve as educators for efficient water use and to cooperate in the rational use of scarce water

6.5.4 Activity to Cope with Constraints on Water Saving Irrigation

The following table summarizes the constraints and countermeasures on irrigation efficiency.

Table 6.5.3 Constraints and Countermeasures on Irrigation Efficiency

Irrigation efficiency		Constraints	Countermeasures
Water conveyance efficiency			
	Springs	• Open earth and concrete canals • Improper water distribution management	• Improvement of spring water conveyance canals • Capacity building of LGU
	Wells	• Old water distribution pipe • Improper water distribution management	• Rehabilitation of agricultural wells • Formation and capacity building of WUA
On-farm application efficiency			
	Water saving irrigation system	• Lack of techniques for water saving irrigation • Improper O&M	• Training of techniques for water saving irrigation • Training of suitable O&M
		• Old facilities for water saving irrigation	• Replacement of old facilities for water saving irrigation
		• Lack of the awareness for water saving irrigation	• Improvement of water distribution and management system • Awareness promotion on efficient water use

Source: JICA Study Team

To realize the efficient water use in the field of irrigation, several strategies should be proposed in the irrigated water management in the Study Area.

(1) To enhance water conveyance efficiency

(i) Improvement of spring water conveyance systems

(ii) Rehabilitation of agricultural wells

(iii) Formation WUA

(iv) Capacity building of WUA and Local Government Unit (LGU)

(2) To enhance on-farm application efficiency

(i) Improvement of techniques and O&M for water saving irrigation

(ii) Replacement of old facilities for water saving irrigation

(iii) Awareness promotion on efficient water use

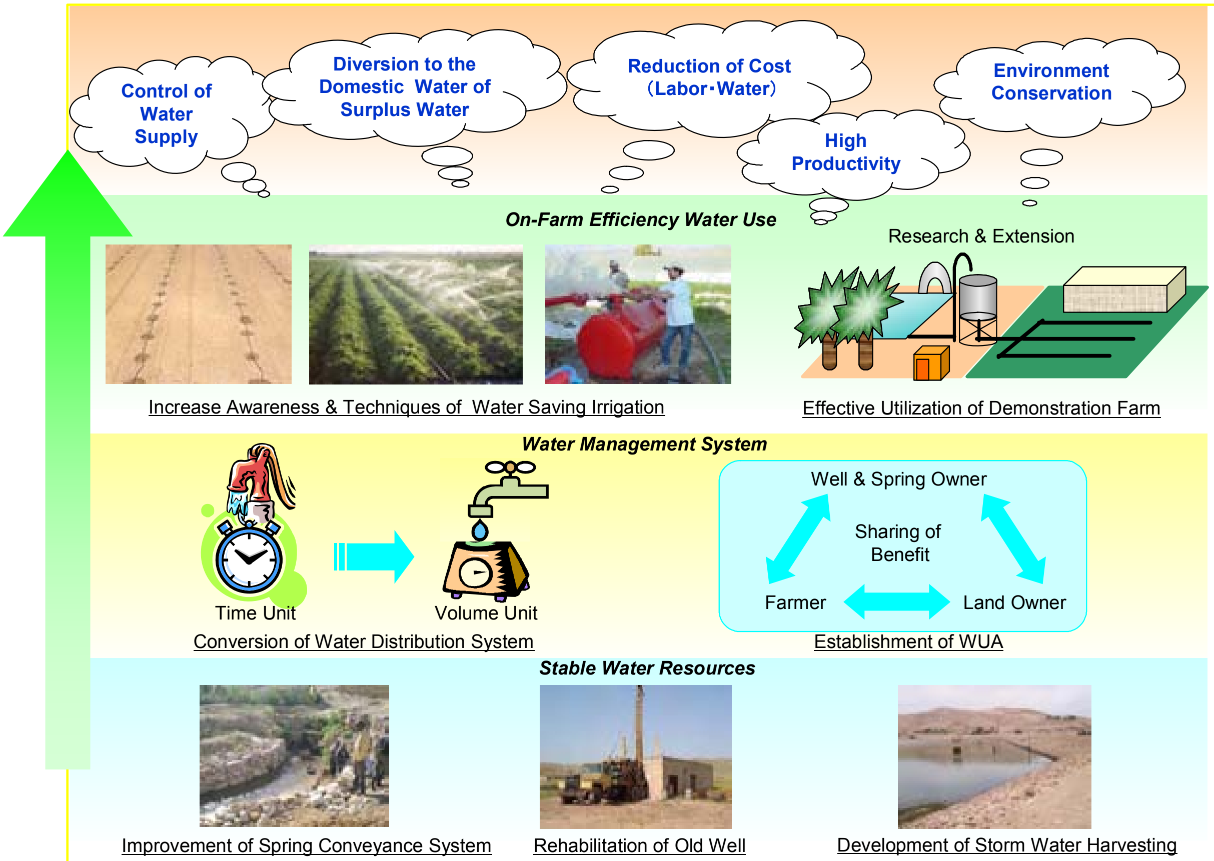
To accomplish the proposed water saving irrigation during the course of the study, the following activities are to be implemented:

1) Initiate pilot project on improvement of spring water conveyance system and rehabilitation of agricultural well (to enhance water conveyance efficiency)

2) Conduct training courses for on-farm water management (to enhance on-farm application efficiency)

6.5.5 Concept on Water Saving Irrigation

Concept of water saving irrigation is illustrated as below.



Source: JICA Study Team

Figure 6.5.1 Concept on Water Saving Irrigation

6.5.6 Training Course for On-farm Water Management

Training course for on-farm water management was conducted during the execution of the Pilot Project in order to verify the effectiveness and impact of the Basic Plan of the on-farm water management.

(1) Objectives of Training

The objectives of the training course are to impart the basic and practical knowledge and skills on water saving irrigation system to the farmers utilizing the rehabilitated wells included in the Pilot Project.

(2) Training Components

The subjects of training course consist of i) design, installation, O&M of water saving irrigation system, ii) fertilization of farm field and iii) farm field practices.
The outline of training components is described in the following table.

Table 6.5.4 Outline of Training Components

Item	Description
Subject	Design, Installation, Operation and Maintenance of Irrigation System, Fertilization of Farm Field, Farm Field Practices
Objectives	To learn basic and practical knowledge and skills on design, installation, operation and maintenance of water saving irrigation system
Training Method	Session, Practice on the Field
Trainer	MoA Staff (Soil & Irrigation Department)
Trainee	Farmers
Class Size	10 - 20 Trainees
Location	Rehabilitation Wells Well Code: 19-19/005A, 18-18/036, 19-17/034, 19-17/047, 19-17/055, 19-17/054, 19-17/027
Training Duration	3 days
Training Equipments / Materials	Training Text, Tools and equipments for field practices

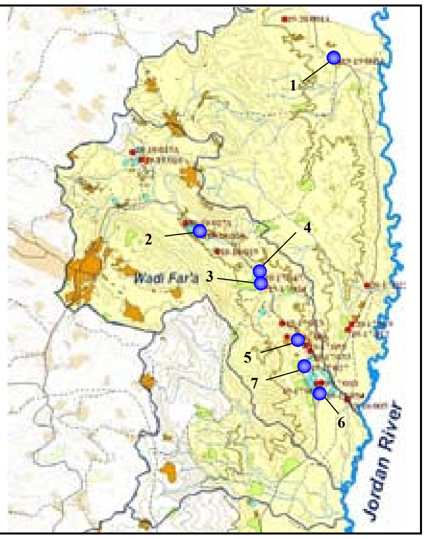
Source: JICA Study Team

(3) Training Site

The seven agricultural wells were selected for the Pilot Project as listed in below.

Table 6.5.5 List of Pilot Project Sites for Well Rehabilitation

No.	Well code	Point name	Locations
1	19-19/005A	Rafeeq Al Zua'bi	Ein Al Byhda
2	18-18/036	Khaleel 'Abed Al Hadi	Fara
3	19-17/034	Rajy Al Skakah	Frush bet dajan
4	19-17/047	Hasan 'Abed Al Jaleel	Frush bet dajan
5	19-17/055	Jawad Al Masri	Jiftlik
6	19-17/054	Ma'rouf Abu Samrah	Jiftlik
7	19-17/027	Hasan Al Sumadi	Jiftlik



Source: JICA Study Team

(4) Training Materials

Training materials were carefully prepared by a trainer in response to the needs of farmers. (refer to Annex 8)

(5) Training Program

The 3-day training program was conducted during rehabilitation period. The daily schedule is shown in the following table.

Table 6.5.6 Training Program

Day	Time	Subject	Location
Day 1	09:30 – 10:00	Opening of the training course	
	10:00 – 11:15	Introduction on plant soil and water relations	Session
	11:15 – 11:30	Coffee Break	
	11:30 – 13:00	Water need and irrigation calculations	Session
	13:00 – 14:00	Lunch	
Day 2	9:00 – 10:30	Irrigation design and maintenance	Session
	10:30 – 10:40	Coffee Break	
	11:40 – 11:40	Salinity effect and salinity management	Session
	11:40 – 11:50	Coffee Break	
	11:50 – 13:15	Fertilization and fertilizers calculations	Session
	13:15 – 14:00	Lunch Time	
Day 3	9:00 – 10:00	Tensio-meters and water tension	Field
	10:00 – 11:00	Measuring pressure and determining pressure problems	Field
	11:00 – 12:00	Measuring the pump and pump characteristics	Field
	12:00– 12:30	Closing of the training course	

Source: JICA Study Team

(6) Training Participants

The training course was conducted from April 2008 to May 2008. Seven training courses were held, where farmers irrigating from one well were gathered together in one training course for 3 days. There were 124 farmers who attended these training courses. The number of trainees per training course varied between 10 farmers and 26 farmers (equivalent to 60 and 90%). The following table shows the participants in the training course.

Table 6.5.7 Training Participants

No.	Well code	Point name	Locations	No. of Trainee	Percentage
1	19-19/005A	Rafeeq Al Zua'bi	Ein Al Byhda	10 - 13	70 - 80%
2	18-18/036	Khaleel 'Abed Al Hadi	Fara	14	80%
3	19-17/034	Rajy Al Skakah	Frush bet dajan	20 - 24	85 - 90%
4	19-17/047	Hasan 'Abed Al Jaleel	Frush bet dajan	20 - 26	85 - 90%
5	19-17/055	Jawad Al Masri	Jiftlik	13 - 15	75 - 80%
6	19-17/054	Ma'rouf Abu Samrah	Jiftlik	10 - 12	75 - 90%
7	19-17/027	Hasan Al Sumadi	Jiftlik	15 - 20	60 - 70%
Total/Average				124	80%

Source: JICA Study Team

(7) Evaluation of Training

For the evaluation of the training course, a questionnaire approach was facilitated. For this purpose, two questionnaires were prepared:

1) Pre-training questionnaire (refer to Annex 8) was filled by farmers who were expected to attend the training. The objective of this questionnaire was to obtain idea on the level of knowledge and practices of farmers in the field of irrigation.
2) Post-training questionnaire (refer to Annex 8) was filled by farmers who have attended the training conducted by trainer from MoA, who carries out the evaluation.

The summary of training evaluation is described in the following sections.

(7-1) Answerer to the pre-training questionnaire

Prior to the training course, a pre-training questionnaire was distributed to the farmers who irrigate their lands/crops from seven agricultural wells. The number of farmers who filled the pre-training questionnaire varies between five farmers (from well 19-19/005A) and 16 (from well 19-17/027). Table 6.5.8 shows the distribution of the concerned farmers.

Table 6.5.8 Answerer to the Pre-training Questionnaire

No.	Well code	Answerer	(%)
1	19-19/005A	5	6.1
2	18-18/036	11	13.4
3	19-17/034	13	15.9
4	19-17/047	12	14.6
5	19-17/055	11	13.4
6	19-17/054	14	17.1
7	19-17/027	16	19.5
Total		82	100.0

Source: JICA Study Team

The questionnaire focused on the following issues:

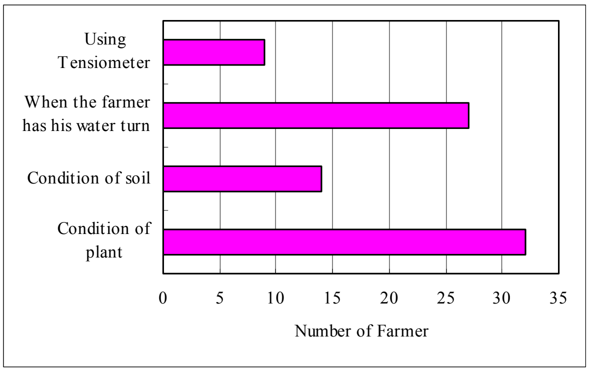
(i) Irrigation practices by targeted farmers, including their methods in managing the irrigation of their farms (when they irrigate, how they determine the volume of water used in irrigation, whether they use fertilization or not, etc.),

(ii) Training needs of farmers.

(7-2) Results of the pre-training questionnaire

Present Irrigation Practices

Figure 6.5.2 shows determination of irrigation timing. 56.1% of the farmers determine irrigation time with respect to the general condition of the plant and soil. Nine farmers meanwhile use Tensiometer to determine proper irrigation timing. It is considered that awareness of irrigation practices of farmers is relatively high. 32.9% of the farmers, however, determine the irrigation timing based on the present water distribution schedule.

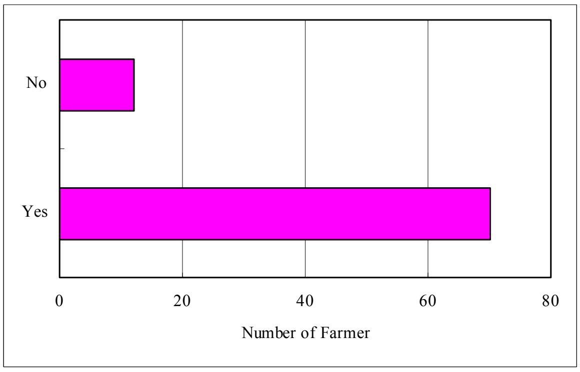


Source: JICA Study Team

Figure 6.5.2 Determination of Irrigation Timing

Training Needs

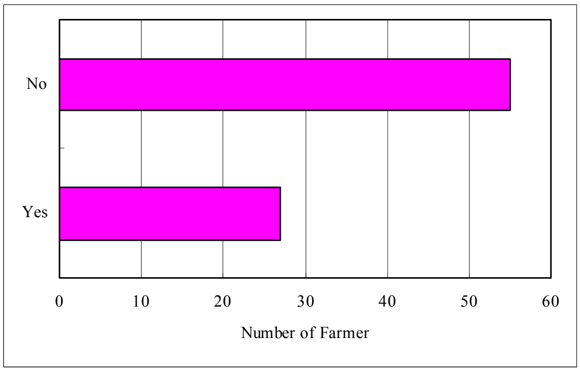
Figure 6.5.3 indicates number of farmers who are in need of a training course in the irrigation field while Figure 6.5.4 indicates number of farmers willing to



Source: JICA Study Team

Figure 6.5.3 Need of Training in Irrigation Field

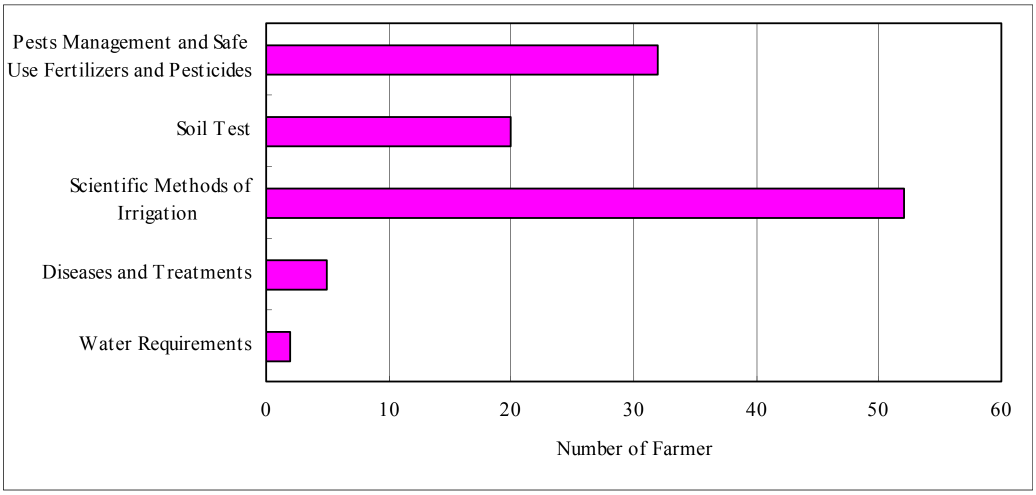
receive training on irrigation techniques. Actually, about 85.4% of the farmers needed the irrigation training in the field level. However, only 27 farmers attended the training course on irrigation techniques.



Source: JICA Study Team

Figure 6.5.4 Receiving Training on Irrigation Techniques

Figure 6.5.5 indicates the training subjects needed by farmers. 46.8% of the farmers expected to attain the scientific methods of irrigation technique after the training course. Lastly, 28.8% of the farmers expressed interest in using fertilizers and pesticides for pest management and safe application.



Source: JICA Study Team

Figure 6.5.5 Training Subjects Needed by Farmers

(7-3) Responses to the post-training questionnaire

After the training course, a questionnaire was distributed among the farmers irrigating their lands/crops from seven agricultural wells. The questionnaire was filled up by 82 farmers. Table 6.5.9 shows the distribution of the concerned farmers.

Table 6.5.9 Answerer to the Post-training Questionnaire

No.	Well code	Answerer	(%)
1	19-19/005A	10	12.2
2	18-18/036	9	11.0
3	19-17/034	15	18.3
4	19-17/047	18	22.0
5	19-17/055	10	12.2
6	19-17/054	12	14.6
7	19-17/027	8	9.7
Total		82	100.0

Source: JICA Study Team

The evaluation of the training focused on three sets of issues:

(i) Training environment: The environment of training and facilitation that included issues like the suitability of place of training, timing of training, arrangement and fixing of training schedule,

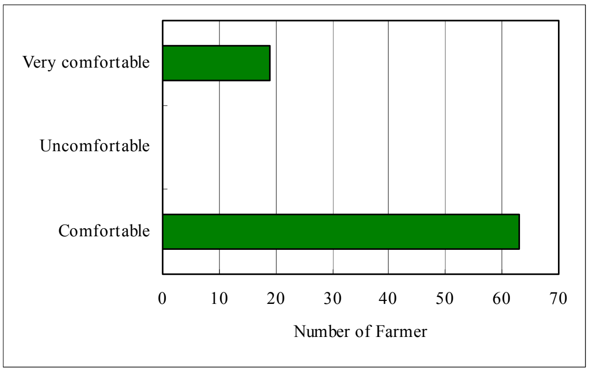
(ii) Timing and duration: The satisfaction of trainees regarding the subjects of training, the nature of training (practical or theoretical), the training methods and the performance of the trainers, and

(iii) Satisfaction in training: The impact of training, and whether it has accomplished its objectives and developed farmers' abilities

(7-4) Results of the pre-training questionnaire

Training Environment

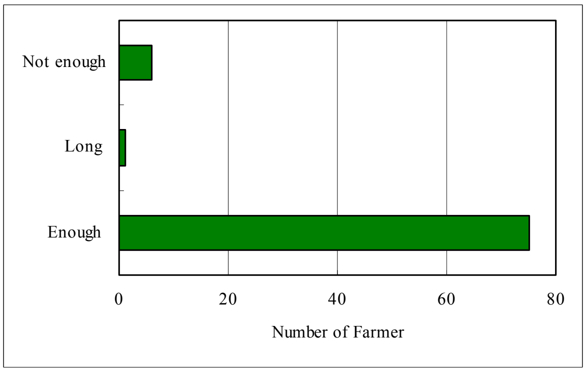
Place of Training: 63 farmers responded that the venue was comfortable (76.8 %); 19 replied that it was very comfortable; and none were unsatisfied. Figure 6.5.6 shows the result of analysis. Hence, attending the sessions was convenient for the farmers since the venues were within their vicinity.



Source: JICA Study Team

Figure 6.5.6 Place of Training

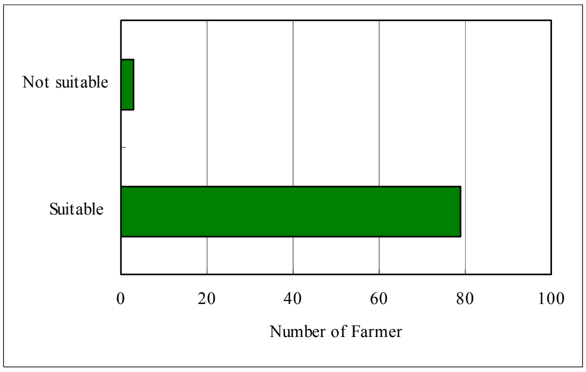
Timing and Duration: The opinion of the trainees about the sufficiency of training duration to tackle related issues was verified. Majority of them (91.5%) indicated that the time given for the training was sufficient. Only one trainee indicated that the training duration was extensive, while 7.3% of the trainees responded that the training duration was insufficient.



Source: JICA Study Team

Figure 6.5.7 Sufficiency of Training Duration

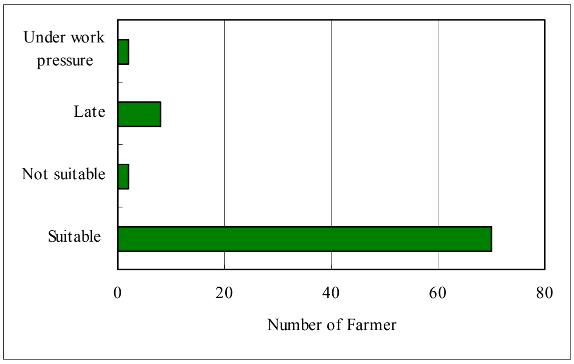
The suitability of time for the training was also investigated. A number of 79 trainees (96.3%) have indicated that the chosen hours for training were suitable to farmers' agenda, while the remaining three trainees expressed an opposite feedback.



Source: JICA Study Team

Figure 6.5.8 Suitability of Training Time

A great majority of trainees have also indicated that the training was held at the right time convenient for them (85.4%). On the other hand, 9.8% of indicated that the training was already late. A minor 2.4% responded that the training was just in time when the farmers are working under pressure. In this respect, it is worth mentioning that trainer and facilitator have conducted long discussions and deliberations with farmers until all issues related to the training hours have been settled. The 82 trainees who filled up the training evaluation questionnaire have indicated that they were actually consulted before fixing the hours for the training.

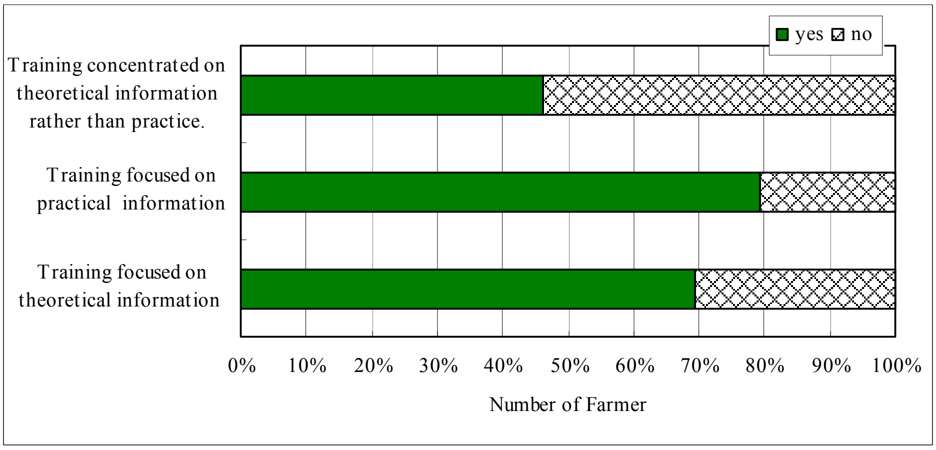


Source: JICA Study Team

Figure 6.5.9 Timing of Training

Satisfaction of Training

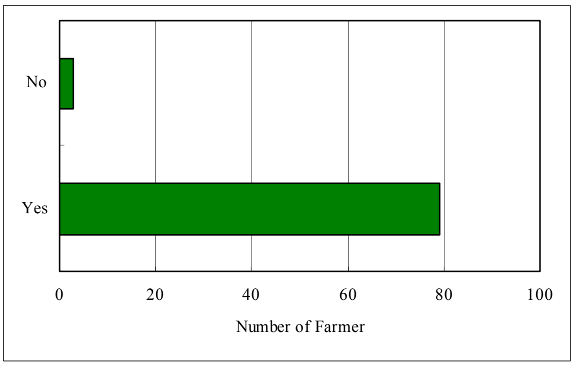
Nature of Training: The trainees were asked about the nature of training whether it focused on theoretical or practical sides and to what degree the trainers were able to present these objectively. The result of the investigation indicates that trainers were keen to the issue and have succeeded in presenting a balanced training. 69.5% of the trainees expressed that the trainers focused on theoretical information. 79.3% informed that the focus was more on practical issues. The nature of answers in fact shows that both aspects of training were given equal attention by the trainers. Figure 6.5.10 shows the results of analysis of the questionnaire concerning this issue.



Source: JICA Study Team

Figure 6.5.10 Nature of Training

Qualification of Trainers: The trainers were chosen by MoA from among their best engineers in the field of irrigation. Their qualification for the assignment was evaluated at the end of the training session. The formulated questionnaire for this purpose has enabled evaluation of the provided training, at different levels:



Source: JICA Study Team

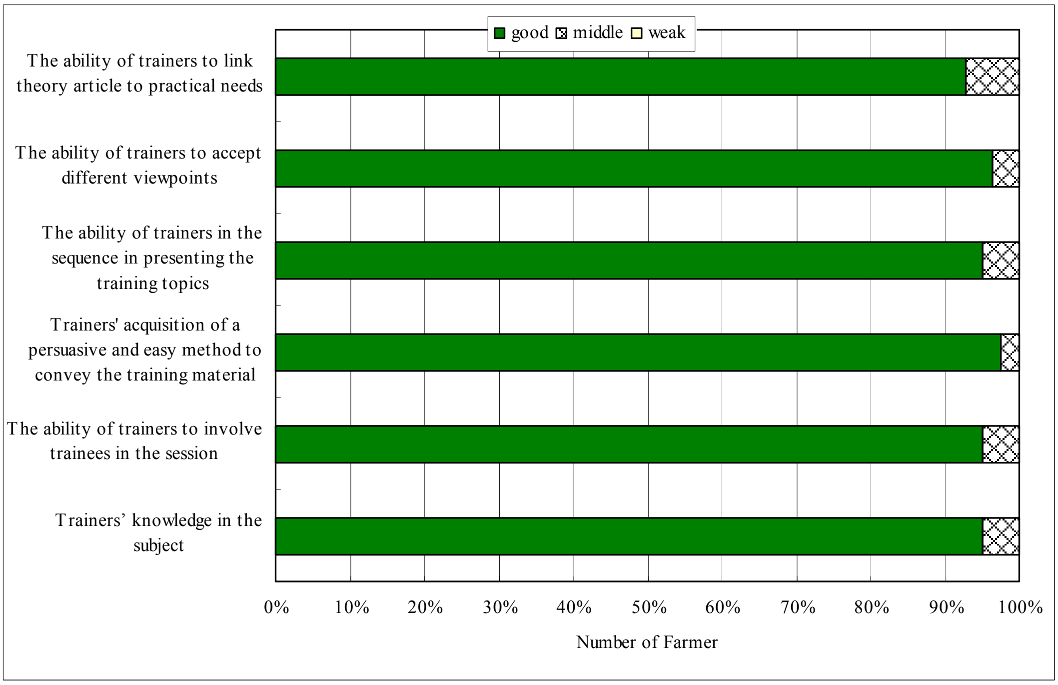
Figure 6.5.11 Qualification of Trainers

(i) A general evaluation was conducted where trainees were asked bluntly whether the trainers are qualified to conduct this training or not. 79 trainees (96.3%) answered “yes” while only three answered “no.”

(ii) The detailed evaluation was based on six criteria described below:

- General cognizance of trainers on the training subjects,
- Capability of the trainers to involve trainees in the training and learning process,
- The skill of the trainers to conduct easy and convincing method of teaching/training,
- The capability of the trainers to shift from one issue to another, and relating different information together,
- The readiness of the trainers to listen to the trainees, and accept opinions,
- The capability of the trainers to link theoretical issues with the practical needs of the farmers trainees.

The analysis of the questionnaires illustrated that a great majority of the trainees who filled up the questionnaire indicated that the trainers were "Excellent." Figure 6.5.11 and 12 show the results of the analysis of the filled-up questionnaires.



Source: JICA Study Team

Figure 6.5.12 Qualification of Trainers

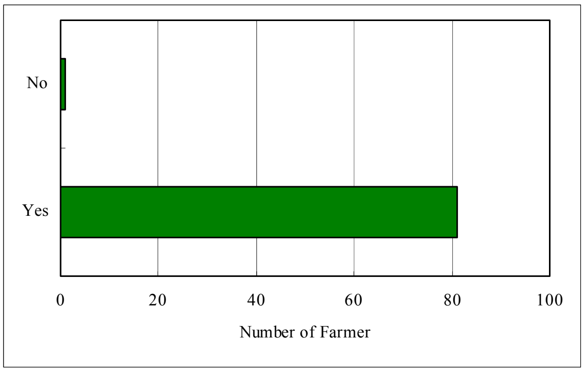
Use of Training Illustrations Means: Different illustration aids were used during the training. This included power point presentations and overhead projectors. The trainers also used various devices to facilitate explanation during the practical training, which included:

(i) Tensiometer,

(ii) Water mark apparatus,

(iii) Pressure gage.

The training also included distribution of handouts that were prepared by the trainers before the session. Each trainee was also provided with a pressure gauge as part of the training kit that they received.



Source: JICA Study Team

Figure 6.5.13 Use of Training Means

The questionnaires that were filled-up by the trainees at the end of the course have enabled the evaluator to conclude that the trainees were satisfied with the illustrations aids used. Figure 6.5.13 which reflects the results of analysis of the questionnaires illustrates that 81 trainees (98.8%) were satisfied with the illustration aids.

Most Interesting Topics of Training: At the end of the training courses, trainees were asked to rank the best newly learned issues. They indicated five main topics which they found most interesting. These were:

(i) Use of Tensiometers in irrigation scheduling - 53 ranked it as the most interesting.

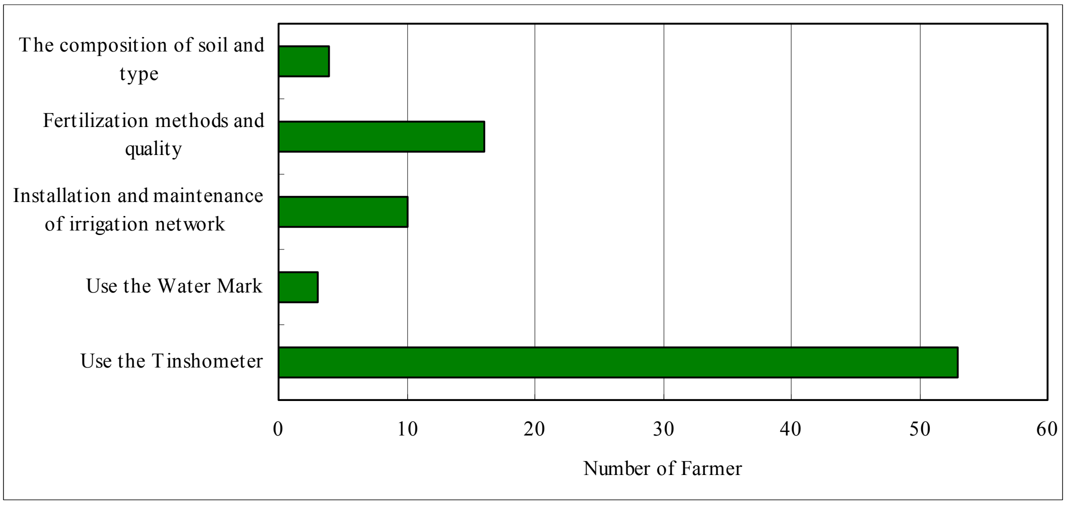
(ii) Fertilization and its different methods - 16 farmers ranked it as among the best five things learned during the training.

(iii) Installation and maintenance of the irrigation network - ranked by 10 trainees as one of the best five things learned in the training,

(iv) Soil texture and its types - mentioned by four farmers as one of the best learned issues

(v) Use of Water Marks as means of irrigation scheduling - mentioned by three farmers as one of the best things learned during the training.

Figure 6.5.14 shows the result of analysis of the questionnaires that were filled by the trainees from among the seven organized courses, which are the subject of this evaluation.



Source: JICA Study Team

Figure 6.5.14 Responses from the Trainee

The Use of Practical Demonstrations: All of those who filled up the questionnaire were satisfied with the practical demonstrations conducted.

Impact of Training

Proper evaluation on the impact of training needs is done appropriately when initiated upon completion of the course. For purposes of this report, the impact of training (whether or not it has achieved its objectives and educated farmers) have been evaluated by analyzing the questionnaires that were filled up by the trainees at the end of the seven courses that were conducted. The study of its impact was made possible through the analysis of responses on the following questions:

a) Will training change the irrigation method you use?
b) Will you change the method of determining time of irrigation?
c) Will you change the method for determining the quantity of irrigation water?
d) After you have known the Tensiometer, are you able to use it in order to determine the irrigation time?
e) Are you able to buy Tensiometer and use it to determine the time to start the irrigation?
f) Do you think that you have received sufficient training to use the Tensiometer yourself?
g) Were the practical demonstrations during the training useful?
h) After you have known the Water Mark, are you able to use it if it's given to you?
i) Do you think that you have received sufficient training to use this Water Mark yourself?
j) After you have known the method of fertilizing process, do you think that you were using the right quantity?
k) Are you ready for using of manure as you learned during training?
l) Do you believe that pressure gauge is necessary to know the distribution efficiency of pressure in the irrigation network?
m) Do you think that the training was sufficient so that you can use the pressure gauge correctly?

Two categories were formed based on the analysis of these questions:

- Questions that explore the intention of trainees to change their future practices, based on the training that they have received,
- Questions that measure the level of knowledge that they have acquired and whether it is sufficient to start new practices.

Subsequent conclusions were made based on the analysis of the results presented in the below table 6.5.10:

Table 6.5.10 Impact of Training

Questionnaire		Number of Farmer	
		Yes	No
a)	Will training change the irrigation method you use?	79	3
b)	Will you change the method of determining time of irrigation?	46	36
c)	Will you change the method for determining the quantity of irrigation water?	51	31
d)	After you have known the Tensiometer, are you able to use it in order to determine the irrigation time?	81	1
e)	Are you able to buy Tensiometer and use it to determine the time to start the irrigation?	80	2
f)	Do you think that you have received sufficient training to use the Tensiometer yourself?	80	2
g)	Were the practical demonstrations during the training useful?	82	0
h)	After you have known the Water Mark, are you able to use it if it's given to you?	77	5
i)	Do you think that you have received sufficient training to use this Water Mark yourself?	77	5
j)	After you have known the method of fertilizing process, do you think that you were using the right quantity?	76	6
k)	Are you ready for using of manure as you learned during training?	82	0
l)	Do you believe that pressure gauge is necessary to know the distribution efficiency of pressure in the irrigation network?	82	0
m)	Do you think that the training was sufficient so that you can use the pressure gauge correctly?	81	1

Source: JICA Study Team

1) About 96.3% of the trainees expressed intentions on changing their irrigation practices, based on the training that they have received. This varies from one practice to another. For example, those who intend to change the way for determining the starting time of irrigation represent 37.8% of the investigated farmers, while those who are willing to change the method of determining the volume of irrigation water represent 43.9%. Those who are interested in changing both represent 18.3% of the interviewees.

2) According to the analysis of the pre-training questionnaire that were filled up by potential participants who later attended the course, a humble percentage of the farmers either knew or were acquainted with the use Tensiometers and water marks. On the other hand, according to the analysis presented in the Table 6.5.10, a great majority of the trainees are fully confident of the level of knowledge and skills that they have acquired during the course, to the extent that they express enthusiasm in adopting what they have just learned without external technical assistance. This shows clearly that the result of the training is remarkable.

(8) Conclusion and Recommendation of the Training Course

Findings from the training evaluation, the conclusions and recommendations are determined as follows:

- Trainer nominated from among MoA engineers exhibit high skills as a trainer for on-farm water management course.
- Majority of trainees, who are also farmers, are aware of the on-farm water management and have relatively high level of understanding.
- Conducting the training course in parallel with rehabilitation of the wells contributes to the sustainability of rehabilitation results.
- The system, funded and managed by WUA through its establishment of microfinance, and with the assistance of PNA, should be developed to replace the old water saving irrigation facilities,
- Capacity development of an extension agent would be necessary to provide training close to the farmer’s residents.
- The survey result on the demonstration farm which is conducted by “The Project for Strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley” should be effectively utilized in order to update the optimum crop water requirements and the appropriate cropping pattern in the Jordan River Rift Valley.

6.5.7 Water Economical Efficiency and Value-added

In order to accomplish water saving irrigation, incentive should be given to the farmers. Such incentive is the potential attractive income. Thus, water saving irrigation should result in conservation of water and high profits. High-profitability agricultural products would improve water economical efficiency in the agricultural sector. These products could then be exported to neighboring countries. In terms of export destination, most agricultural products were exported to Israel since 2001. However, in recent years, the market of Palestinian agricultural products gradually expanded to Jordan, Europe and the Gulf Countries.

Table 6.5.11 Palestinian Export of Fresh Fruits and Vegetables by Destination Country/Area, 1999-2005

(Value in Thousand US$, Percentage in total value in respective year)

	1999	2000	2001	2002	2003	2004	2005
Israel	36,491.53	44,729.88	16912.08	11542.16	14,908.10	16,566.427	14,103.96
	98.24%	69.52%	91.69%	65.15%	70.61%	74.80%	66.11%
Jordan	654.32	848.12	564.03	324.75	1,527.21	464.201	498.36
	1.76%	1.32%	3.06%	1.83%	7.23%	2.10%	2.34%
Europe	0	0	923.16	5,827.61	4,651.29	3,832.64	5,625.84
	0%	0%	5.01%	32.90%	22.03%	17.31%	26.37%
Gulf Countries	0	18,762.08	45.41	20.30	25.58	75.780	102.91
	0.00%	29.16%	0.25%	0.11%	0.12%	0.34%	0.48%
Other Arab League Count	0	0	0	0	0	0.336	32.36
	0%	0%	0%	0%	0%	0.00%	0.15%
North/South America	0	0	0	0	0	0.334	0.64
	0%	0%	0%	0%	0%	0.00%	0.00%
Other Countries	0	0	0	0.66	1.97	1,206.718	970.81
	0%	0%	0%	0.004%	0.01%	5.45%	4.55%
TOTAL	37,145.85	64,340.08	18,444.68	17,715.48	21,114.14	22,146.43	21,334.88
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: PCBS

The competitive agricultural products, being exported products, should be produced in the Study Area. It is necessary to enhance the value of agricultural products in order to improve competitiveness. The production process of value-added agricultural products could be divided into two phases, namely, 1) cultivation phase and 2) processing phase.

6.5.8 Value-added in Cultivation Phase

(1) High Quality Products

Greenhouses and plastic tunnels make efficient use of scarce water resources and generate high quality agricultural products. Greenhouse provides good climate control. Under the greenhouse condition, high profitability agricultural crops, such as selected varieties of tomatoes, strawberries, herbs, leaf vegetables and cut flowers, could be cultivated.

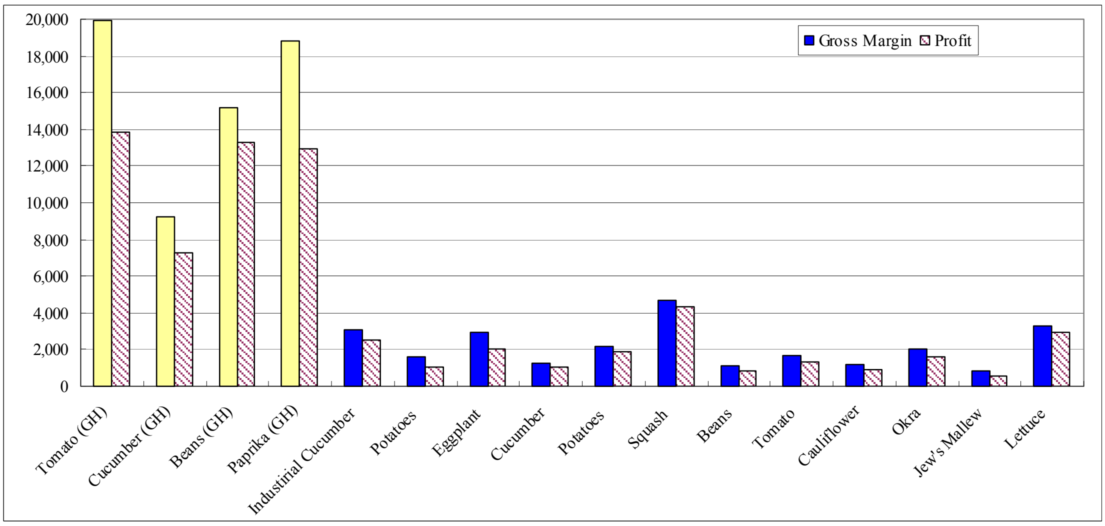
The profitability of crop cultivation per dunum is estimated in the Study Area, as summarized in the following table.

Table 6.5.12 Comparison Table of Gross Margin and Profit of Major Crops in the Study Area (2006/2007)

	Cropping	Yield kg/Dunum	Gross Profit NIS/Dunum	Total Cost NIS/Dunum	Gross Margin NIS/Dunum	Profit NIS/Dunum
Green House Vegetables						
Tomato (GH)	year round	17,000	28,900	8,988	19,912	13,813
Cucumber (GH)	winter	10,000	15,000	5,793	9,207	7,254
Beans (GH)	winter	3,000	18,000	2,830	15,170	13,302
Paprika (GH)	autumn	9,000	27,000	8,166	18,834	12,926
Outdoors Vegetables						
Industrial Cucumber	spring	3,000	6,000	2,924	3,076	2,529
Potatoes	autumn	4,000	4,000	2,366	1,634	1,066
Eggplant	spring	6,000	6,000	3,059	2,941	2,037
Cucumber	autumn	2,000	3,000	1,717	1,283	1,056
Potatoes	spring	3,000	4,500	2,333	2,167	1,889

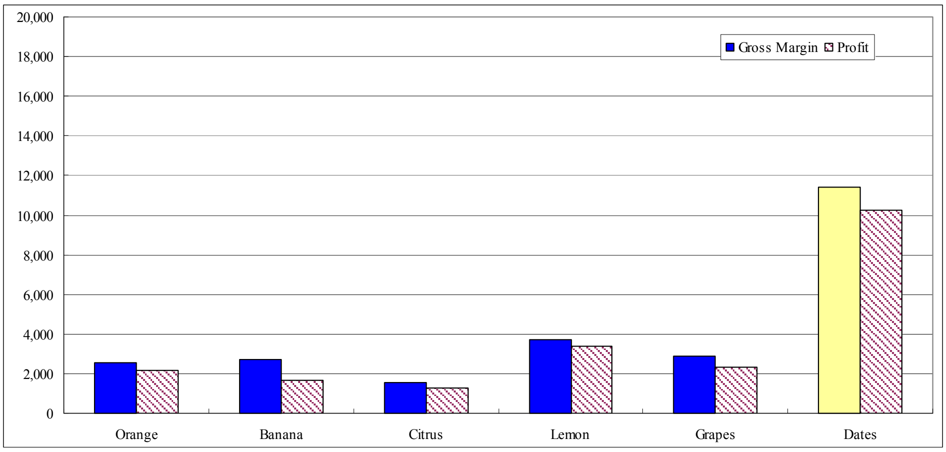
	Cropping	Yield kg/Dunum	Gross Profit NIS/Dunum	Total Cost NIS/Dunum	Gross Margin NIS/Dunum	Profit NIS/Dunum
Squash	spring	2,200	6,600	1,947	4,653	4,354
Beans	spring	900	2,700	1,567	1,133	871
Tomato	spring	4,000	4,000	2,355	1,645	1,317
Cauliflower	autumn	2,000	2,600	1,420	1,180	883
Okra	spring	300	4,500	2,483	2,017	1,584
Jew's Mallow	summer	2,500	2,500	1,636	864	573
Lettuce	autumn	3,500	5,250	1,971	3,279	2,963
Fruits						
Orange	6-20 ys	2,500	4,250	1,728	2,522	2,169
Banana	3-6ys	3,500	5,250	2,520	2,730	1,647
Citrus	6-20 ys	2,560	3,840	2,273	1,567	1,290
Lemon	6-20 ys	3,000	5,550	1,819	3,731	3,369
Grapes	6-20 ys	1,900	6,300	3,438	2,862	2,302
Dates	6-20 ys	1,400	17,600	6,175	11,425	10,258

Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.15 Gross Margin and Profit of Vegetables in the Study Area



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.16 Gross Margin and Profit of Fruits in the Study Area

It is evident that the high profitability vegetables are cultivated under green house conditions in the Study Area. However, greenhouses cover only 1,997 dunums, which is just 3% of the total irrigated area in the Study Area. It is thus necessary to expand the greenhouse horticulture to realize the additional value of high quality.

(2) Food Safety

Recently, customers who live in developed country, prefer quality as well as safety of agricultural products, even its price is high. In the Study Area, proper safety control at the production level is hardly accomplished. There are some requirements and international standards such as EurepGAP (Euro-Retailer Produce Working Group Good Agricultural Practices) for agricultural products. Most of the small-sized farmers have no financial resources to invest in such facilities, technologies and human resources. This should be supported by MoA so that the farmers could obtain the EurepGAP certification to gain the additional value of safety.

(3) Off-seasons Products

Warm climate of the Study Area made it possible to produce agricultural crops during the off-season in EU market. For example, while vegetables such as tomatoes and eggplants are cultivated at the beginning of April in European countries, their cultivation season is between October and April in the Study Area. Similarly, the cultivation of seedless grapes in the Jordan Valley is in May, which is two months earlier than in Europe. Thus, such seasonal difference opens the path to compete with cash crops from Europe. To make best use of the advantage of shipping during off-season in EU market, MoA should promote the cropping pattern that considers the needs of the market.

(4) Profitability and Water Economy

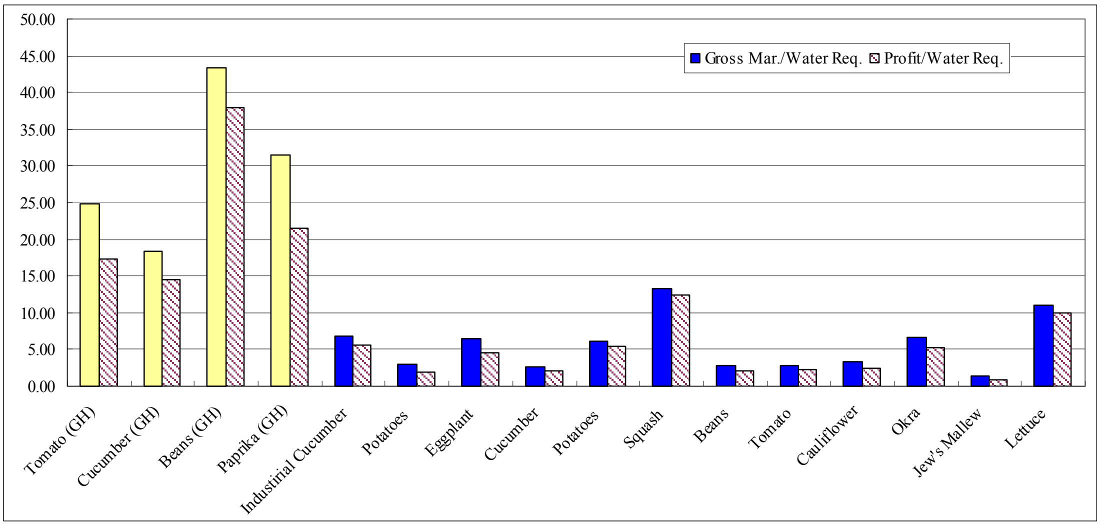
Water saving agriculture should be promoted strategically both for water efficiency and profitability from the crops. In view of the limited water available for irrigation, the profitability of crops cultivated based on per water consumption should be considered in the Study Area. The following table shows the water requirement and the profitability per cubic meter of water.

Table 6.5.13 Comparison Table of Water Efficiency of Major Crops in the Study Area (2006/2007)

	Cropping	Gross Margin NIS/Dunum	Profit NIS/Dunum	Water Requirement m^3	Gross Mar./Water Req. NIS/m^3	Profit/Water Req. NIS/m^3
Green House Vegetables						
Tomato (GH)	year round	19,912	13,813	800	24.89	17.27
Cucumber (GH)	winter	9,207	7,254	500	18.41	14.51
Beans (GH)	winter	15,170	13,302	350	43.34	38.01
Paprika (GH)	autumn	18,834	12,926	600	31.39	21.54
Outdoors Vegetables						
Industrial Cucumber	spring	3,076	2,529	450	6.84	5.62
Potatoes	autumn	1,634	1,066	550	2.97	1.94
Eggplant	spring	2,941	2,037	450	6.54	4.53
Cucumber	autumn	1,283	1,056	500	2.57	2.11

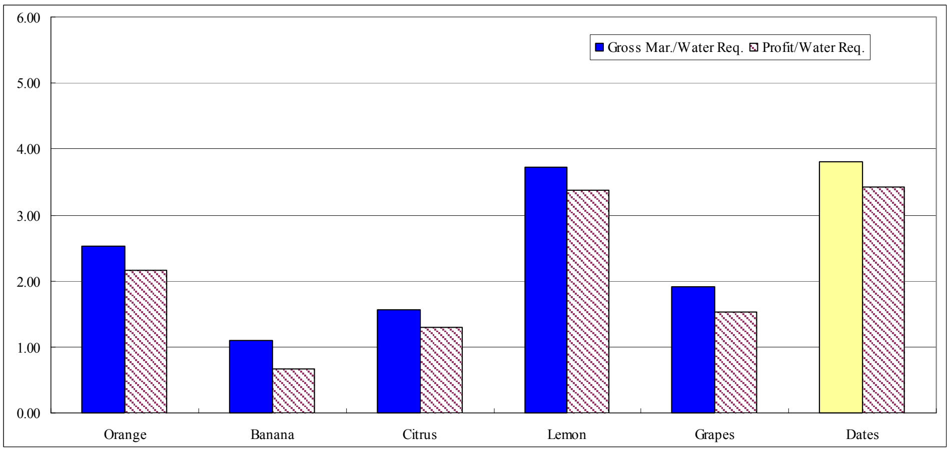
Cropping		Gross Margin NIS/Dunum	Profit NIS/Dunum	Water Requirement m^3	Gross Mar./Water Req. NIS/m^3	Profit/Water Req. NIS/m^3
Potatoes	spring	2,167	1,889	350	6.19	5.40
Squash	spring	4,653	4,354	350	13.29	12.44
Beans	spring	1,133	871	400	2.83	2.18
Tomato	spring	1,645	1,317	600	2.74	2.20
Cauliflower	autumn	1,180	883	350	3.37	2.52
Okra	spring	2,017	1,584	300	6.72	5.28
Jew's Mallow	summer	864	573	600	1.44	0.96
Lettuce	autumn	3,279	2,963	300	10.93	9.88
Fruits						
Orange	6-20 ys	2,522	2,169	1,000	2.52	2.17
Banana	3-6ys	2,730	1,647	2,500	1.09	0.66
Citrus	6-20 ys	1,567	1,290	1,000	1.57	1.29
Lemon	6-20 ys	3,731	3,369	1,000	3.73	3.37
Grapes	6-20 ys	2,862	2,302	1,500	1.91	1.53
Dates	6-20 ys	11,425	10,258	3,000	3.81	3.42

Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.17 Gross Margin and Profit per Water Unit Required by Vegetables in the Study Area (NIS/m^3)



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.18 Gross Margin and Profit per Water Unit Required by Fruits in the Study Area (NIS/m^3)

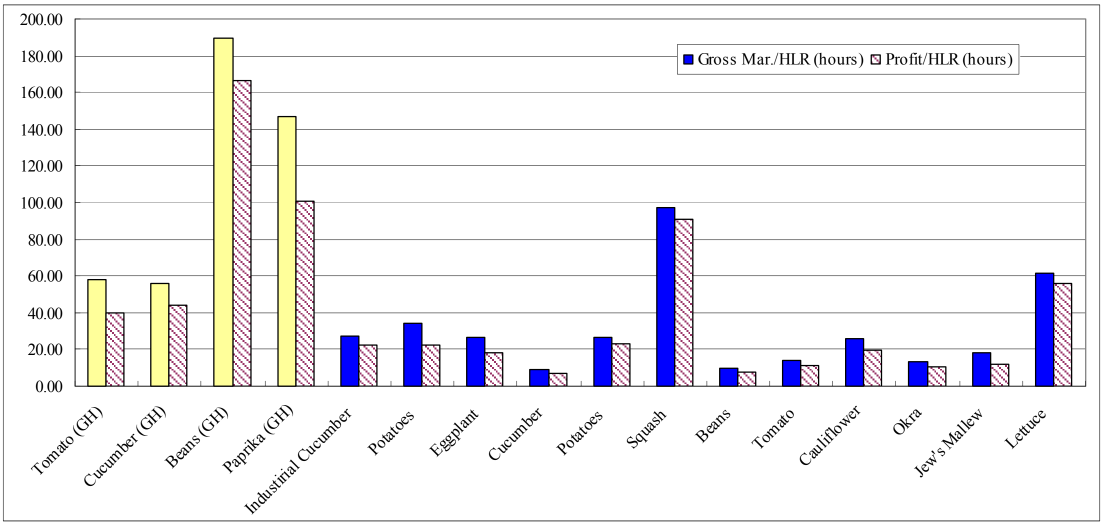
The water profitability for the products grown in greenhouses is high compared to those grown in open field. The main reason for this is assumed to be the higher quality of products and its stable and constant supply. Producers seldom take the water productivity into consideration water is not costly. However, the optimization of water use for agriculture should consider both the water efficiency and the profitability of crops. For further information, the profitability per unit of hired labor is estimated as shown in the following table and figures.

Table 6.5.14 Comparison Table of Labor Efficiency of Major Crops in the Study Area (2006/2007)

	Cropping	Gross Margin	Profit	Hired Labor Requirement	Gross Mar./HLR (hour)	Profit/HLR (hour)
		NIS/Dunum	NIS/Dunum	hours	NIS/hour	NIS/hour
Green House Vegetables						
Tomato (GH)	year round	19,912	13,813	344	57.88	40.15
Cucumber (GH)	winter	9,207	7,254	164	56.14	44.23
Beans (GH)	winter	15,170	13,302	80	189.63	166.28
Paprika (GH)	autumn	18,834	12,926	128	147.14	100.98
Outdoors Vegetables						
Industrial Cucumber	spring	3,076	2,529	112	27.46	22.58
Potatoes	autumn	1,634	1,066	48	34.04	22.20
Eggplant	spring	2,941	2,037	112	26.26	18.19
Cucumber	autumn	1,283	1,056	144	8.91	7.33
Potatoes	spring	2,167	1,889	81	26.75	23.32
Squash	spring	4,653	4,354	48	96.94	90.72
Beans	spring	1,133	871	115	9.85	7.57
Tomato	spring	1,645	1,317	118	13.94	11.16
Cauliflower	autumn	1,180	883	45	26.22	19.61
Okra	spring	2,017	1,584	152	13.27	10.42
Jew's Mallow	summer	864	573	48	18.00	11.94
Lettuce	autumn	3,279	2,963	53	61.87	55.91
Fruits						
Orange	6-20 ys	2,522	2,169	89	28.33	24.37
Banana	3-6ys	2,730	1,647	40	68.25	41.18
Citrus	6-20 ys	1,567	1,290	64	24.48	20.15

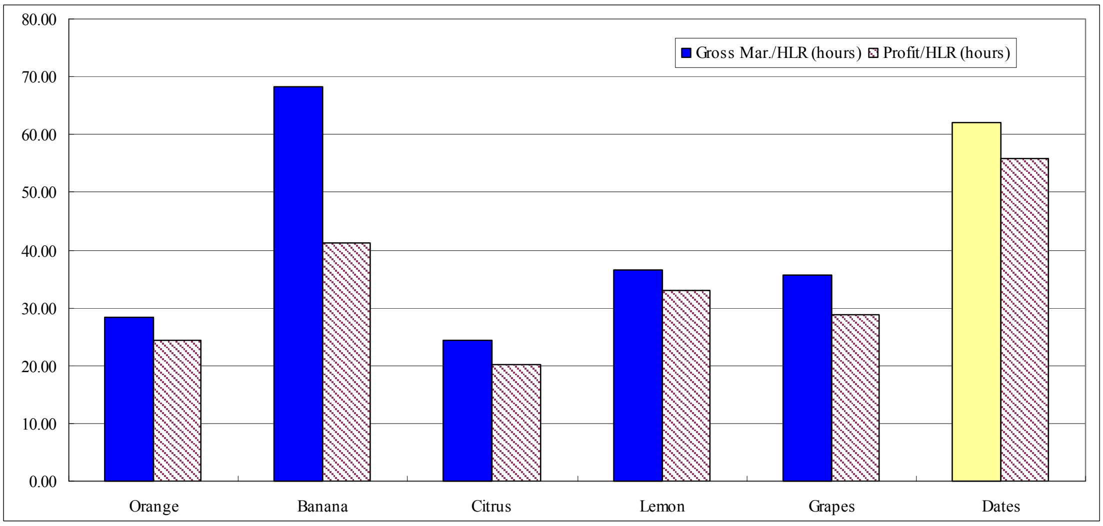
Cropping		Gross Margin NIS/Dunum	Profit NIS/Dunum	Hired Labor Requirement hours	Gross Mar./HLR (hour) NIS/hour	Profit/HLR (hour) NIS/hour
Lemon	6-20 ys	3,731	3,369	102	36.57	33.03
Grapes	6-20 ys	2,862	2,302	80	35.78	28.77
Dates	6-20 ys	11,425	10,258	184	62.09	55.75

Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.19 Gross Margin and Profit per Labor Unit Required by Vegetables in the Study Area (NIS/hour)



Source: JICA Project Team "The project for strengthening Support System Focusing on Sustainable Agriculture in the Jordan River Rift Valley"

Figure 6.5.20 Gross Margin and Profit per Labor Unit Required by Fruits in the Study Area (NIS/hour)

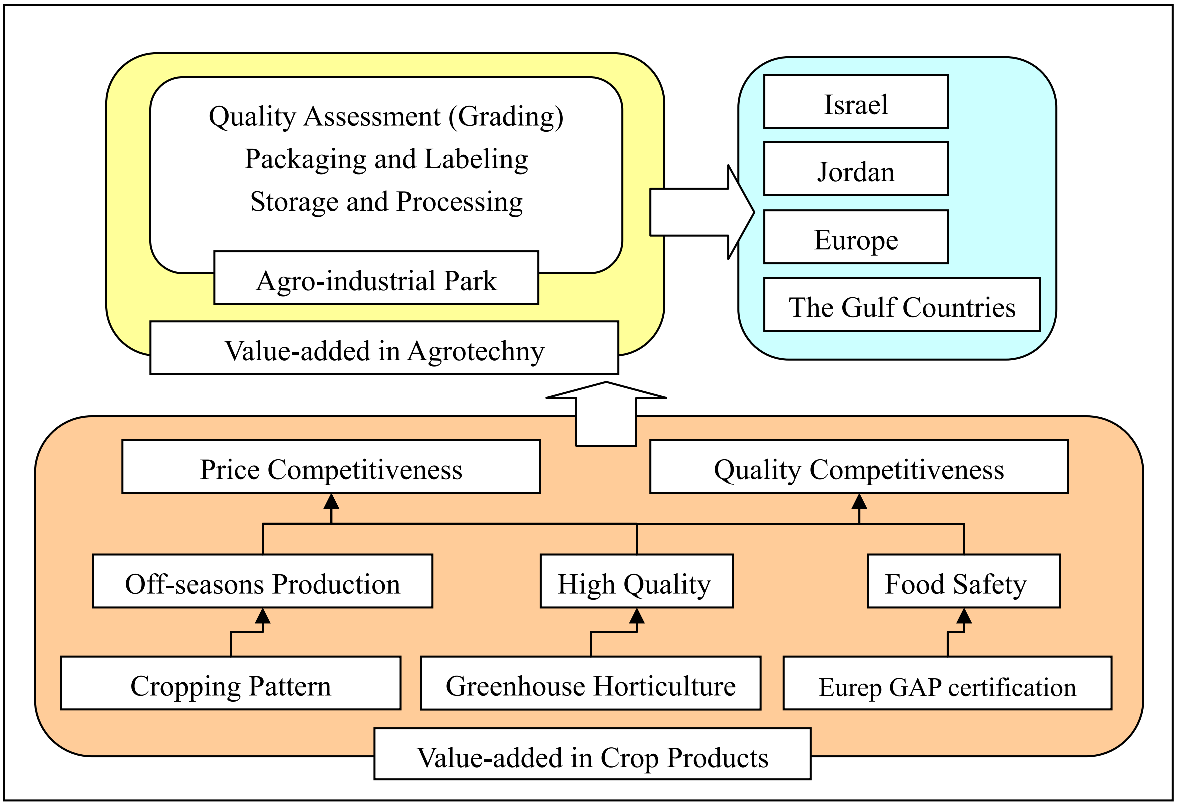
6.5.9 Value-added in Processing Phase

There are many factors to prevent the reasonable price of agricultural products in the processing stage. One is the absence of proper grading system. This means lack of differentiation of prices according to size, color, shape, quality, and so on. As a result, the current pricing is not related to proper grading system, which would result in maximization of profits. According to PalTrade, cash crops in Palestine are largely characterized by low quality control, minimal grading (if any), poor inspection, basic packaging techniques and limited storage and handling facilities. Moreover, packaging and labeling is poor in Palestine, which is increasingly important and complicated for exporting products, especially to Europe.

Another problem is the transportation cost, which has been nearly doubled after the second Intifada in 2000[4]. Under the current situations, frequent delivery delay and increasing cost for storage and cooling system impose financial burden on producers in Palestine and weakens the price competitiveness.

6.5.10 Concept of Value-added Process

As described in aforesaid sections, the concept to enhance the value-added process is illustrated as below.



Source: JICA Study Team

Figure 6.5.21 Concept of Value-added Process

[4] The Palestinian Cash Crops Sector: Trade Development Strategy, PalTrade, 2004

6.6 Implementation Program for Water Resources Development

The Basic Plans for rehabilitation and integrated management of agricultural wells and improvement of spring water conveyance system were formulated for efficient utilization of water for agriculture in the Study Area as described in the preceding sections. And the Prospective Plan for storm water harvesting was also proposed for new water resources development.

Based on the Basic Plans and the Prospective Plan, it is proposed that the water resources development in the Study Area should be implemented under short, medium and long term plans. Urgency, scale, political risks for executing the construction works, and other factors are also taken into consideration in the implementation plans.

The implementation program for water resources development is presented in the following table.

Table 6.6.1 Implementation Program for Water Resources Development

Plan	Short Term (2010-2012)	Medium Term (2013-2015)	Long Term (After 2016)
Improvement of Spring Water Conveyance System	Al 'Auja Spring	Al Nwai'mah and Al Dyuk Spring	16 springs
Rehabilitation of Agricultural Wells	11 wells (excluding 8 wells from 19 priority wells which was executed as the pilot project)	30 wells	30 wells
Development of Storm Water Harvesting	Collection and analysis of relevant data and information for the preparation of storm water harvesting plan		Major wadis such as Wadi Qilt, Wadi Auja and Wadi Far'a
	Implementation of Pilot Projects		

Source: JICA Study Team