CHAPTER IV DESIGN OF PROJECT FACILITIES

4.1 Topography and Geology

4.1.1 Topography

The Wadi Jizzi basin is roughly divided into three topographical classifications; lowlying area consisting of farm land and gravel, hill area consisting of river terrace, talus and the foot of the mountain, and central mountain mass consisting of ophiolite. The proposed dam site is located at the middle stream of Wadi Jizzi and has the river bed of 650 m wide and terrace rising steeply therefrom.

The topographical features of the dam site are described hereunder in order of the left bank, right bank and river beds.

The left and the right banks are the river terraces consisting of sand and gravel, and rise on the dam axis with slope of about 20 degrees from the river bed. The crests, however, present flat at an elevation ranging from EL 165 m to EL 170 m and are widely spread. On the flats lie many deep gullies which are being developed vigorously.

The recent river bed of Wadi Jizzi, formed with flood plain deposits, grows abruptly wider at the confluence with Wadi Awhin - the proposed dam site, and reaches in the coastal area about 10 km wide. In the upperstream portion, the river bed width varies with bulges of the mountain. Four flow courses can be clearly observed at Wadi Jizzi around the dam site including Wadi Awhin. The river bed slope does not show a large fluctuation in the areas where the wadi deposits are recognized, and the slope is about 1/100 in the mid-stream area including the dam site, while about 1/150 in the downstream area.

4.1.2 Geology

The Wadi Jizzi basin is geologically mainly composed of Hawasina group of sedimentary rocks, metamorphic rocks, Semail ophiolite of the igneous rocks, and Quaternary deposits.

Geology of the dam site consists of recent river deposits, middle terrace deposits, upper terrace deposits and bed rocks. The main geological features of them are:

Bed rock consists of serpentine, and is overlain by upper terrace deposits. It is generally hard except some parts, and impermeable layer. However it does not come into contact with the dam embankment.

Upper terrace deposits consist of well consolidated sands and gravels. Because the consolidated condition of the deposits are regarded as soft rock.

They are overlain by middle terrace deposits, and outcrop at the both abutments that come into contract directly with the dam embankment. They are weathered and weakly cemented in the surface. Therefore those permeabilities are high at the abutments.

Middle terrace deposits consist of consolidated sands and gravels. They are moderately soft, but are regarded as soft rock. They are overlain by recent river deposits. Because they have abundantly opened joints and vesicle in lower part, those permeabilities are high.

Recent river deposits distribute in the Wadi channel, and consist of very loose sands and gravels. An average thickness of the deposits is 3.1 m.

As for the permeability, the foundation is divided into 5 zones from lugeon values as follows:

Zone 1 consists of very loose recent river deposits. An average permeability coefficient is 9.8×10^{-3} cm/sec.

Zone 2 corresponds to subsurface layer of terrace deposits. Average permeability coefficient is 1.8×10^{-3} cm/sec.

Zone 3 consists of lower part of middle terrace deposits. An average permeability coefficient is 5.1×10^{-4} cm/sec. This zone is weakly consolidated and generally vesiculor.

Zone 4 distributes narrowly around above mentioned area. An average permeability coefficient is 1.3×10^{-4} cm/sec. The zone is moderately hard and joints are rather sparse.

Zone 5 consists of upper terrace deposits and bed rocks. An average permeability coefficient is 1.8×10^{-5} cm/sec. This zone is practically impervious layer.

As for the bearing capacity of foundation, it seems that terrace deposits in the foundation have sufficient bearing capacity for the embanked load, because N-value (cone penetration resistance) in the terrace deposits is more than 100. However, for the recent river deposits and upper layer of terrace deposits, it is necessary to remove wholly from the trench base of detention dam so that the dam foundation be free from the liquefaction, bearing capacity and seepage problems.

No faults and shear-zones have been revealed by the results of field investigations, interpretation of areal photographs and core drillings.

4.2 Dam Body and Foundation

4.2.1 Typical Section

a) Dam Type

As the purpose of the detention dam is to temporarily retain flood discharge and to cut the peak of flood which flows down uselessly into the sea in a short time, a relatively large quantity of seepage water can be allowed to flow out through the dam body. Abundant embankment materials are easily obtained from terrace deposits and talus deposits. The required bearing capacity and shearing strength of the foundation are not good enough for a concrete dam. A zone type fill dam with sand and gravel is economical in comparison with the concrete dam in this Project.

In the downstream of sand and gravel zone, the intersepter with horizontal drain is planned in order to reduce the seepage water pressure and to allow the seepage water to flow safely out from the zone.

The surface of both slopes should be protected by the handplaced riprap in order to prevent the fine materials in the sand and gravel zone from movement and suction by wave action at the upstream slope and erosion by rainy water at the downstream slope.

b) Embankment Material

The embankment materials for each zone are obtained from borrow areas as follows.

Sand and gravel material ..... Materials excavated at both spillway sites (Terrace deposits)

Filter materials ..... Materials excavated at the wadi course (River deposits)

Riprap materials ..... Boulders selected from the sand and gravel materials

The terrace deposits spreaded at both the service spillway and emergency spillway are utilized as the borrow area for the sand and gravel materials taking into accout the excavation volume and physical properties of the materials.

Materials of the filter zone are obtained from the receent river deposits on the wadi course by using the screening plant for the arrangement of grading.

The boulders obtained from screening of terrace deposits will be mainly used for the riprap materials. The talus deposits, located about 2 km upstream from the dam site can be also used.

c) Crest Elevation

The crest elevation of non-overflow section of the detention dam is determined by adding a height of wave due to the wind to the maximum water surface level of a reservoir.

Uprushing height of wave varies in accordance with the gradient and roughness of the embankment slope and the uprushing height of wave caused by wind is estimated at 0.8 m.

According to the hydraulic study of spillway, a rise of water from the full water surface level is estimated at 5.3 m when the design flood discharge or maximum probable flood with extremity of safety is released from the spillway.

The crest elevation of detention dam without extra banking can be obtained as follows.

Dam crest elevation EL. 169.2 + 0.8 = EL. 170.0 m

d) Typical Section

The typical cross section of the detention dam is shown in Fig. 4-1.

4.2.2 Stability Analysis

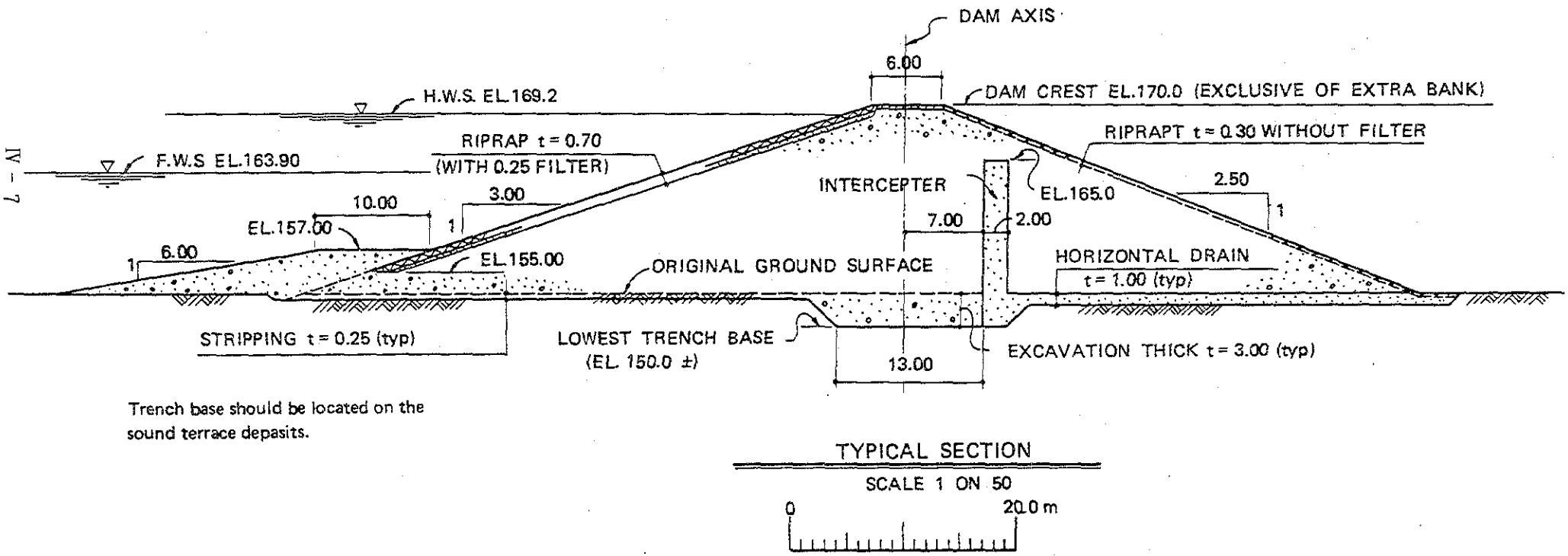
a) Design Values

Design values of density and shearing strength for the embankment materials and dam foundation are influenced by water content and degree and method of compaction. The materials to be used for the embankment of the detention dam are rather coarse and the natural water content is in the dry side from the optimum water content. The embankment works can be carried out around the optimum water content by splinkling water. The design values of the density are estimated at 98 percent of the maximum dry density of compaction tests. The design value of the shearing strength is decided at 90 percent of the result of shear box tests at the optimum water content.

Materials composing the dam foundation in the river course are classified into two layer. The upper layer with less than 30 of cone penetration value(N) is stripped. The internal friction angle for the upper layer materials is obtained by Dunhams Formula assuming N value is 15. The lower layer has N-values more than 100. The design value of the shear strength is decided at the same value of the sand and gravel materials. The design value of the riprap materials is estimated based on the data obtained from similar soil formerly.

Design values of the above-mentioned embankment and dam foundation materials for the detention dam are summarized in Table 4-1.

Fig. 4-1 TYPICAL SECTION OF DETENTION DAM



Trench base should be located on the sound terrace depasits.

TYPICAL SECTION

SCALE 1 ON 50

0 20.0 m

Table 4-1 SUMMARY OF DESIGN VALUES FOR DETENTION DAM

Material	Density		Shearing Strength			K[6]
	γ_d[1]	γ_t[2]	γ_{sat}[3]	ϕ[4]	C[5]	
	(t/m³)	(t/m³)	(t/m³)	(deg.)	(t/m²)	(cm/sec)
Sand and Gravel	1.92	2.06	2.21	35°00'	0.0	1.9×10^{-4}
Filter	2.07	2.16	2.35	35°00'	0.0	7.7×10^{-4}
Foundation Layer						
Upper (River Deposit)	1.63	1.75	2.06	28°00'	0.0	-
Lower (Terrace Deposit)	1.98	2.07	2.26	35°00'	0.0	-
Riprap	1.98	1.99	2.27	38°00'	0.0	-

1/ dry density, 2/ wet density, 3/ saturated density
4/ angle of internal friction, 5/ cohesion
6/ coefficient of permeability,

b) Sliding Failure Analysis

There are a number of methods available for slope stability analysis of the dam body. However, the slip cricle method is exclusively employed because this method gives the most severe factor of safety. The seismic coefficients of 0.1 is to be adopted as horizontal seismicity for the design of the dam body. The stability analysis is carried out for the several cases with different reservoir water levels and seismic coefficients. The calculation has been made on different slip circles until the smallest factor of safety is obtained.

The calculation result for the above cases with reservoir conditions at the detention dam is shown in Table 4-2.

Table 4-2 RESULT OF STABILITY ANALYSIS ON DETENTION DAM

Case	Reservoir Condition	K[1/]	Slope	Factor of Safety
1	After Completion F.W.S. [2/]	0.10	Upstream	F.S=1.265
2	- do -	0.10	Downstream	F.S=1.239
3	After Completion M.W.S. [3/]	0.10	Upstream	F.S=1.327
4	- do - L.W.S. [4/]	0.10	- do -	F.S=1.551
5	- do - H.W.S. [5/]	Nil	- do -	F.S=2.326
6	- do -	Nil	Downstream	F.S-1.820
7	Immediately After Completion, Empty	0.05	Upstream	F.S=2.090
8	- do -	0.05	Downstream	F.S=1.569
9	Rapid Drowdown F.W.S. to L.W.S.	0.05	Upstream	F.S=1.241

1/ Seismic coefficient, K=0.10 in normal case and K=0.05 or zero in special case

2/ full water surface level and EL. 163.90 m is adopted

3/ middle water surface level and EL. 159.0 m is adopted

4/ low water surface level and EL. 154.0 m is adopted

5/ high water surface level and EL. 169.20 m is adopted

(C) Surface slope stability

It may sometimes happen that a critical slip circle approaches to the surface of dam body in case the dam body has been constructed with cohesionless materials. In this case, safety factors for the slip of slope surfaces can be obtained by the following formula.

For upstream slope;

For downstream slope;

Where, S.F.; factor of safety

K ; seismic coefficient and adopted by 0.10

Table 4-2 RESULT OF STABILITY ANALYSIS ON DETENTION DAM

Case	Reservoir Condition	K 1/	Slope	Factor of Safety
1	After Completion F.W.S. 2/	0.10	Upstream	F.S=1.265
2	- do -	0.10	Downstream	F.S=1.239
3	After Completion M.W.S. 3/	0.10	Upstream	F.S=1.327
4	- do - L.W.S. 4/	0.10	- do -	F.S=1.551
5	- do - H.W.S. 5/	Nil	- do -	F.S=2.326
6	- do -	Nil	Downstream	F.S-1.820
7	Immediately After Completion, Empty	0.05	Upstream	F.S=2.090
8	- do -	0.05	Downstream	F.S=1.569
9	Rapid Drowdown F.W.S. to L.W.S.	0.05	Upstream	F.S=1.241

1/ Seismic coefficient, K=0.10 in normal case and K=0.05 or zero in special case

2/ full water surface level and EL. 163.90 m is adopted

3/ middle water surface level and EL. 159.0 m is adopted

4/ low water surface level and EL. 154.0 m is adopted

5/ high water surface level and EL. 169.20 m is adopted

(C) Surface Slope Stability

It may sometimes happen that a critical slip circle approaches to the surface of dam body in case the dam body has been constructed with cohesionless materials. In this case, safety factors for the slip of slope surfaces can be obtained by the following formula.

For upstream slope;

$$F.S. = \frac{\left(1 - K \frac{\gamma sat}{\gamma sub} \cdot \tan\alpha \right)}{K \cdot \frac{\gamma sat}{\gamma sub} + \tan\alpha} \times \tan\Phi$$

For downstream slope;

$$S.F. = \frac{1 - K \cdot \tan\alpha}{K + \tan\alpha} \times \tan\Phi$$

Where, S.F.; factor of safety

K ; seismic coefficient and adopted by 0.10

γ_{sat} ; saturated density of riprap material and adopted by 2.27 t/m^3 (refer to Table Z-1)

γ_{sab} ; submerged density of riprap material ($\gamma_{sab} = \gamma_{sat} - 1$) and adopted by 1.27 t/m^3

α ; tangential value of slope and adopted by 18°26' for upstream slope and 21°48' for downstream slope, respectively.

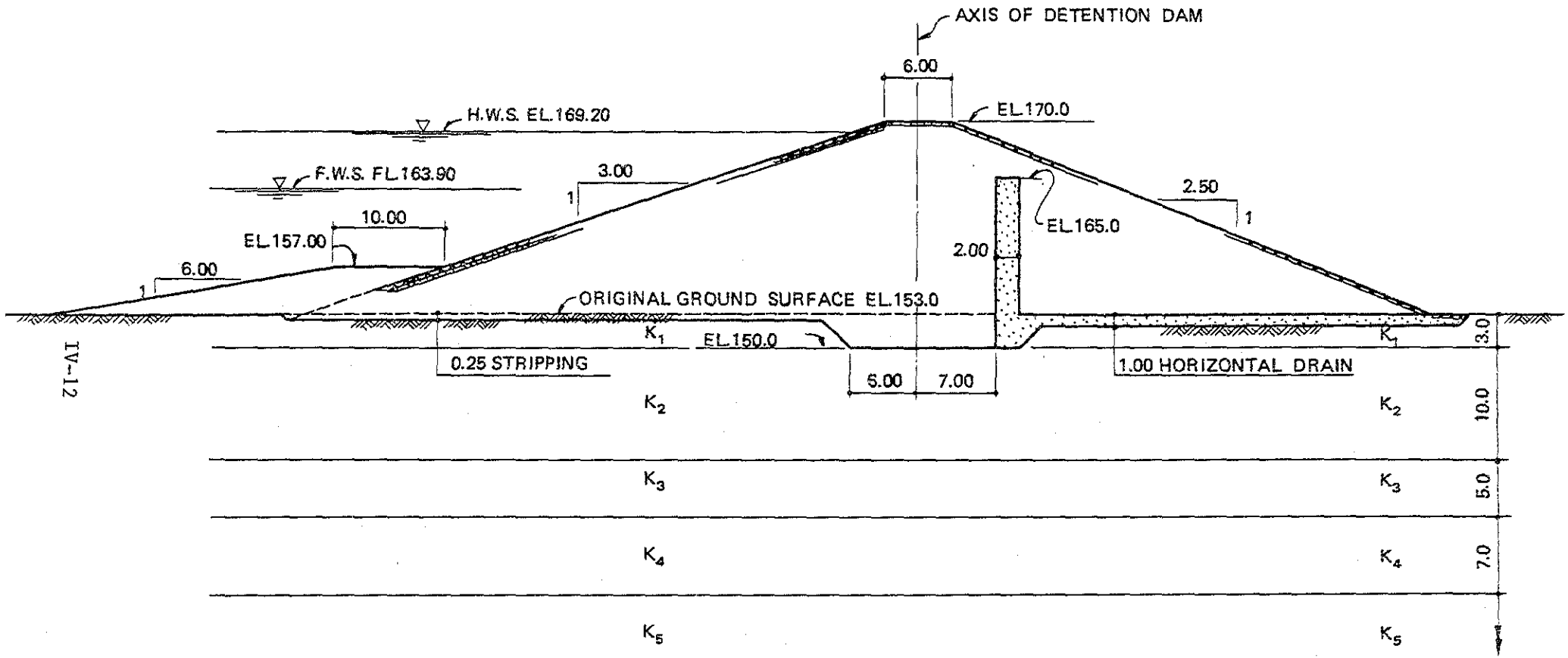
ϕ ; internal friction angle of riprap materials and adopted by 38°00' (refer to Table Z-1)

Safety factors for the surface sliding are 1.435 in upstream with slope of 1 on 3.00 and 1.500 in downstream with slope of 1 on 2.50. For the above calculation results, the values of safety factor are more than 1.20 of the allowable one, therefore, there is no problem for the sliding failure of surface slopes at the detention dam body.

4.2.3 Seepage Analysis

According to the result of geological investigations at the damsite, the foundation of the dam is unhomogeneous and the seepage condition varies from place to place. The foundation is composed of recent river deposits, terrace deposits and serpentine of the Cretaceous period in descending order. Permeability tests have been performed in the bore holes and the test pits, and permeability coefficnets at the foundation are classified into five groups, very low (less than 10 Lugeon) , low (10 to 50 Lugeon), moderate (50 to 100 Lugeon), high (100 to 250 Lugeon) and very high (more than 1000 Lugeon). Although the permeability coefficient varies according to places, they are considerably correlated with depths. The permeability coefficient is schematically assumed as shown in Fig. 4-2. The two-dimentional seepage analysis by Finite Element Method has been carried out on the representative cross section by using an electronic computer.

Fig. 4-2 EXEMPLARY MODEL OF PERMEABILITY FOR DETENTION DAM



K_1 : Very high (more than 1000 Lugeon), recent river deposits.
K_2 : High (100 to 250 Lugeon), middle terrace deposits.
K_3 : Moderate (50 to 100 Lugeon), middle and upper terrace deposits.
K_4 : Low (10 to 50 Lugeon), upper terrace deposits.
K_5 : Very low (less than 10 Lugeon, upper terrace deposits and serpentine.

The seepage analysis on hydraulic gradient, seepage velocity and seepage quantity has been made for the following 3 cases.

Case 1 ..... Base of trench EL. 152.5 m (in river deposit)
Case 2 ..... Base of trench EL. 150.0 m (on terrace deposit)
Case 3 ..... Base of trench EL. 147.5 m (in terrace deposit)

The permeability coefficients of the embankment and foundations used for the seepage analysis are assumed as follows:

Material		Permeability Coefficient		
Sand and gravel zone[1/]		$K = 5 \times 10^{-4}$	cm/sec,	50 Lugeon
Foundation, River Deposits, Very high[2/]		$K_1 = 1 \times 10^{-2}$	"	1,000 "
" Terrace Deposits,	High	$K_2 = 1.5 \times 10^{-3}$	"	150 "
" "	Moderate	$K_3 = 7.5 \times 10^{-4}$	"	75 "
" "	Low	$K_4 = 3.0 \times 10^{-4}$	"	30 "
" "	Very low	$K_5 = 1 \times 10^{-4}$	"	10 "

1/ This value is assumed based on the results of soil tests.

2/ These values are assumed based on the data of geologiccal investigations.

The effect of trench depth at the detention dam is shown in the following table.

Case	Trench Depth (m)	Max. Hydraulic Gradient	Max. Seepage Velocity (cm)	Leakage[1/] Discharge (m^3/day/m)
1	1.0	1.006	1.01×10^{-2}	23.972
2	3.0	0.574	3.54×10^{-3}	23.381
3	5.5	0.388	4.59×10^{-3}	23.754

The critical velosity has been calculated based on the Justin's formula.

From results of the seepage analysis, the maximum seepage velocity at the detention dam is 1.01×10^{-2} cm/sec and appears in the foundation around the trench base, and this value is less than the critical velocity of 8.75×10^{-2} cm/sec. Consequently, the foundation of detention dam has sufficient safety against the piping failure in view of the critical velocity.

The evaluation of piping failure is made based on the critical hydraulic gradient method which is derived from the potential gradient of flow lines. The critical hydraulic gradient is given as follows.

$$ic \leq \frac{Gs-1}{1+e} = 1.146 \qquad (Gs=2.81,\ e = 0.58)$$

From the seepage analysis for the different trench depth revealed, the design trench depth should be determined at EL. 150.0 m taking into account the permeability condition in the foundation and hydraulic gradient of the downstream side of the trench.

Judging from the effect of the hydraulic gradient in the embankment and the foundation, the dam body and the foundation are safe from the piping failure.

The seepage discahrge per unit length through the dam body and the foundation is estimated at full water reservoir condition. The total amount of seepage discharges is obtained by multiplying the unit seepage discharge by the equivalent dam length. The total amount of seepage through the dam body and the foundation is equal to 9,487 cu.m/day and 2,785 cu.m/day respectively.

4.2.4 Extra-banking

The settlement of the dam body at the fill dam is mainly caused by consolidation of the embankment materials. Since the detention dam is made of coarse material of sand and gravel, no consolidation would be expected after completion of the embankment. The final integrated

settlement by other factors such as water pressures, earthquakes, etc. is estimated by the following equation.

$$S = 0.001\ H^{3/2}$$

where S : Settlement of the dam body
H : Height of dam

The settlement after completion of the embankment is computed to be about 0.1 m from the above formula, and another 0.2 m is added to this value taking into consideration the possible settlement in the foundation. The total settlement amount is, therefore, fixed at 0.3 m corresponding to 1.5 percent of the dam height.

The height of extra-banking is determined at zero meter on both abutment and 0.3 m on river-bed portion, and the profile of dam crest forms a trapezoidal shape.

4.2.5 Filter and Riprap

a) Filter

In order to prevent the sand and gravel zone from washing out fine materials by the seepage water and to flow out the water in safety from the zone, an intercepter (vertical filter zone) is planned in the dam body and at the downstream side of the dam axis.

The filter materials should satisfy the relation of gradation between the intercepter and the sand and gravel zone as follows;

$$\frac{\text{15\% grain size of intercepter materials}}{\text{15\% grain size of sand and gravel materials}} > 5$$

$$\frac{\text{15\% grain size of intercepter materials}}{\text{85\% grain size of sand and gravel materials}} < 5$$

° It is desirable that the gradation curve of intercepter materials is approximately parallel to that of the sand and gravel.

° If materials of sand and gravel zone contain coarse materials, above two equations shall be applied to the materials under 25 mm size.

° Intercepter materials shall not be cohesive and does not contain more than 5 percent of materials finer than 0.074 mm.

° The maximum grain size of intercepter materials is to be 76 mm.

From the above definite relations, the intercepter zone (vertical filter zone) of the detention dam shall be composed of a gradation within the limitation as shown in Fig. 4-3.

(b) Riprap

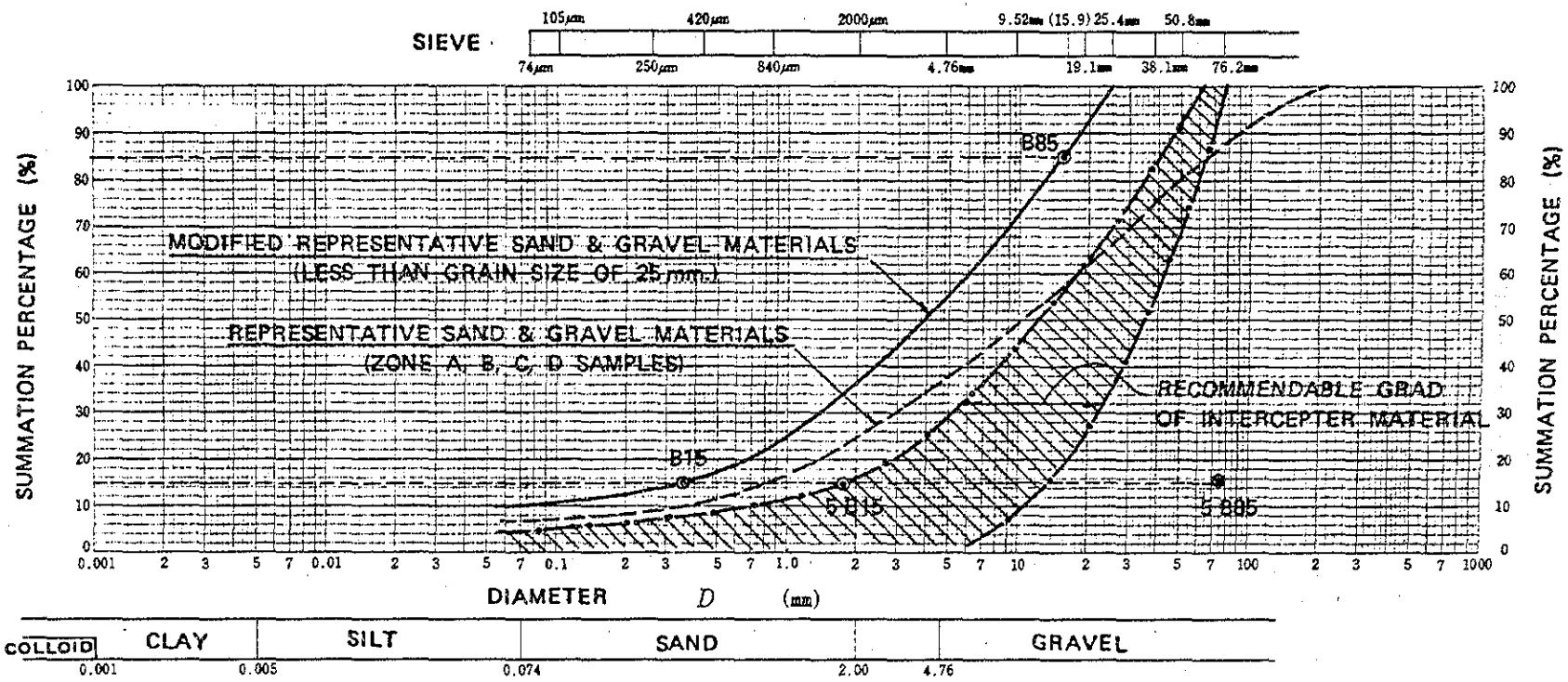
The embankment of sand and gravel materials on the upstream slope should be protected by the hand placed riprap against scoring by wave action. Materials for the riprap must be hard and sound having enough durability against weathering.

The required weight of a piece of the riprap is estimated at not less than 40 kg taking into account wave height, slope grade, unit weight and friction angle of the materials. The riprap layer of 0.45 m is planned according to the required weight.

4.2.6 Foundation Treatment

Since the aim of the detention dam is to recharge the groundwater of aquifer through infiltration of the water stored temporarily by the dam, there is no need to construct hydraulic barrier structure from a view point of the quantity of leakage discharge. However, the foundation treatment is required to secure the sufficient bearing

Fig. 4-3 GRADING DISTRIBUTION OF INTERCEPTER MATERIALS



capacity and to ensure the stability against the piping failure and liquifaction.

The excavation of dam foundation consists of two parts, one is for the whole dam body base and the other for the trench base along the dam axis. Judging from the deposit conditions at the dam foundation, the excavation depth for the dam body base is planned at 0.25 m on an average including the removal of objectional materials such as mud, organic materials, plants and roots. The trench along the dam axis shall be excavated up to 4.0 m on an average where the N value is expected more than 100. However, the excavation depth will vary from place to place according to the deposit condition.

Judging from the result of the seepage analysis, no grouting work is required against piping failure or liquifaction. The cut-off trench plays sufficient role of counter-measures against them.

4.3 Spillway

4.3.1 Type and Layout

An open type service spillway should be provided for the fill type dam from the view point that the dam body has no resistance against over-topping caused by unexpected large floods. Gates are not provided in order to avoid the possible danger caused by mis-operation of the gate.

As for the alignment of the service spillway, the site at terrace plain on the right bank is more advantageous than the left abutment because the topographical features are favourable in connection with existing wadi course.

As for the alignment of the emergency spillway, the small channel carved on the left bank will be utilized as a tailrace of the emergency spillway.

4.3.2 Design Flood Discharge

For the spillway design purpose, two flood discharges are defined. One is the design flood discharge of 4700 m^3/sec which is applied for the design discharge of the service spillway and the other is the maximum probable flood discharge of 7,800 m^3/sec with extremity of safety which corresponds to the discharge capacity of the service spillway and emergency spillway. The design flood discharge of the emergency spillway is 3,100 m^3/sec.

4.3.3 Service Spillway

(a) Hydraulic Dimension

The over-flow depth of the crest of the weir is determined at 5.3 m taking into consideration the dam crest elevation, the crest length of the weir and the total construction cost of the detention dam.

Under the condition of complete flows, the crest length of the weir has a close relation to a shape of the weir. The nappe shaped crest is employed in order to get a large discharge coefficient, and a discharge coefficient and crest length were obtained as follows:

$C = 2.091$

$L = 184.2$ m

The flow conditions at the chute and tailrace have been simulated by applying Bernoulli's Theorem setting the two control points at the center of the crest and the end of the gabion protection. Judging from Froude numbers, there is no difinite hydraulic jump occurring in the service spillway. However, the running water in the spillway has excessive energy to bring about erosion and scouring.

Although the service spillway is situated on the well consolidated terrace deposits, the sufficient resistivity is not expected against

erosion and scouring. The protection works with gabion are planned on the chute and tailrace.

(b) Structural Dimension

The safety of weir body against reversing, sliding and bearing capacity has been studied taking into consideration, dead weight, hydraulic pressure, earth pressure and uplift.

In order to simplify the stability calculation, a trapezoidal section is employed for the weir-body.

The thickness of the apron is estimated at 0.9 m based on the velocity and the unit flow quantity of the channel.

4.3.4 Emergency Spillway

This spillway is provided for the maximum possible flood with extremity of safety. This is also non-control open type spillway and the crest of the weir is set at 165.7 m which is 1.8 m higher than that of the service spillway. The service spillway discharges 940 m^3/sec corresponding to 1/5 of the design flood discharge with overflow depth of 1.8 m.

If the large flood comes to the reservoir, the water level rises above the full water surface and spillage begins at the service spillway. When the water level goes up higher than the crest of the emergency spillway, the spillage also takes place at the emergency spillway. The relation between the water level and the flood discharge capacity is shown in Fig. 4-4. The overflow depth of the emergency spillway at the maximum possible flood is 3.5 m. A board crested weir is employed for the overflow crest of the emergency spillway. The discharge coefficient and the crest length were obtained by Beresinski's formula as follows:

Discharge coefficient = 1.7014

Crest length = 278.2 m

In order to eliminate the submerged overflow condition at the weir, the bottom elevation of the downstream apron should be located at elevation of 163.2 m.

The flow condition at the chute and the tailrace has been simulated by applying Bernolli's Theorem setting two control points at the end of the weir crest and end of the tailrace. According to the Froude numbers, no definite hydraulic jump occurs in the emergency spillway except some turbulance and small rollers on the water surface at the end of the chute.

Since the emergency spillway is constructed on the terrace deposits which has no sufficient resistivity against erosion and scouring, protection works with gabion are planned on the chute and the tailrace.

The thickness of the apron at the end of the weir is estimated at 0.7 m based on the velocity and unit flow quantity.

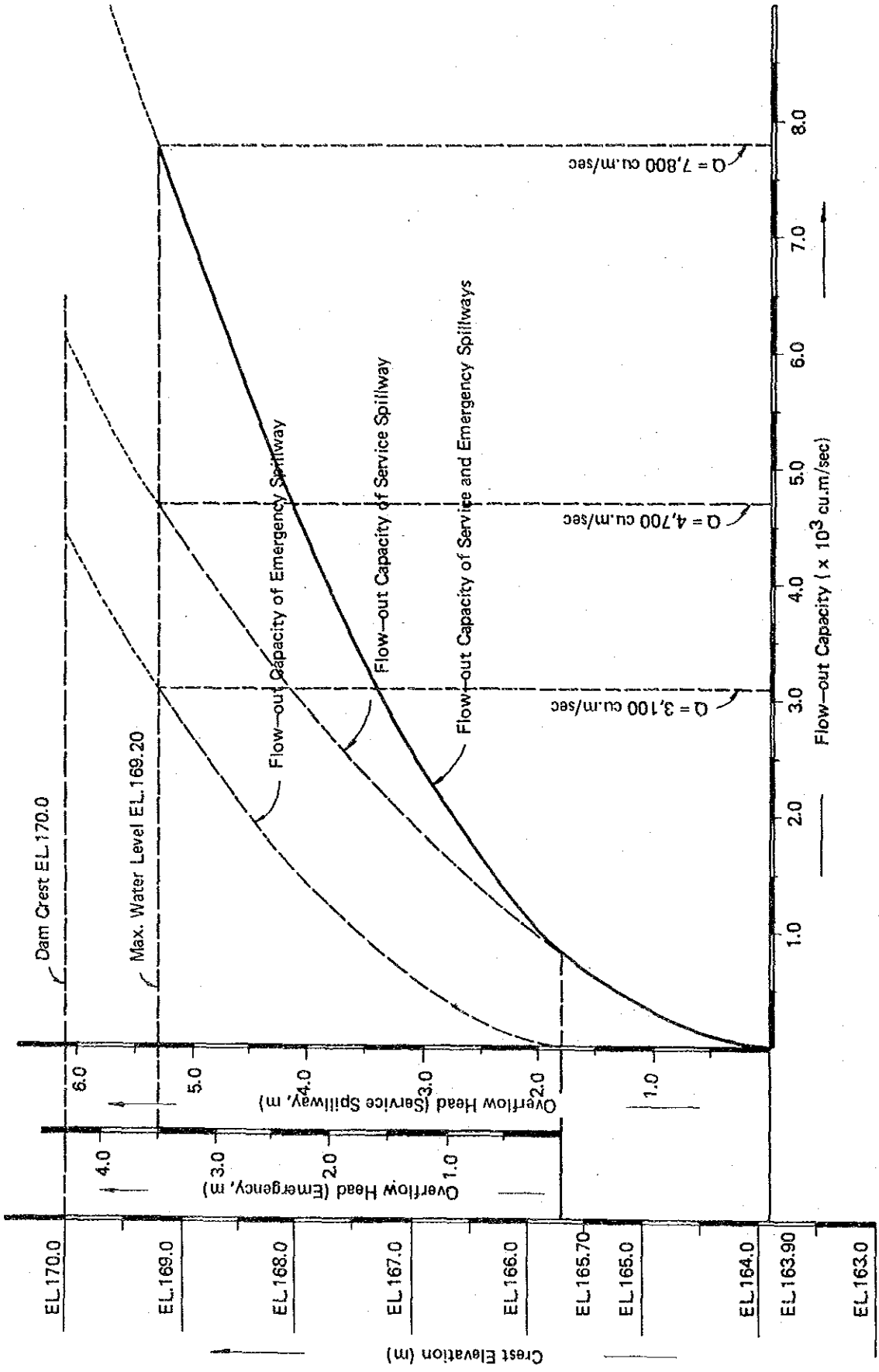
4.4 Outlet Facilities

4.4.1 Function and Design Discharge

The water stored temporarily in the detention dam will be released through the outlet facilities embedded beneath the dam body. The outlet facilities are composed of the service outlet and emergency one. Usually, the water is released from the service outlet. However, in case of an accidental blockage of the service outlet, the gate of the emergency outlet will be operated and the water will leased to downstream side.

According to the hydrological analysis, the optimal release rate of the water stored in the detention dam was estimated at 13.0 cum/sec

Fig. 4-4 FLOW-OUT CAPACITY OF SPILLWAY (SERVICE & EMERGENCY SPILLWAYS)



through the service outlet taking into account the infiltration potential in downstream wadi course of the detention dam. Consequently, the released rate of 13.0 cum/sec in maximum is employed as the design discharge of the service outlet.

4.4.2 Service Outlet

The service outlet will be embedded at the bottom of the dam body at the lowest portion of the river bed in order to extrude the stored water from the reservoir area. Otherwise, standing water might breed mosquitoes which is a medium of malarial parasites.

A circular shape steel pipe conduit with inner diameter of 1,500 mm is planned and a trash rack is provided at the entrance of the outlet conduit in order to prevent the objectionable materials and stones flowing into the conduit.

The outer shape of the conduit is so designed as to eliminate development of cracks in the dam body caused by differential settlement. The cracks bring about leakages of storage water. It will induce piping phenomenon through the dam body and finally may result in collapse of the dam body.

In order to prevent the corrosion and abrasion on the inside surface of the conduit and to ensure the watertight function, a steel liner with inside diameter of 1.50 m is installed at the whole length of the conduit. And also, this steel liner has a function as the inner form for concrete placing.

The thickness of steel liner is employed at 6 mm without stiffeners.

4.4.3 Emergency Outlet

The emergency outlet will be embedded at the bottom of the dam body

at the left abutment in order to release the stored water through this outlet when the service outlet is blocked by unexpected accidents. A circular section provided with steel pipe of 1.50 m inside diameter is planned as the conveyance conduit equiped with trashrack and slide gate at the inlet and outlet portals of the conduit, respectively. The slide gate is usually closed, however in case of blockade at the service outlet, the gate will be operated manually.

The inlet sill is located at elevation of 158.0 m to keep the facilities free from the sediment trouble.

As the running water from the emergency outlet has energy to bring about erosion and scouring, protection works with wet masonry and gabion are planned at the tailrace.

The outer shape of the conduit is so designed as to eliminate the tensile stress in the reinforced concrete members and around the conduit based on the stress analysis by applying the finite element method.

In order to prevent the corrosion and abrasion on the inner surface of the conduit and to ensure the water-tight function, a steel liner with inside diameter of 1.50 m is installed at the whole length of the conduit. And also, this steel liner has a role as the inner form for the placing of concrete.

The minimum thickness of steel liner is employed at 6 mm under no stiffness condition.

4.5 Dispersion Facilities

In order to effectively utilize the excess flood discharge flowing out from the spillway, the dispersion facilities are planned to be provided at 3.3 km downstream of the detention dam site. The facilities consist of a gabion dike to dam up a stream with outlet conduit located

on the main water course and a connecting canal to divert the excess flood discharge to old reticulated tributaries isolated by small sand bank on the wadi course.

These old reticulated tributaries will be rejuvenated by the connecting the channel. The flood discharge diverted to the old channels will run down to every small tributaries through the connecting canal and the ground water recharge will be augmented by the percolation in the tributary wadi courses.

The discharge capacity of the connecting canal is estimated at 7.0 cum/sec based on the potential infiltration capacity. The principal dimensions of the connecting canal are as follows:

canal length	468.5 m
bottom slope	1/500
bottom width	12.5 m
intake water level	135.29 m

The crest elevation of the dispersion dike is set at 135.4 m with 3.7 m height. Three outlet conduits with inside diameter of 1.2 m are provided.

CHAPTER V MONITORING SYSTEM

5.1 Observation Facilities

Under the conception of the monitoring system aforementioned in Chapter III, 3-3, following facilities are prepared at the Project site.

5.1.1 Locations of the Facilities

1) Water Level Gauge

An additional water level gauge will be installed within the reservoir area and close to the dam body in order to measure direct inflow into the reservoir. In addition, two staff gauges will be set at both spillways to measure the discharges flown out from spillway..

2) Observation Well

In order to analyse the hydrograph and to evaluate the effect of the groundwater recharging brought by the Project, five(5) numbers of the observation well, in addition to existing wells, were planned in up/downstream of the detention dam. Moreover those wells will be used for the monitoring and sampling of the groundwater to control the sea water intrusion and for confirmation of chemical pollution of the groundwater by the copper mine.

3) Existing Facilities

Three (3) numbers of rain gauge, two (2) numbers of water level gauge and more than 15 numbers of observation well have been prepared at the feasibility stage. These facilities will also be advisable to be directly operated by the MAF.

5.1.2 Dimensions of the Facilities

Dimensions of the additional facilities are as follows:

1) Water Level Gauge

Height of tower	16 m
Diameter of twoer	ϕ = 500 mm
Automatic recorder	1 set

2) Observation Well (with automatic recorder)

No. of Well	Depth (m)	Diameter (mm)
NJ-1	40	100
-2	70	100
-3	70	100
-4	70	100
-5	20	100

5.2 Measurement

5.2.1 Water Level Gauge

The automatic water level gauge is available to measure throughout the year.

5.2.2 Observation Well

The purposes of the monitoring system are 1) monitoring the groundwater levels to evaluate the effect of recharge, 2) sampling groundwater for analysis to evaluate sea water intrusion and for confirmation of chemical pollustion.

1) Observation of Groundwater Table

Automatic recording water level gauges of one (1) month recorder have already installed at JA-1 to JA-4, and other 14 wells are measured manually with interval of one(1) time per month.

2) Observation of Groundwater Quality

i) Electric Conductivity

Wells for the observation of electric conductivity in each depth are as follows:

Nos. of well	11 wells
Monitoring interval	One time/month

ii) Wells for chemical analysis of the water are as follows:

Nos. of well	16 wells
Monitoring interval	One time/month

CHAPTER VI PROJECT IMPLEMENTATION

6.1 Implementation Mode

6.1.1 Project Implementation

Since the major works involved in the Wadi Jizzi Agricultural Development Project are the construction of a detention dam (including two spillways, two outlet conduits), dispersion facilities and monitoring facilities, the Directorate General of Water Resources and Irrigation (W.R.I), Ministry of Agriculture and Fisheries (MAF) will be the executing agency for the implementation of the Project. The Director General of W.R.I will appoint engineers of W.R.I who coordinates and cooperates with the Consultants for administrative affairs.

The Consultants who have prepared the detailed design of the Wadi Jizzi Agricultural Development Project shall conduct the supervisory works under the contract with the Government of Oman.

The Wadi Jizzi Project includes various kinds of civil works such as construction of dam, spillways, outlet conduits, and related structures. There are two ways in implementing such civil works; one is a force account basis and the other on contract basis. The construction of the Project has been planned to be undertaken on a contract basis, with due consideration of the present construction systems in the various fields such as petroleum, road and water resources in the Sultanate of Oman.

6.1.2 Implementation Schedule

The working spaces of the dam site are fairly limited due to construction method, i.e., construction in two halves, which inevitably restricts the number of machinery that can be operational at a time. Besides, as the total embankment volume of

the dam body is small, it is not recommendable to employ numerous machinery and to complete the work in a short period. The construction period of 17 months including preparation and taking over is scheduled in consideration of the embankment volume of the dam body and the excavation volume of two spillways.

As a total period of Project implementation, 3 years are planned from 1986 to 1988 (Oman fiscal years) as shown in Fig. 6-1. Within this period, 8 months for tendering and contracting, 2 months for preparation and one month for taking over of the construction site are included.

6.2 Management and Maintenance Plan

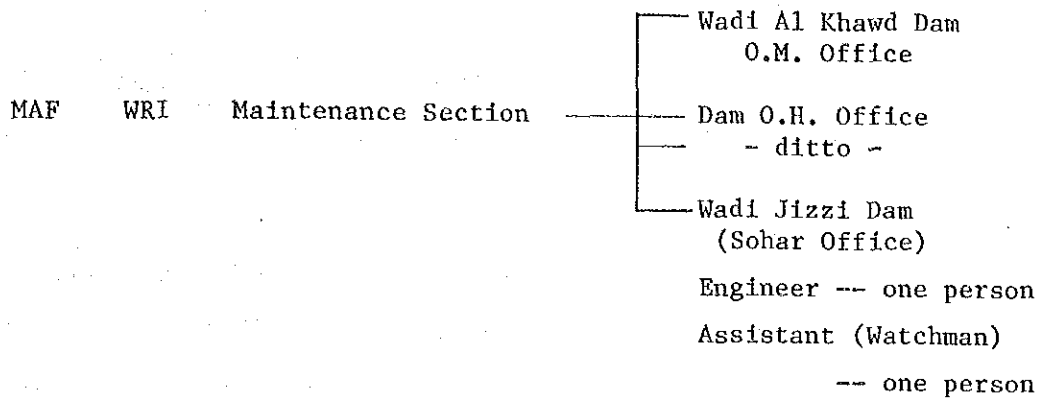
6.2.1 Management

Water management shall be executed under the responsibility of MAF.

6.2.2 Maintenance

A step had been taken by the Directorate General of Water Resources and Irrigation (WRI) to create a new section within the WRI in order to maintain all dams and flood protection facilities in the Sultanate of Oman.

This section will have senior and junior engineers and technical assistants responsible for such works. The Wadi Jizzi dam will be managed by this section including the new organization and one senior engineer and one assistant will be assigned to the regional office in Sohar.



6.2.3 Maintenance Cost

The maintenance office is charged with the control and maintenance of the facilities. The annual running cost is as below. The maintenance office will not be additionally established for the Wadi Jizzi dam, but the Sohar Office of W.R.I will be used for this purpose.

Maintenance Cost

Items	Cost (R.O)
1. Personnel	6,000
2. Operation of machinery	1,645
3. Administration	0
4. Maintenance of dam	16,055
5. Miscellaneous	1,300
Total	25,000

6.2.4 Maintenance of Wadi Jizzi Dam

I. Maintenance

a) Maintenance of Structures

1) Classification

Maintenance works are classified into 4 steps, namely, measurement, inspection, detailed investigation and repairing.

i) Measurement

This work can be made by the measurement of basic points set at both abutment and surface settlement and deformation points set at the dam crest.

ii) Inspection

The inspection is performed at field sites by comparison and study between field conditions and construction drawings.

iii) Detailed Investigation

If accidents were found at the structures, detailed investigations are made in order to rehabilitate to former conditions.

iv) Repairing

On the basis of the detailed investigations, required materials, equipment, budgets and period are prepared, and the accident portions are repaired to the original form using the said materials and equipment.

2) Basic Data to be utilized for the Maintenance

Among the data relating to plan, investigations, design and construction for the structures, the data to be utilized for the maintenance shall be pigeonholed.

Major data required to maintain the structures are as follows:

. A table of dimensions for the dam and related structures.
. Data for the dam foundation

. Data for hydrology and meteorology
. Plans and designs for the reservoir, dam body and structures,
. Construction drawings and data
. Other data, if necessary.

3) Record

Results of measurements, inspections and detailed investigations shall be recorded and stored in the working station.

i) Measurement Data

Data shall prepare by tables of graphes.

ii) Inspection Data

The results of inspection shall be recorded in detail and clearly, and attached drawings relating to this inspection, if necessary.

iii) Detailed Investigation

Data of detailed investigations shall involve objectives and reasons of the investigation and its result.

iv) Record of Maintenance and Necessary Treatments

The records of maintenance and necessary treatments are to be noted the data, objectives, methods and results of the treatment, and specifications, drawings, test data, pictures and required data explaining the details of these treatment are attached to the record.

b) Measurement

Measurement and inspections for behavior and conditions of the dam body and related structures shall be performed at regular intervals.

c) Inspection

Objectives of the inspection are to seize the existence of accidents for the dam body, its abutment, circumferential related structures.

1) Periodical Inspection

i) Dam Body

The change of leakage quantity, existence of muddy matter and new leaked places shall be checked.

ii) Concrete Structures

The existence of cracks for concrete structures is proposed, and if the crack was found on the concrete surface, it shall be cleared whether the crack is extending.

iii) Abutment and Circumferential Reservoir

Leakages from abutments cracks, slidings and collapses of slopes in the reservoir shall be checked.

iv) Outlet Structures

The leakage from gate frame shall be checked.

v) Spillway

Abrasion and erosion shall be checked for spillway structures.

d) Detailed Investigation

In case the detailed investigations are required from results of the measurement and inspection, the investigations are conducted and based on those data, required treatments shall be disposed.

1) Execution

The detailed investigations are conducted on the basis of the items determined by Engineers.

2) Amendment

During the investigations, the Engineers shall be held field conditions and if necessary, the investigation method shall be altered according to the field investigations.

e) Repair

The repair required shall be conducted by the design and construction methods determined on the basis of the analysis of detailed investigations.

II. Engineering Data

This chapter lists engineering data which should be collected from records of the Project including the feasibility study report. The list is intended to serve as a check list. Such a complication should also facilitate future inspections and investigations.

a) General Project Data

1) Regional Vicinity Map

The map showing the location of the dam, reservoir and downstream area are required.

2) Structure's Drawings

The drawings including plans, elevations and sections of the dam appurtnant structures.

3) Hydrology and Groundwater

- Catchment area and basin run-off
- Storage capacity in the reservoir
- Elevation of maximum design water level
- Dam height and freeboard
- Elevation of dam crest
- Elevation of crest, type, width, crest length and location of spillway
- Type, location, entrace and exist of outlet conduits

b) Foundation Data

Foundation data and geological features including logs of drilling, geological maps, profiles and cross sections and reports of the foundation investigation.

c) Material Data

Properties of embankment materials including the results of laboratory tests, field permeability tests, quality control tests.

d) Concrete Data

Concrete properties including the source and type of aggregates, cement used, mixing design data and results of testing during construction stages.

e) Construction History and Progressing

Construction history including pertinent sequence of the construction, construction problems, alternations, modifications and repairs.

III. INSPECTION ITEMS

This chapter provides a guidance for performing field inspections and may serve as the basis for developing a detailed checklist for the dam.

a) Concrete Structures

1) Surface

The conditions of concrete surfaces shall be examined to evaluate the deterioration and continuing service ability of the concrete.

2) Structural Cracking

Concrete structures shall be examined for structural cracking which may occur from overstress due to applied loads, shrinkage and temperative effects of differential movements.

3) Movement (Horizontal and Vertical)

Concrete structures shall be examined for evidence of any abnormal settlements, heaving, deflections, or lateral movements.

4) Connection

The conditions at the connection between structures and abutments or embankments shall be confirmed.

5) Water Passages

All water passages and other concrete surfaces which are subjected to running water shall be examined for erosions, cavitations, obstructions, leakages or significant structural cracks.

6) Construction Joints

All construction joints shall be examined to determine the condition of the joint and filler materials, any movement of joints, or any indication of distress or leakages.

7) Foundation

The foundation shall be examined for damages or possible undermining of the downstream toe.

8) Abutments

The abutments shall be examined for sign of instability or excessive weathering.

b) Embankment Structures

1) Settlement

The embankment and downstream toe areas shall be examined for any evidenced of localized or overall settlement, depressions on sink holes.

2) Slope Stability

Embankment slopes shall be examined for irregularities in alignment and variances from smooth uniform slopes, unusual changes from original crest alignment and elevation, evidence of movement at or beyond the toe, and surface cracks which indicate movement.

3) Slope Protection

The slope protection shall be examined for erosion-formed gullies and wave-formed notches and benches that have reduced the embankment cross-section or exposed less wave resistant materials. The adequacy of the slope protection against waves, currents, and surface run-off that may occur at the site shall be evaluated.

c) Spillway Structures

Examination shall be made for the structures and features including bulkheads and flashboards.

1) Approach and Outlet Channels

The approach and outlet channels shall be examined for any conditions which may impose constraints on the function of the spillway and present a potential hazard to the safety of the dam.

2) Stilling Basin

Stilling basins shall be examined for any conditions of the stilling basin to prevent downstream scour or erosion which may create or present a potential hazard to the safety of the dam.

d) Outlet Conduit

The outlet conduit examination shall include all structures and features designed to release reservoir water below the spillway crest through or around the dam.

1) Approach and Outlet Channel

The approach and outlet channels shall be examined for any

conditions which may impose constraints on the functioning of the discharge facilities of the outlet conduit, or present a hazard to the safety of the dam.

e) Sedimentation

The reservoir and drainage area shall be examined for excessive sedimentation or recent developments in the drainage basin which could cause a sudden increase in sediment load thereby reducing the reservoir capacity with attendant increase in maximum outflow and maximum pool elevation.

6.3 Consulting Services

6.3.1 Objectives

Objectives of the Consulting Services are to assist the Government in effective implementation of the Project. The Consulting Services are divided into following two stages:

1) Tendering and Evaluation of the Tender
2) Construction Supervision of the Project

6.3.2 Terms of Reference

The Consultants will provide a term to undertake the following consulting services:

1) To assist the tendering and evaluation of the tender
2) To supervise the construction and assist Omani engineers who coordinate the Consultant supervisors
3) To train local counterpart personnel in all phases of the project activities.

The detailed terms of reference are mentioned in 6-3-5.

6.3.3 Experts

1)	Project Engineer	17 months
2)	Civil Engineer	17 "
3)	Engineering Geologist	5 "
4)	Hydro-Geologist	6 "
5)	Soil Mechanical Engineer	15 "
6)	Tender Experts	3 "
	Total	63 "

6.3.4 Schedule of the Services

As shown in Figure 6-2, a schedule of the consulting services will be commenced in September 1986 in order to assist the tendering of the construction, and one person of the consultant staff (tender expert) will assist the governmental staff for the tendering. In April 1987, the consulting services of supervisions for the construction will be commenced and it will be continued by August 1988.

6.3.5 Terms of Reference for Consulting Services

I. Background Information

Introduction

Recognizing the need for the development of the groundwater in the Wadi Jizzi basin, about 220 km north-west of the Muscat capital area of Sultanate of Oman, Oman Government requested the Japanese Government for technical assistance in the study of the Wadi Jizzi Agricultural Development Project in February 1980. In response to the request, the Japanese International Cooperation Agency (JICA) sent a study team to the Sultanate of Oman to conduct the study with counterpart support from

the Ministry of Agriculture and Fisheries. Completed in March 1982, the study was able to demonstrate the technical and economical priority of the Project.

The detailed engineering design of project facilities started in March 1985 by JICA Detailed Design Survey Team. On the basis of the Detailed Design, the Government of Sultanate of Oman determined the implementation of the Project. The Project was proposed the construction of a detention dam across the Wadi Jizzi basin, a dispersion facilities and monitoring facilities.

Project Scheme

The Project has been formulated to strengthen groundwater by the detention dam and dispersion facilities, and using the strengthened groundwater, about 130 hectares of irrigable lands would be enable to produce year-round vegetable and fruits. Through this, farm income and generation of additional employment in the area will be expected.

The detention dam site is located at about 20 km southern part from Sohar. The dam will be constructed at the narrow ravine which will impound temporarily run-off water from catchment area of about 812 sq.km, with a total storage capacity of 5.4 MCM. It consists of fill type dam, two spillways and two outlet conduits. The dam requires an embankment volume of 0.7 million cu.m, a maximum height of 19 m. The spillways are service and emergency one, and the crest length is 184 m and 278 m respectively. The outlet conduits, of two lines (normal and emergency) of 1,500 mm steel pipe and related structures will be constructed at the dam base and a gate is installed at the tailrace of emergency outlet conduit.

A dispersion facility will be constructed at 3.3 km downstream from the dam axis and the facility consists of a gabion dike and open channel of about 243 meters and 496 meters respectively.

Monitoring facilities such as a water level gauge and five (5) numbers of observation well will be constructed at the reservoir area and Wadi basin.

The Project is estimated to cost about R.O. 8,097,000 and economic benefits to be derived is expected to reach R.O. 638,000 annually. The Project is scheduled to be implemented in about 17 months including mobilization and de-mobilization.

In order to strengthen local staff capabilities for carrying out construction techniques, selected project staff will receive training in abroad. The training program will be developed by the Executing Agency and the Consultant.

II. General Terms of Reference

The Agricultural Development will engage the Services of Consultants to ensure the successful implementation of the Wadi Jizzi Agricultural Development Project. The Consultant who have prepared the detailed Design will be hired as a term.

The Term shall be composed of;

1. Project Engineer
2. Civil Engineer
3. Engineering Geologist
4. Soil Mechanical Engineer
5. Hydro-geologist
6. Tender Expert
7. Specialist as required

Their services will be covered all activities concerning pre-qualification of tenders, tendering and evaluation of tenders, site supervision of construction works from the technical and financial

aspects, organize trainning programs both in Oman and Japan.

The qualification and specific duties and responsibilities will be according to the standard consulting service conditions of the Sultanate of Oman.

1. Project Engineer/Team Leader

With at least twenty (20) years of extensive experience in planning, design, and management and construction supervision. He shall undertake the following tasks:

1) To act as Team Leader who will coordinate and supervise the activities of team members in carrying out their assignment during the course of consulting services;

2) To ensure smooth and effective operation of the consulting services by maintaining good communication with the Government;

3) To coordinate the relating between the Government and the executing agency/ies for the project implementation;

4) To measure the quantities of earth, concrete stone and steel works;

5) To verify the progress claims and payment for the construction;

6) To prepare status reports required by the Government;

7) To inspect the work methods for Wadi Jizzi dam;

8) To confirm logistics and materials control;

9) To supervise the safety and security of works;

10) To prepare recommendations for corrective actions; and

11) To train counterpart personnel of the Government.

2. Civil Engineer

With minimum of fifteen (15) years' experience in construction supervision of dam and related facilities with adequate experience in construction management and quality control works. He shall perform the following duties;

1) To assist the Team Leader as acting Team Leader when he is absent from the site;

2) To assist the Team Leader for measuring the quantity of the earth, concrete, stone, and steel works;

3) To assist the Team Leader for preparation of status reports required by the Government;

4) To supervise the progress of the works;

5) To check survey data and batter boards on every structure, and

6) To undertake other tasks related to his field of experts and may be prescribed by the Government and/or the Team Leader.

3. Engineering Geologist

With extensive experience at least ten (10) years in conducting geological investigations. He shall undertake the following duties:

1) To review and evaluate all available data and reports relating to dam foundation and quarry site;

2) To analyse data and recommend method to Team Leader regarding dam and spillway foundation, and,

3) To undertake other tasks related to his field of expertise as may be prescribed by the Government and/or the Team Leader.

4. Soil Mechanical Engineer

With extensive experience at least ten (10) years in conducting soil mechanics investigations and soil tests. He shall undertake the following duties;

1) To review and evaluate all available data and reports relating to materials investigation, soil tests and make recommendations for additional surveys and/or investigations, if necessary;

2) To supervise the embankment test conducted at the dam site in order to confirm the embankment method such as thickness of spreading, numbers of roller's passes, quantity of water to be spreaded in the materials, etc.;

3) To assist the quality control of embankment of dam body conducted by the Contractor;

4) To analyze the test data of the quality control, and

5) To undertake other tasks related to his field of experts as may be prescribed by the Government and/or the Team Leader.

5. Hydro-geologist

With extensive experience at least ten (10) years in conducting hydrogeological investigations, planning and design of groundwater. He shall undertake the following duties:

1) To review and evaluate all available data and reports relating to groundwater;
2) To determine the locations of observation wells;
3) To supervise the drilling of the wells;

4) To assist the contractor in the pumping-up test for each well and analyze the data, and

5) To undertake other tasks related to his field of experts as may be prescribed by the Government and/or the Team Leader.

6. Tender specialist

With extensive experience at least ten (10) years in preparation of tender documents and evaluation of tenders. He shall undertake the following duties:

1) Evaluation of pre-qualification documents.

2) Support for preparation of tender documents.

3) Evaluation of tenders and recommendations of the best firm.

FIGURE 6-1 IMPLEMENTATION SCHEDULE

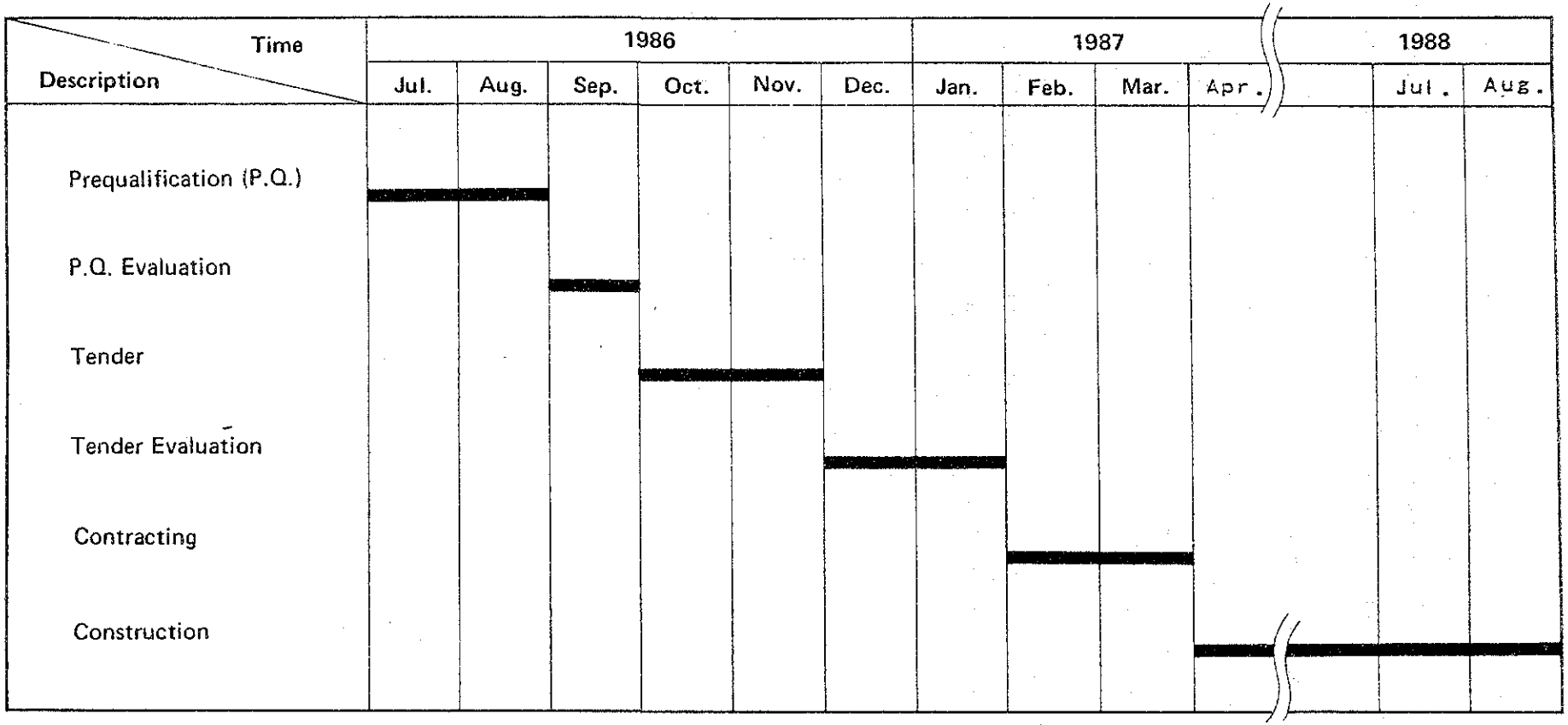
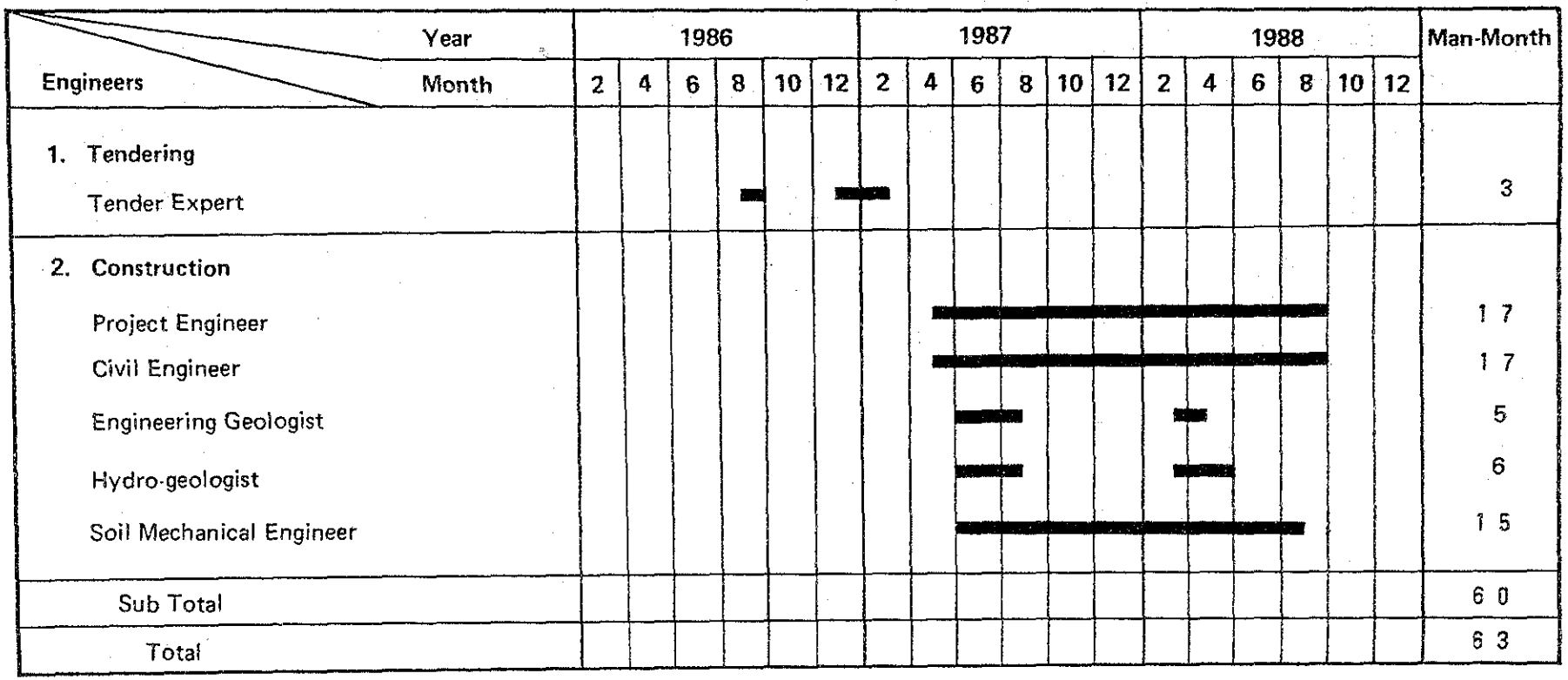


FIGURE 6-2. SCHEDULE OF CONSULTING SERVICES



CHAPTER VII TENDER DOCUMENTS AND SPECIFICATIONS

Tender documents are prepared for the tendering purpose. They are divided in two major categories, i.e., Prequalification documents and (main) Tender documents, which are further subdivided as follows:

1) Prequalification Documents

   a) Instructions to Applicants for Prequalification
   b) Prequalification Questionnaire
   c) Project Description
   d) Exhibits

2) Tender Documents

   a) Instructions to Tenderers
   b) Omani Standard Documents for Building and Civil Engineering Works, 3rd Edition
   c) Technical Specifications
   d) Bill of Quantities
   e) Schedule of Daywork Rates
   f) Construction Schedule
   g) Tender Drawings .

A short description of each of the above component documents is given below.

7.1 Prequalification Documents

In order to avoid confusion at the time of tender of so many unqualified tenderers applying for the award of Contract, it is advisable to prescreen the tenderers as to their technical capability, experience, financial soundness, reputation, etc. so that a limited competitive tender can be conducted thereafter among the prequalified tenders.

The Prequalification documents are prepared in a manner so that prospective tenderers may fill in the blanks of items to prove their eligibility for the tender.

a) Instructions to Applicants for Prequalification

These instructions indicate the requirements procedures and formalities of application for prequalification.

b) Prequalification Questionnaire

This questionnaire consists of 6 prescribed forms, a certificate and affidavits, where the applicants enter required information, according to which qualifications of the applicants are evaluated.

c) Project Description

A summary description of the various aspects of the Project is given, such as the location, geography, meteorology, hydrology, topography, geology, socio-economic conditions and the scope of work.

d) Exhibits

3 exhibits are included for visual illustration of the Project, i.e., project location, project map and general plan.

7.2 Tender Documents

Tender documents will be distributed to the prequalified tenderers for submission for tender. These documents will also form a part of the Contract documents after award of Contract.

a) Instructions to Tenderers

These instructions are intended to familiarize the tenderers with the conditions of tendering and to describe and specify the procedure of tendering, i.e., qualification of tenderers, formalities of tendering (place, date and form of submission), tender bond, method of payment, acceptance of tenders, award of contract, etc.

b) Omani Standard Documents for Building and Civil Engineering Works, third Edition, July 1981, prepared by Directorate General of Finance.

These Omani standard documents will be used in its entirety which comprise the following documents.

° Form of Tender
° Appendix to the Form of Tender
° Form of Agreement
° Appendices to Form of Agreement
° Standard Conditions of Contract
° Form of Tender Bond
° Form of Advance Payment Bond
° Form of Performance Bond

c) Technical Specifications

These specifications describe the general requirements and conditions for the construction works, detailed definition, scope and description of each item of the works, and requirements on the materials, equipment and machinery to be employed as well as the methods of measurement and payment.

d) Bill of Quantities (B.Q.)

The bill of quantities shows a list of work items with their units and quantities in which tenderers fill out the unit prices and the extended amounts, taking account of the provisions of the tender documents.

e) Schedule of Daywork Rates

This schedule is provided for the valuation and offer by the tenderer of the labour, materials and construction plant to be made available by the contractor at the work site which will be paid on a daywork basis pursuant to Clause 52(4) of the Standard Conditions of Contract.

f) Construction Schedule

Various categories of construction works are listed in this blank Schedule. The Tenderers are requested to fill in this Schedule by drawing bar chart to indicate the period and sequence of each work item.

g) Tender Drawings

Drawings issued along with the Tender Documents are to be considered as Tender Drawings which are given for contractors to make assessment of his construction methods, programme and cost of various items involved in the construction. Based on Contract Drawings, the Contractor will prepare shop drawings and submit to the Consultant for approval prior to actual construction works.

CHAPTER VIII CONSTRUCTION PLAN

8.1 Construction Method

The attached construction schedule itemized the construction works under the Wadi Jizzi Agricultural Development Project. The detailed descriptions for the construction works of the detention dam are hereinafter made.

The representative schedule was enumerated based upon the following items:

i) A working system of seven hours a day was employed for net equipment operation, excluding the check time for equipment before and after operation, and restriction times of the equipment are 8 hours. While the working hour for labours was determined at 8 hours based on the field conditions and work schedule.

ii) The construction schedule was planned based upon the output of equipment, and required construction equipment are tabulated in 8-2.

8.1.1. Staging of Detention Dam Construction

Since the river bed is almost dry throughout the year except the winter season in November to March and is fair wide about 700m, the construction of the detention dam in two stages by using the multiple-staged diversion system will be introduced.

In the first stage, the existing water course near the right bank will be utilized as temporary open water way with about 310 m wide, and the channel which consists of cut and bank cross-section having a capacity of 500-year probability flood discharge of about 1700 cu.m/sec.

8.1.2 Excavation Works

The river bed and both abutments contain objectional materials in their surface layers such as top-soil, loose rocks, debris, mud, plants and roots, therefore the surface layer of 0.25 meter deep in average will be removed prior to commencement of the dam embankment works. The top soil excavated will be utilized as embankment materials of a coffer dam.

For the trench along the dam axis, the excavation will be performed so as not to remain extremely irregular surface, very steep slope and weak and permeable zone, and the excavation depth of 4 meters in average is assumed. These excavation works will be carried out in a conventional way by backhoe shovels of 1.2 cu.m bucket, and these materials will be directly transported to the dam body in order to use as embankment materials.

Since there is no rock foundation around both spillway sites, major works of the spillway are to excavate sand and gravel and to place gabions. Equipment used for the excavation will be bulldozers, front end loaders and dump trucks, and excavated materials will be transported to a screening plant and spoil banks of No.1 and 2.

Excavation works for the conduits will be carried out at the dam foundation by a combination with backhoe shovels and bulldozers. No special measurement such as dewatering will be required in excavation works for the dam foundation because of deep groundwater table.

8.1.3 Embankment Works

The detention dam was designed at the dam type consisting of three zones, that is, semi-pervious, filter and stone zone. The semi-pervious zone is embanked by terrace deposits containing silt obtained from spillway sites. While, the filter zone is embanked by

river deposits not containing silt and clay. The stone zone is the riprap protecting the dam surface and it is constructed by cobbles collected from river bed of Wadi Jizzi basin.

The semi-pervious zone of the dam body will be constructed by following method. The materials will be spreaded with thickness of 0.3 meter by bulldozers and compacted with 6 times of 11 ton vibrating rollers. Since the spillway materials are to dry side compared with its optimum moisture content, water spreading works will be required to obtain the maximum density. Detailed construction method for the dam embankment will be determined by embankment tests.

The filter zone will be spreaded at 0.2 meter thick and compacted by 6 passes of vibrating compactors.

The riprap for up/downstream slope surface will be constructed by laying cobble stones and filter collected from the river basin.

8.1.4 Gabion Works

Two spillways, service and emergency spillway will be constructed at right bank for service one and left bank for emergency one respectively. The bottoms and slopes will be protected by steel wire gabions containing cobble stones excepting the crest and apron constructed by concrete and wet masonry. A size of the gabion is 2 meter long, one meter wide and 0.5 meter high.

8.1.5 Concrete Works

Concrete to be used for the structures of the Project will be specified into two kinds as follows;

Kind of Concrete	Standard of Proportion	
	Weight of Cement (kg/m)	Max. sized of Aggregate (mm)
Reinforced concrete	350	30
Plain concrete	250	30

As regard cement, portland cement will be used since it can be obtained in markets of the Oman. Aggregate materials will be collected from river deposits around the dam site. In order to remove silty materials and to obtain appropriate size of the aggregate, the river deposits will be washed and screened by an aggregate screening plant provided at the site.

The concrete will be mixed at the dam site by portable mixers with a capacity of 0.5 cu.m/batch, and the mixed concrete will be carried to respective job sites by front carriers of 1.0 cu.m bucket capacity, and placed by chuting gutter and/or manpowers.

8.1.6 Pipe Works

The outlet conduit consists of those for normal case and emergency case. The conduit will be made of 1,500 mm diameter steel liners, and the joint will be welded from in/out side carefully. The steel liner will be fixed by anchor bolts which have been embedded in the base concrete placed previously, and reinforced concrete will be placed in the trench so as not to remain voids under the liner.

8.1.7 Dispersion Facility

The dispersion facilities consist of a gabion dike to divert the water courses of the Wadi Jizzi and a connection channel to lead water released from the conduit to old water courses. At the bottom

of the dike, 3 lines of corrugated pipe with 1,200 mm inside diameter will be laid to let some flowing water to downstream wadi basin.

The connection channel will be excavated by backhoe shovels and the excavated materials will be transported to the dike to use as embankment materials.

8.1.8 Monitoring Facilities

1) Water Level Gauge

Works of the water level gauge are divided into fabrication of a steel tower and installation of the tower. The installation will be performed by excavation, concrete placing and gabions to protect a base of the gauge from scoring by floods.

2) Observation Well

Wells will be drilled by boring machines, and steel and PVC casing pipes are installed in the holes. After the civil work has been completed, pumping out tests will be conducted to investigate transmissibility and storage coefficient of the aquifer, and finally, water level gauges are installed at the top of the casing.

The wells of five (5) holes are constructed and total length of the wells are 270 meters with 100 mm inside diameters.

8.2 Construction Schedule

Civil works of the Project are divided into earth works including gabion and concrete works. The earth work consists of embankment of dam body using excavated materials from two spillways and river bed, excavation of spillways and excavation and embankment of dispersion facilities. While, concrete works will be for the spillway's crest and outlet conduits. Major construction equipment required for the said works are proposed as follows:

No.	Name of Machine	Specification
1	Bulldozer	18 ton class
2	- do -	21 " "
3	Backhoe shovel	0.6 cu.m "
4	- do -	1.2 " "
5	Front end loader	4 " "
6	Front carrier	1 " "
7	Dump truck	10 ton "
8	- do -	20 " "
9	Truck crane	15 " "
10	Vibrating roller (self propeller)	11 " "
11	Vibrating compactor	100 kg "
12	Motor grader	180 ps "
13	Water tank truck	10 ton "
14	Screening plant (concrete aggregate)	screen area 1.5m x 3.6m
15	- do - (embankment material)	" 4.0m x 8.0m
16	Generator	100 KVA
17	Portable batching plant with mixer	0.5 cu.m
18	Vibrator for concrete with engine	ϕ38 - 46 mm
19	Boring machines	150 m deep, ϕ250 mm bit
20	Miscellaneous	

It is economical and safe to execute the construction works of the dam by using the multiple-stage diversion system. The construction plan will be scheduled to start the works of the left bank in April, 1987, while keeping space of the right bank for flood way during the rainy season, whereas the right bank construction works of the dam will be commenced immediately from beginning of 1988 and completed by August 1988.

The excavation works of the spillway may be commenced concurrently the embankment works of the dam body in consideration of the direct haul of the materials excavated at the spillway site to the embankment place.

Since the outlet conduits are located at the bottom of the dam body, the conduit works will be completed prior to the embankment works of the dam body.

A proposed construction schedule of major works is as attached in Figure 8-1.

CONSTRUCTION SCHEDULE (Sheet 1/3)

	Description	Quantity	Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Remarks
1.	Mobilization, Demobilization and and Services	L.S.																					
2.	Dam Body																						
2-1	Clearing and Stripping	23,100 cu.m																					
2-2	Common Excavation	44,700 "																					
2-3	Dam Embankment	629,300 "																					
2-4	Filter (Vertical)	25,600 "																					
2-5	Filter (Horizontal)	5,400 "																					
2-6	Slope Surface Trimming	76,900 sq.m																					
2-7	Hand Placed Riprap	31,700 cu.m																					
2-8	Riprap Bedding	12,200 "																					
2-9	Gabion Constructed at Crest Shoulders	450 "																					
3.	Service Spillway																						
3-1	Clearing and Stripping	44,200 cu.m																					
3-2	Common Excavation	987,100 "																					
3-3	Reinforced Concrete	5,400 "																					
3-4	Reinforcing Bar	60.5ton																					
3-5	Dowel Bar	2.5 "																					
3-6	Plain Concrete	350 cu.m																					
3-7	Wet Masonry	850 "																					
3-8	Boulder Concrete	1,100 "																					
3-9	Gabion	26,000 "																					
3-10	Hand Placed Riprap	13,500 "																					
3-11	Embankment of Dike	37,800 "																					
3-12	Slope Surface Trimming	5,500 sq.m																					
3-13	Underdrain	150 cu.m																					
3-14	Geotextile Mat	55,400 sq.m																					
4.	Emergency Spillway																						
4-1	Clearing and Stripping	26,000 cu.m																					
4-2	Common Excavation	367,000 "																					
4-3	Plain Concrete	1,500 "																					
4-4	Wet Masonry	2,800 "																					
4-5	Gabion	14,800 "																					
4-6	Hand Placed Riprap	6,800 "																					
4-7	Dike Embankment	4,300 "																					
4-8	Slope Surface Trimming	700 sq.m																					
4-9	Underdrain	200 cu.m																					
4-10	Geotextile Mat	23,500 sq.m																					

CONSTRUCTION SCHEDULE (Sheet 2/3)

Description	Quantity	Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Remarks
5. Service Outlet Conduit																						
5-1 Common Excavation	5,000 cu.m																					
5-2 Backfill	800 "																					
5-3 Plain Concrete	200 "																					
5-4 Reinforced Concrete	750 "																					
5-5 Reinforcing Bar	22 ton																					
5-6 Steel Liner	114 m	Preparation																				
5-7 Trashrack	1.3ton		- ditto -																			
5-8 Perforated PVC Pipe	6 pcs																					
5-9 Wet Masonry	320 cu.m																					
5-10 Hand Placed Riprap	180 "																					
5-11 Debris Deflector	1 set																					
6. Emergency Outlet Conduit																						
6-1 Common Excavation	4,400 cu.m																					
6-2 Backfill	1,700 "																					
6-3 Plain Concrete	200 "																					
6-4 Reinforced Concrete	500 "																					
6-5 Reinforcing Bar	12 ton				Preparation																	
6-6 Steel Liner	66 m																					
6-7 Trashrack	1.6ton																					
6-8 Steel Gate	1 set				- ditto -																	
6-9 Wet Masonry	350 cu.m																					
6-10 Debris Deflector	1 set																					
7. Dispersion Facilities																						
7-1 Clearing and Stripping	1,300 cu.m																					
7-2 Common Excavation	10,300 "																					
7-3 Sand Bed	30 "																					
7-4 Corrugated Steel Pipe	24 pcs																					
7-5 Dike Embankment	4,200 cu.m																					
7-6 Gabion	1,400 "																					
7-7 Hand Placed Riprap	1,200 "																					
7-8 Wet Masonry	40 "																					
7-9 Slope Surface Trimming	3,900 sq.m																					
7-10 Geotextile Mat	4,800 "																					
7-11 Debris Deflector	1 set																					

CONSTRUCTION SCHEDULE (Sheet 3/3)

Description	Quantity	Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Remarks
8. Water Level Gauge	1 set								----	----	----	----	----	----	----	----						
9. Observation Well	5 wells									———	———	———	———	———	———	———						
10. Relocation Road	5 km						———	———														
11. Protection of Historical Facility																						
11-1 Clearing & Stripping	1,400 cu.m				———	———																
11-2 Dike Embankment	2,400 "					———	———	———														
11-3 Hand Placed Riprap	700 "							———	———													
11-4 Slope Surface Trimming	2,300 sq.m						———	———														
12. Diversion Facilities																						
12-1 Clearing and Stripping	5,100 cu.m	———	———																			
12-2 Common Excavation	66,600 "		———	———	———																	
12-3 Embankment	32,200 "		———	———	———																	
12-4 Hand Placed Riprap	750 "			———	———																	
12-5 Slope Surface Trimming	2,500 sq.m		———	———																		

CHAPTER IX PROJECT COST

9.1 Construction Costs

Basic costs of labours, materials and constrution machineries were determined taking into account of the costs used for similar projects which are being carried out by the Government in the Oman.

9.1.1 Components of the Construction Cost

Components of the construction cost are as follows:

1) Mobilization and Re-mobilization

Site office, access road, surveying, working signs, commemoration plaque and other related works.

2) Dam Body

Excavation, screening, embankment, slope protection, etc.

3) Spillways (service and emergency)

Excavation, embankment, concrete, gabion, wet masonry, riprap, geotexicle mat, etc.

4) Outlet Conduits (service and emergency)

Excavation, concrete, steel liner and its installation, gabion, deflector, geotexicle mat, etc.

5) Dispersion Facility

Gabion dike, concrete pipe and its embedded, connection channel, deflector, etc.

6) Associated Facilities

Relocation road .....excavation, etc.

Protection of historical facility ... embankment, riprap, etc.

7) Monitoring Facilities

Water level gauge ..... steel tower, excavation, concrete, etc.

Observation wells ..... drilling, installation of casing, etc.

8) Diversion Facilities

Excavation, embankment, riprap, etc.

9) Maintenance Cost of Facilities

Maintenance costs of facilities by the contractor during contractor's guarantee period.

9.1.2 Daywork Rates for Labours and Material Costs

As regards labour wages and costs of construction materials, following figures are applied in this study.

Description	Unit	Rate R.O
Labour		
Foreman	hour	2.20
Skilled labour	"	1.38
Unskilled labour	"	0.87
Operator (heavy)	"	2.20
" (light)	"	1.38
Iron worker, Mason	"	1.68
Materials		
Cement	ton	25.00
Reinforcing bar	"	110.000
Gabion cage (2.0 x 1.0 x 0.5m)	1 No	5.200
Diesel fuel	liter	0.135

9.2 Associated Cost

Since the detention dam and related facilities are constructed in the river basin of Wadi Jizzi and state lands, no purchase or compensation are required. However, a local road is passing from the left bank to right bank of Wadi Jizzi, and this road is submerged by impounded water of the detention dam. Therefore, a relocation road is required and it will be constructed at upstream of the reservoir and at the location where the road is not submerged even if the reservoir is filled with flood water. Moreover, in order to protect an old historical facility from the inundation by the impounded water, a dike embanked by sand and gravel will be constructed at the front of the facility.

9.3 Project Cost

9.3.1 Civil Works

The total cost of civil works including all components of the construction cost mentioned in 9.1.2 was estimated at R.O 7,050,058 (US$20,614,000).

9.3.2 Compensation

There are a little date palm trees and two temporary houses in the river land and they are submerged by the impounded water. Therefore, those trees and houses will be compensated by the MAF and required compensative expenses will be included in the Project cost. The proposed expense was estimated at R.O. 15,000 (US$43,900).

9.3.3 Consulting Services

As mentioned in 6.3.4 "Schedule of the Services", total man-months of the consulting services were estimated at 63 man-months and the cost is R.O. 326,000 (US$953,000). (The conversion rate between R.O and Japanese yen is one per 730.) Details of the cost are as follows:

Description	Amount
. Remuneration	R.O 211,741
. Perdiem	26,040
. Trip	12,200
. Accommodation	32,000
. Equipment	4,000
. Labour	8,500
. Vehicles	2,000
Sub-total	296,481
. Miscellaneous	29,519
Total	326,000

9.3.4 Contingency

Contingencies are included in the total base to allow for minor differences in actual and estimate quantities, unforeseeable difficulties in construction, possible changes in the plan because of site conditions or uncertainties regarding the foundation. The percentage of contingencies adopted for the civil work is 10 percent.

9.3.5 Project Cost

The project cost, allowing for the physical contingency was estimated at R.O 8,097,000 (US$23,676,000).

Table 9-1 shows the breakdown of the project cost for major items, and annual disbursement schedule for the investment cost is as follows:

Year	Cost (RO)
1986	22,820
1987	4,539,520
1988	3,534,660
Total	8,097,000

TABLE 9-1. PROJECT COST

(Unit: R.O.)

Items	Costs
I. Civil Works	
1-1 Mobilization, Re-mobilization and Services	290,000
1-2 Main Works	
1) Dam Body	1,869,773
2) Service Spillway	3,153,277
3) Emergency Spillway	1,239,905
4) Service Outlet Conduit	124,931
5) Emergency Outlet Conduit	93,178
6) Dispersion Facility	64,672
Sub-total	6,545,736
1-3 Monitoring Facilities	
1) Water Level Gauge	8,041
2) Observation Well	31,668
Sub-total	39,709
1-4 Associated Facilities	
1) Relocation Road	9,264
2) Protection of Historical Facility	18,334
Sub-total	27,598
1-5 Diversion Facility	139,975
1-6 Maintenance Costs of Structures	7,040
TOTAL	7,050,058
II. Compensation	15,000
III. Consulting Services	326,000
GRAND TOTAL	7,391,058
IV. Physical Contingency	705,942
TOTAL of I to IV	8,097,000

TABLE 9-2. DISBURSEMENT SCHEDULE

(unit: R.O)

Item	Total	1986	1987	1988
1. Mobirization, Re-mobilization & Services	290,000	-	232,000	58,000
2. Main Works	6,545,736	-	3,600,155	2,945,581
3. Monitoring Facilities	39,709	-	-	39,709
4. Associated Facilities	27,598	-	-	27,598
5. Diversion Facilities	139,975	-	139,975	-
6. Maintenance Costs of Structures	7,040	-	-	7,040
Sub total	7,050,058	-	3,972,130	3,077,928
7. Compensation	15,000	15,000	-	-
8. Consulting Services	326,000	7,820	170,180	148,000
Total	7,391,058	22,820	4,142,310	3,225,928
9. Physical Contingency	705,942	-	397,210	308,732
Grand Total	8,097,000	22,820	4,539,520	3,534,660

CHAPTER X. PROJECT EVALUATION

10.1. Economic Evaluation

10.1.1. Economist Cost

1) Agricultural Materials

All prices have been estimated based on the collected informations and data obtained up to June 1985. For estimating present and future prices of agricultural materials such as urea, muriate of potash and triple super phosphate, "Price Prospects for Major Primary Commodities" published by IBRD, January 1985 has been used (for detail, refer to Tables F-16 to F-20 in Annex F).

Fertilizers

	1985		1995	
	Financial	Economic	Financial	Economic
Urea (RO/ton)	110	109.5	141	140.5
TSP (")	100	99.5	112	111.5
Muriate of Potash (")	94	93.6	102	101.5
N (RO/kg)	0.27	0.24	0.32	0.31
P (")	0.25	0.25	0.28	0.28
K (")	0.16	0.16	0.17	0.17

2) Agricultural Products

As for the agricultural products such as vegetables and fruits, farm-gate prices collected in the farm management survey conducted in June 1985 was used. These financial farm-gate prices are converted into economic ones by applying a standard conversion factor for economic evaluation (for detail, refer to Table F-15 in Annex F).

Farm-gate Price of Crops

(Unit: RO/ton)

Crops	Financial	Economic
Onion	300	295
Tomato	250	246
Watermelon	250	246
Cabbage	250	246
Eggplant	200	197
Red Pepper	300	295
Dates	200	197
Lime	650	641
Banana	250	246
Alfalfa	70	69
Cauliflower	300	295

3) Standard Conversion Factor (SCF)

The standard conversion factor is calculated based on the statistics on foreign trade value recorded on Statistical Year Book, 1983. As the result of calculation, the standard conversion factor was estimated at 0.986 (refer to Table F-14 in Annex F).

4) Economic Project Cost

a) Initial Cost

By deducting a price contingency from the estimated financial initial cost and by applying the standard convesion factor mentioned before for the local currency portion, the economic initial cost can be estimated.

Table 10-1 shows the summary of economic initial costs. 7,968,850 RO is estimated as economic initial cost.

b) Operation and Maintenance Cost (O & M Cost)

By applying the same method as initial cost mentioned above, the economic cost for operation and maintenance of the project facilities can be estimated. Annually 25,000 RO will be needed for the economic operation and maintenance (O & M) cost after full development of the project.

Table 10-1 Economic Initial Cost

(Unit: R.O.)

	Item	Total	1986	1987	1988
I	Civil Works				
	1. Mobirization, Re-mobilization and Services	285,940	-	228,752	57,188
	2. Main Works	6,454,096	-	3,549,753	2,904,343
	3. Monitoring Facilities	39,152	-	-	39,152
	4. Facilities	27,211	-	-	27,211
	5. Diversion Facilities	138,015	-	138,015	-
	6. Others	6,941	-	-	6,941
	Sub total	6,951,355	-	3,916,520	3,034,835
II	Compensation				
III	Consulting Services	321,436	7,710	167,797	145,929
	Total	7,272,791	7,710	4,084,317	3,180,764
III	Physical Contingency	696,059	-	391,643	304,416
	Grand Total	7,968,850	7,710	4,475,960	3,485,180

Note: Economic initial costs are estimated by using following method:

Initial cost = project cost x 0.986[1/]

1/: Standard conversion factor (refer to Table F-14 in Annex F)

10.1.2. Economic Benefit

1) Components of the Project Benefits

a) Incremental Agricultural Benefit

By constructing detention dam, 3.47 MCM of groundwater could be recharged. Out of them 1.39 MCM will be available for future agricultural use. These recharged groundwater will make it possible to extend cultivable land, resulting in increase of agricultural production.

According to the estimation, 130 ha could be cultivated by 1.39 MCM of groundwater and 4,677 tons of vegetables, fruits and fodder crop would be produced after the full development of the project. These are computed as an incremental agricultural benefit.

Net production value (NPV) of the agricultural products can be accounted by deducting production cost (PC) from Gross Production Value (GPV) (for detail, refer to Table F-27 in Annex F).

The amount of net production value after the full development of the project is estimated at 638,000 RO.

Net Production Value/ha

(Unit: RO/ha)

Crops	GPV	PC	NPV	Cropped Area (ha)	Incremental NPV (1,000 RO)
Lime	12,820	2,360	10,460	39	407
Banana	3,198	2,529	669	19	13
Tomato	9,840	3,066	6,774	9	61
Cabbage	6,150	2,415	3,735	9	34
Watermelon					
(Winter)	3,690	2,005	1,685	9	15
(Summer)	2,460	2,111	349	9	3
Eggplant	4,925	2,674	2,251	11	25
Red Pepper	4,425	2,184	2,241	11	25
Alfalfa	4,140	2,740	1,400	40	55
Total				156	638

Note: Cropped area: 130 ha x 120 % = 156 ha

b) Benefit of Flood Damage Prevention

In the project area, flood have caused mostly one time in a year. The flood flow down the Wadi and discharge into the sea. On the way to the sea, the flood have caused damages such as following to the area :

- Social and economic damages with cut-off the traffic at the Irish-crossing point on the national road
- Vegetables cropped along the national road and seaside area are inundated
- Damage of the passenger's cars
- Inundation in the residence area by overflowing river dike occurred at high tide
- Destroy and erosion of the sandy levees surrounding farm lands along the wadi.

By the construction of the proposed detention dam, the damages by the flood of precipitation below the five year probability would be controlled.

Of the items mentioned above, damages of vegetables, farm ridges and wadi bank were estimated in monetary terms.

The amount of flood damages was estimated base on the damages given by flood caused on February 12 to 14 in 1982, amounting to 35,000 RO annually taking into consideration the flood frequency of once for five years.

c) Benefit by Prevention of Sea Water Intrusion

Recently sea water intrusion into the aquifers has been caused by overdrafting of the groundwater in the coastal strip. Therefore, some existing cultivated areas mainly for date palms have suffered from the high salinity in irrigation water.

According to Figure B-7 in Annex B shown as Iso-EC Contour Line which is made based on groundwater quality survey, date palms area along the coast irrigated by groundwater with 1,000 ppm EC is measured about 300 ha and similarly 800 ha located inland area are irrigated by 700 to 1,000 ppm EC, respectively.

Since the groundwater could be recharged by constructing of detention dam, sea water intrusion into the aquifers would be deducted and resulted in increased production of dates. The amount of incremental production of dates is estimated at 44,000 RO annually (for detail, refer to Table F-28 in Annex F).

d) Water Supply Benefit

There are two water supply projects in relation to the Project area. One is the Sohar Copper Mining Development Project and the other is the Sohar Water Supply Plan. Water sources of these two projects, amounting 1.06 MCM, are scheduled to use groundwater of the Wadi Jizzi basin. Of the two projects, 0.2 MCM of water supply in the Sohar Urban Development Plan has already begun at the beginning of 1984. Water requirement of the Sohar Copper Mining Development Project and Sohar Water Supply Plan is 0.31 MCM and 0.75 MCM respectively.

The proposed detention dam is projected taking into account water requirement for the aforesaid two water supply projects. Therefore, the groundwater recharged by the dam is

considered contributing to successful development of the two water supply projects.

In case of without project, the groundwater table would be declined heavily with increased utilization of groundwater for these two projects and be resulted in salt and drought damages for crops as well as an increase of irrigation cost because of the provision of deeper tube wells for pumping up the groundwater.

Since these damages as mentioned above could not estimate readily in monetary terms, the marginal cost of water was used for computing the water supply benefit to be created from 1.06 MCM of groundwater recharged.

For estimating marginal cost per cubic meter, water cost of the existing Ghubrah Desalination Plant was used. Available data on the variable cost are quoted from the Feasibility Report on the Wadi Al Khawd and additionally Ministry of Electricity and Water gave a useful information on the same item.

According to the aforesaid reports and informations, variable cost per cubic meter is 440 Baiza and 503 Baiza, respectively. The former cost of 440 Baiza was adopted for evaluation in considering it more reasonable than the latter 503 Baiza.

The fixed cost consists of depreciation cost and interest. The capital cost per cubic meter is estimated at 1.0 RO on the basis of the construction cost of the Ghubrah extension desalination plant. The annual fixed cost per cubic meter is calculated at 117 Baiza assuming the interest rate of 10 percent and the durable life of the facilities of 20 years.

Therefore, the total water cost is computed by 557 Baiza based on the variable cost of 440 Baiza per cubic meter (for detail, refer to Tables F-29 to F-31 in Annex F).

Consequently, the water supply benefit is estimated at 590,420 RO.

e) Total Economic Benefit

Annual benefit of respective sectors are summarized as follows:

Sectors	Annual Benefit (RO)
Agriculture	638,000
Prevention of Flood Damages	35,000
Prevention of Sea Water Intrusion	44,000
Water Supply	590,000
Total	1,307,000

10.1.3. Economic Internal Rate of Return

On the basis of the estimated economic cost and return, streams of them and net benefit are computed for 50 years of the evaluation period, and then present worth values of the incremental net benefit are computed by discounting these streams with discount rates.

Table 10-2 shows the streams of cost and benefit and project return at respective discount rate. As the result of calculation, the economic internal rate of return (EIRR) can be estimated at 12.2 percent.

(In case the 30 years of the evaluation period, the EIRR can be estimated at 11.7 percent.)

TABLE 10-2 PROJECT ECONOMIC COST AND RETURN

(UNIT : THOUSAND R.O.)

YEAR	PROJECT COST			INCREMENTAL BENEFITS	PROJECT RETURN	PRESENT WORTH VALUE	
	CAPITAL	O & M	TOTAL (1)	(2)	(3) =(2)-(1)	(3)*DISCOUNT RATE (12 %)	(13 %)
1 1986	8.00	0.0	8.00	0.0	-8.00	-8.00	-8.00
2 1987	4476.00	0.0	4476.00	0.0	-4476.00	-3996.43	-3961.06
3 1988	3485.00	0.0	3485.00	0.0	-3485.00	-2778.22	-2729.27
4 1989	0.0	25.00	25.00	733.00	708.00	503.94	490.68
5 1990	0.0	25.00	25.00	862.00	837.00	531.93	513.35
6 1991	0.0	25.00	25.00	932.00	907.00	514.66	492.29
7 1992	0.0	25.00	25.00	984.00	959.00	485.86	460.63
8 1993	0.0	25.00	25.00	984.00	959.00	433.80	407.64
9 1994	0.0	25.00	25.00	1102.00	1077.00	434.98	405.13
10 1995	0.0	25.00	25.00	1102.00	1077.00	388.38	358.52
11 1996	0.0	25.00	25.00	1102.00	1077.00	346.77	317.28
12 1997	0.0	25.00	25.00	1102.00	1077.00	309.61	280.77
13 1998	0.0	25.00	25.00	1102.00	1077.00	276.44	248.47
14 1999	0.0	25.00	25.00	1307.00	1282.00	293.80	261.74
15 2000	0.0	25.00	25.00	1307.00	1282.00	262.32	231.63
16 2001	0.0	25.00	25.00	1307.00	1282.00	234.22	204.98
17 2002	0.0	25.00	25.00	1307.00	1282.00	209.12	181.40
18 2003	0.0	25.00	25.00	1307.00	1282.00	186.72	160.53
19 2004	0.0	25.00	25.00	1307.00	1282.00	166.71	142.06
20 2005	0.0	25.00	25.00	1307.00	1282.00	148.85	125.72
21 2006	0.0	25.00	25.00	1307.00	1282.00	132.90	111.26
22 2007	0.0	25.00	25.00	1307.00	1282.00	118.66	98.46
23 2008	0.0	25.00	25.00	1307.00	1282.00	105.95	87.13
24 2009	0.0	25.00	25.00	1307.00	1282.00	94.60	77.11
25 2010	0.0	25.00	25.00	1307.00	1282.00	84.46	68.24
26 2011	0.0	25.00	25.00	1307.00	1282.00	75.41	60.39
27 2012	0.0	25.00	25.00	1307.00	1282.00	67.33	53.44
28 2013	0.0	25.00	25.00	1307.00	1282.00	60.12	47.29
29 2014	0.0	25.00	25.00	1307.00	1282.00	53.68	41.85
30 2015	0.0	25.00	25.00	1307.00	1282.00	47.93	37.04
31 2016	0.0	25.00	25.00	1307.00	1282.00	42.79	32.78
32 2017	0.0	25.00	25.00	1307.00	1282.00	38.21	29.00
33 2018	0.0	25.00	25.00	1307.00	1282.00	34.11	25.67
34 2019	0.0	25.00	25.00	1307.00	1282.00	30.46	22.72
35 2020	0.0	25.00	25.00	1307.00	1282.00	27.19	20.10
36 2021	0.0	25.00	25.00	1307.00	1282.00	24.28	17.79
37 2022	0.0	25.00	25.00	1307.00	1282.00	21.68	15.74
38 2023	0.0	25.00	25.00	1307.00	1282.00	19.36	13.93
39 2024	0.0	25.00	25.00	1307.00	1282.00	17.28	12.33
40 2025	0.0	25.00	25.00	1307.00	1282.00	15.43	10.91
41 2026	0.0	25.00	25.00	1307.00	1282.00	13.78	9.66
42 2027	0.0	25.00	25.00	1307.00	1282.00	12.30	8.54
43 2028	0.0	25.00	25.00	1307.00	1282.00	10.98	7.56
44 2029	0.0	25.00	25.00	1307.00	1282.00	9.81	6.69
45 2030	0.0	25.00	25.00	1307.00	1282.00	8.76	5.92
46 2031	0.0	25.00	25.00	1307.00	1282.00	7.82	5.24
47 2032	0.0	25.00	25.00	1307.00	1282.00	6.98	4.64
48 2033	0.0	25.00	25.00	1307.00	1282.00	6.23	4.10
49 2034	0.0	25.00	25.00	1307.00	1282.00	5.56	3.63
50 2035	0.0	25.00	25.00	1307.00	1282.00	4.97	3.21
TOTAL	7969.00	1175.00	9144.00	58304.00	49220.00	144.49	-473.14

I E R R = 12 ..... 12 + 144.49 / (144.49 + 473.14) = 12.23

10.1.4. Sensitivity Analysis

Sensitivity analysis is the effective measures of testing the riskness of this project. The analysis has been made on the following items.

1) Cost Increase

The project involves the considerable amount of the initial investment cost which is spread over a number of year. Therefore, sensitivity tests are made on increase of the initial investment cost by 10 percent and 20 percent.

2) Delay in Completion of Construction Works

Generally, many projects might not be implemented as planned. The effect of sensitivity analysis on this indicator is estimated in case of one year extension of construction period.

3) Crop Yield

The target yield of crops is also very important factor of the project, thus the sensitivity test is made of 10 percent and 20 percent decrease in the proposed target yield.

The result of the sensitivity analysis is summarized below.

Item	EIRR (%)
(1) Original	12.2
(2) Initial Investment Cost	
10% increase	11.3
20% increase	10.5
(3) One Year Extension of Construction Period	11.6
(4) Crop Yield	
10% decrease	11.4
20% decrease	10.9

10.2. Socio-economic Impacts

In addition to the direct project benefit, the Project will create the indirect benefit and give socio-economic impacts to farm economy in the Project area and to regional and national economy.

(1) From the viewpoint of farm economy, the following impacts can be considered;

- The recovery of groundwater table will contribute to saving the irrigation cost and to protect the crops from drought damages. This effect will not only influence the existing cultivated land of 2,835 ha but also the undeveloped cultivable lands. As the result, the crop yield will increase and additionally the fallow land or abandoned land could be converted into the arable lands.

- An increased yield will be accompanied by an increase in farm incomes. However, it is difficult to estimate these benefits in the monetary terms, because the beneficiaries are unspecified.

  The indirect benefits will also contribute to improvement of the standard of living and regional welfares.

(2) From a viewpoint of the national or regional economy, the following items are enumerated;

- Flood control will contribute to the stabilization of the regional welfare.

- The Project will contribute to improvement of self-sufficiency in national food supply, resulting in saving foreign currency.

° The Project will serve as a model of the water resources development strategy in the Third Five-Year Plan.

° The income of the local people will increase by means of employment during the construction period of the project works.

Computation Method of EIRR

$$EIRR = P + \Sigma A/(\Sigma A+\Sigma B)$$

where, P: EIRR 11%
A: Present worth value for 11%
B: Present worth value for 12%

CHAPTER XI LATENT POLLUTION BY COPPER MINING

11.1 Survey of Pollution

As mentioned in 1.4, commercial operation of copper mining was commenced from 1983 and since this time, chemical tests for groundwater collected from existing wells located in Wadi Jizzi basin have been conducted at the laboratory. From results of the test, no pollution for life has been found in the groundwater. However, it is seemed that the pollution by gas on fumes exhausted from chimnies of the smelting plant has adhered at the surface of stones and ground neighbouring with the plant, and the pollution will be washed out by rain and recharged to groundwater. Therefore, careful survey for following items is required.

1) Environmental pollution by waste water of groundwater from minings and smelting plant
2) Irrigation water pollution and soil contamination by downflow movement of surface run-off discharge and groundwater created by rainfall
3) Waste smoke pollution

11.2 Kinds of Mine Pollution

The mine pollution for agriculture will result from the direct or indirect harmful effect of such pollutant to crops as generated by waste water from the underground and ore dressing works and smoke by plant operation, etc..

The pollution mechanism to the agriculture in the Project area by Lasail Copper Mining is illustrated in Figure 11-1.

11.3 Agricultural Products and Pollution by Mining

Pollution to the agricultural crops by those pollutions of acidic or saline water containing heavy metals, and SO_2 gases or fume containing heavy metals will be generated when the pollutant concentration or accumulation exceeds the permissible level and are directly in contact with plants or soils. In this case, the resistivity of the plant to the pollutants has a close relation with the vulnerability of the plant to the pollution. Pollutants drifting through water or atmospheric current will contaminate the plants when they contact the soils or are absorbed thereto through the air current.

11.4 Monitoring of the Environmental Degradation by Mine Pollution

11.4.1 Fundamental Matters of Pollution Control

As the fundamental items of the control measures for the environmental pollution caused by chemical and physical emission of pollutants from mining, it is considered necessary to provide systematic activities for protecting the area from environmental pollution.

Pollutants emitted by mining will continue to move throughout the whole period of operation of the Copper mining, and as the time goes by, the pollutants will gradually be condensed into the ground between the copper mining and the Agricultural Development Project Area.

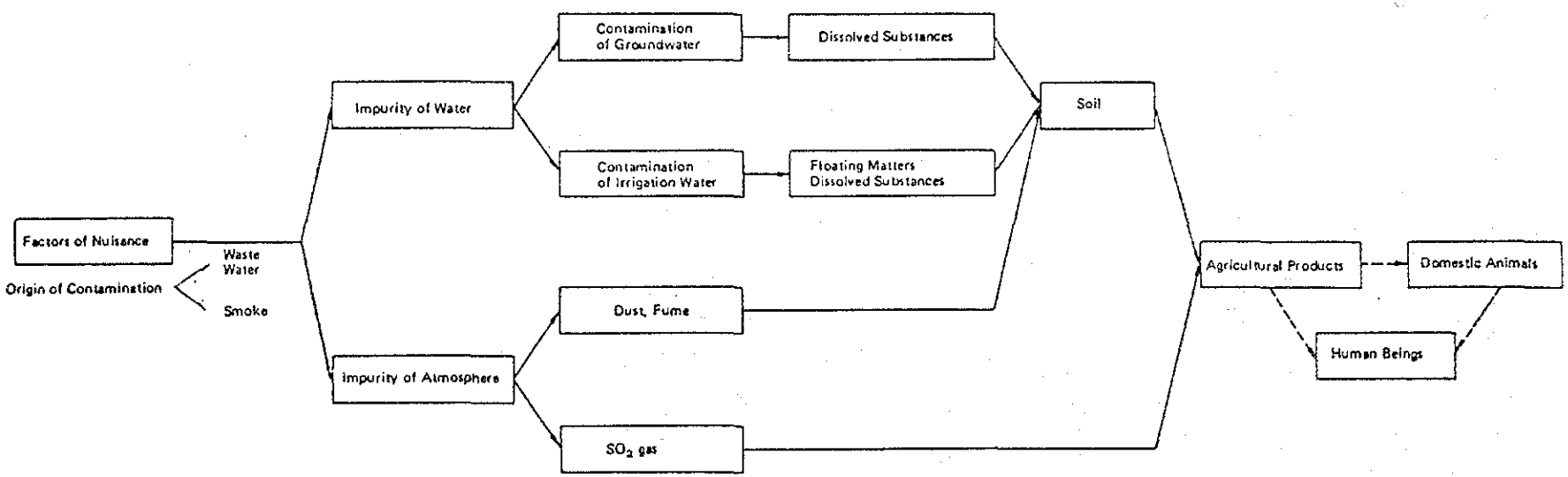
A monitoring system of the environmental degradation should be established for the purpose of successful pollution control and the system will be operated by a department under the Ministry of Environment and Water Resources. Effective monitoring systems can be specified into three;

1) Measurement and observation should be made to monitor the environmental conditions and its change.
2) Through the evaluation and analysis of the environmental data, the forecast of various environmental change should be made.
3) Positive actions should be taken for protecting the environment from worsening.

11.4.2 Monitoring

1) Water Quality
   ° Cu, Pb, Zn, Fe, Cd, As, Mg, Cr, Hg.
   (refer to 4.3)
2) Air Pollution
   Two or three observation points shall be selected in the vicinity of the smelters and in the Wadi Jizzi basin. Analysis items are falling dust or fume and sulfur dioxide (SO_2).
3) Waste Water Quality Check
   Routine works of check and control of the quality and feature of waste water emitted from the underground and dressing plants should be made by the Sohar Copper Mining.

Fig 11-1 FLOW CHART FOR PROCESS OF EFFECT TO AGRICULTURAL PRODUCTS



CHAPTER XII List of Construction Drawings

Dwg. No.1.	General Plan	
" 2.	Detention Dam	(1) (Typical Section and Profile)
" 3.	"	(2) (Cross Section)
" 4.	"	(3) (Cross Section)
" 5.	Service Spillway	(1) (Profile & Plan)
" 6.	"	(2) (Detail of Cross Section, Access Road
" 7.	"	(3) (Typical Section of Weir)
" 8.	"	(4) (Detail of Staff Gauge)
" 9.	"	(5) (Detail of Weir)
" 10.	"	(6) (Detail of Cross Section)
" 11.	"	(7) (Detail of Cross Section)
" 12.	Emergency Spillway	(1) (Plan & Profile)
" 13.	"	(2) (Detail of Weir and Typical Section)
" 14.	"	(3) (Typical Cross Section)
" 15.	"	(4) (Weir and Staff Gauge)
" 16.	Service Outlet	(1) (Plan and Profile)
" 17.	"	(2) (Drop Inlet and Trash Rack)
" 18.	"	(3) (Under Drain)
" 19.	"	(4) (Typical Section and Detail of Conduit)
" 20.	"	(5) (Tailrace)
" 21.	Emergency Outlet	(1) (Plan and Profile)
" 22.	"	(2) (Detail of Conduit Entrance)
" 23.	"	(3) (Trash Rack)
" 24.	"	(4) (Steel Roller Gate)
" 25.	"	(5) (Detail of Roller Gate Portion)
" 26.	"	(6) (Typical Section and Exist Section)
" 27.	"	(7) (Tailrace)
" 28.	Dispersion Facilities	(1) Location Map, Longitudinal Profile Typical Section, Connection Channel
" 29.	"	(2) Detail
" 30.	"	(3) Connection Channel
" 31.	Water Level Gauge	
" 32.	Observation Well	
" 33.	Debris Deflectors	
" 34.	Associated Facilities	
" 35.	Map of Water Surface	
" 36.	Location Geometrics	
" 37.	Coffer Dam	

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