10.1.3 Option IIIa

The intake will located at the same place as that of Option II, and water will be channeled through the headrace tunnel, penstock, underground powerhouse and tailrace located 6 km downstream of the dam axis. In comparison with Option II, this alternative involves a much longer tailrace tunnel, but generates more energy because of the increased head for generation. Option IIIa includes the same waterway route between the intake and powerhouse as Option II, and a detoured tailrace tunnel. In this option, a draft chamber will be constructed just downstream of the powerhouse to ensure the tailrace tunnel is non-pressured. The general plan and waterway section are shown in **Figs. 10.1.3-1 and 10.1.3-2**.

(1) Road for the Construction and Main Service Facilities

The land utilization plan during construction is shown in **Fig. 10.1.3-3**

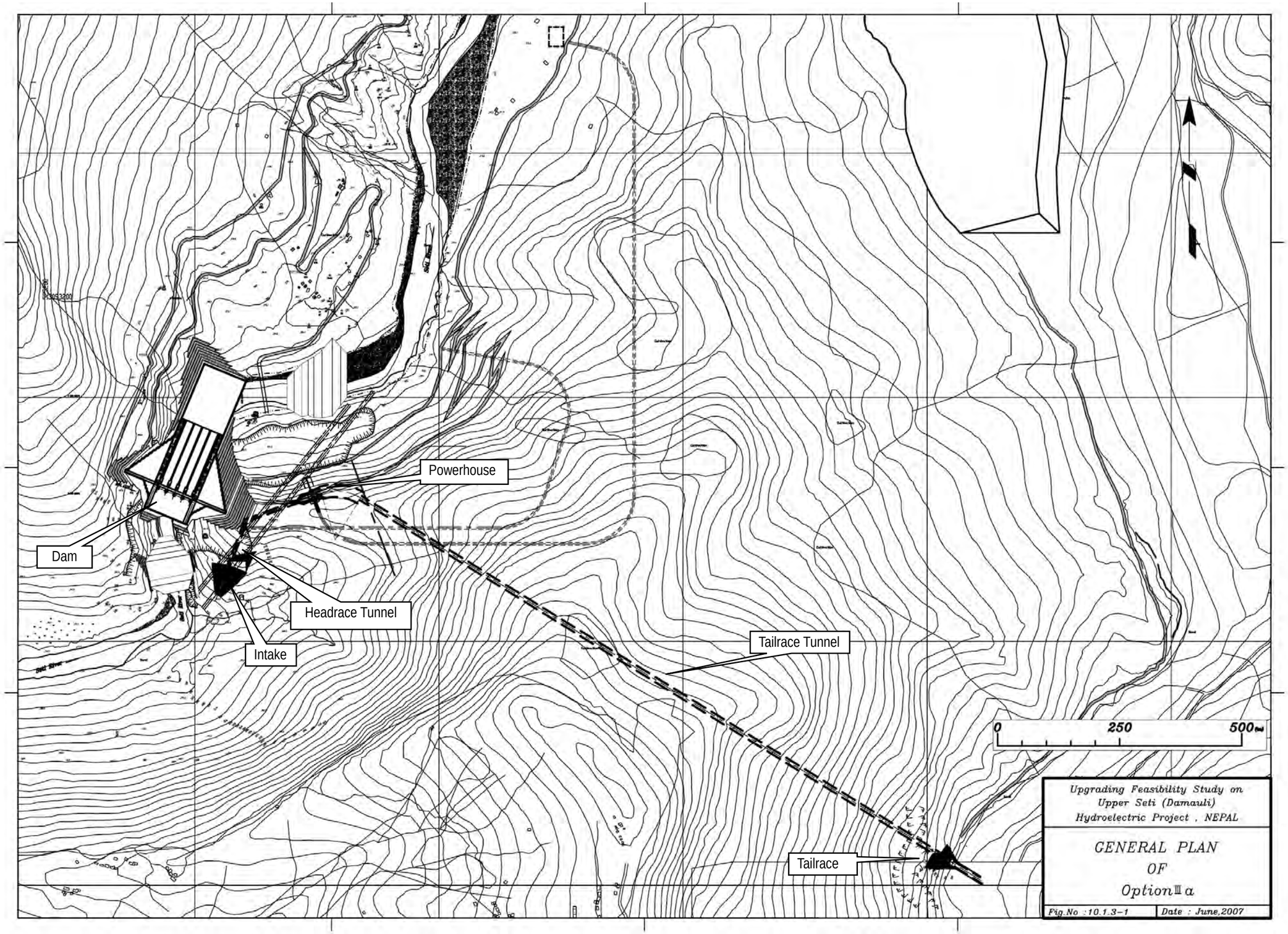
Though the plan is basically the same as Option II, a further new road will be constructed between the downstream facility area and tailrace, of around 1,600 m in length, because the tailrace is located 6 km downstream of the dam axis. The road should be constructed at a higher elevation with the design flood in mind. The length of the powerhouse access tunnel will be about 2,000 m horizontally, because the adit route changes, due to the change of direction of the cavern from Option-II.

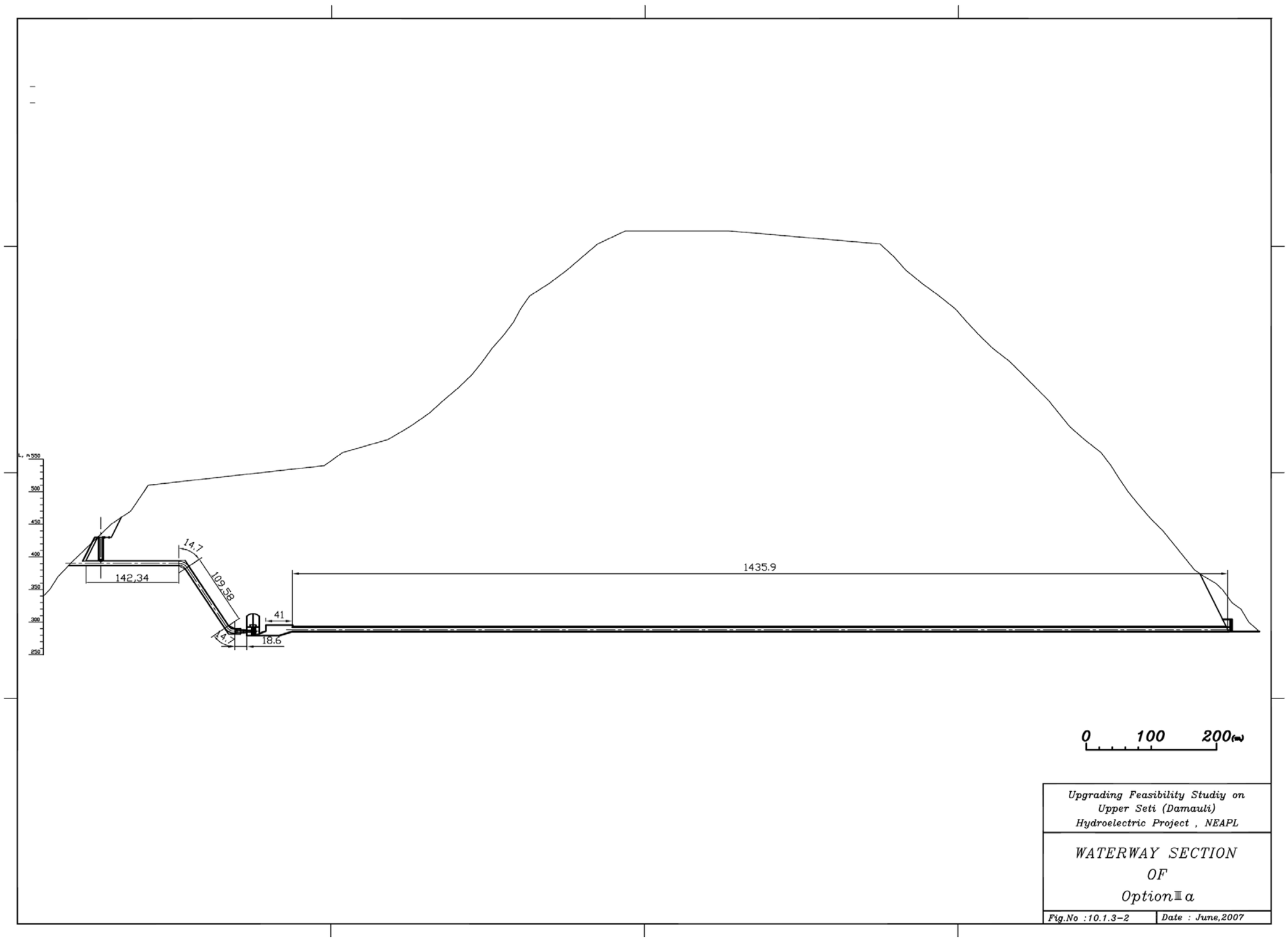
(2) Dam

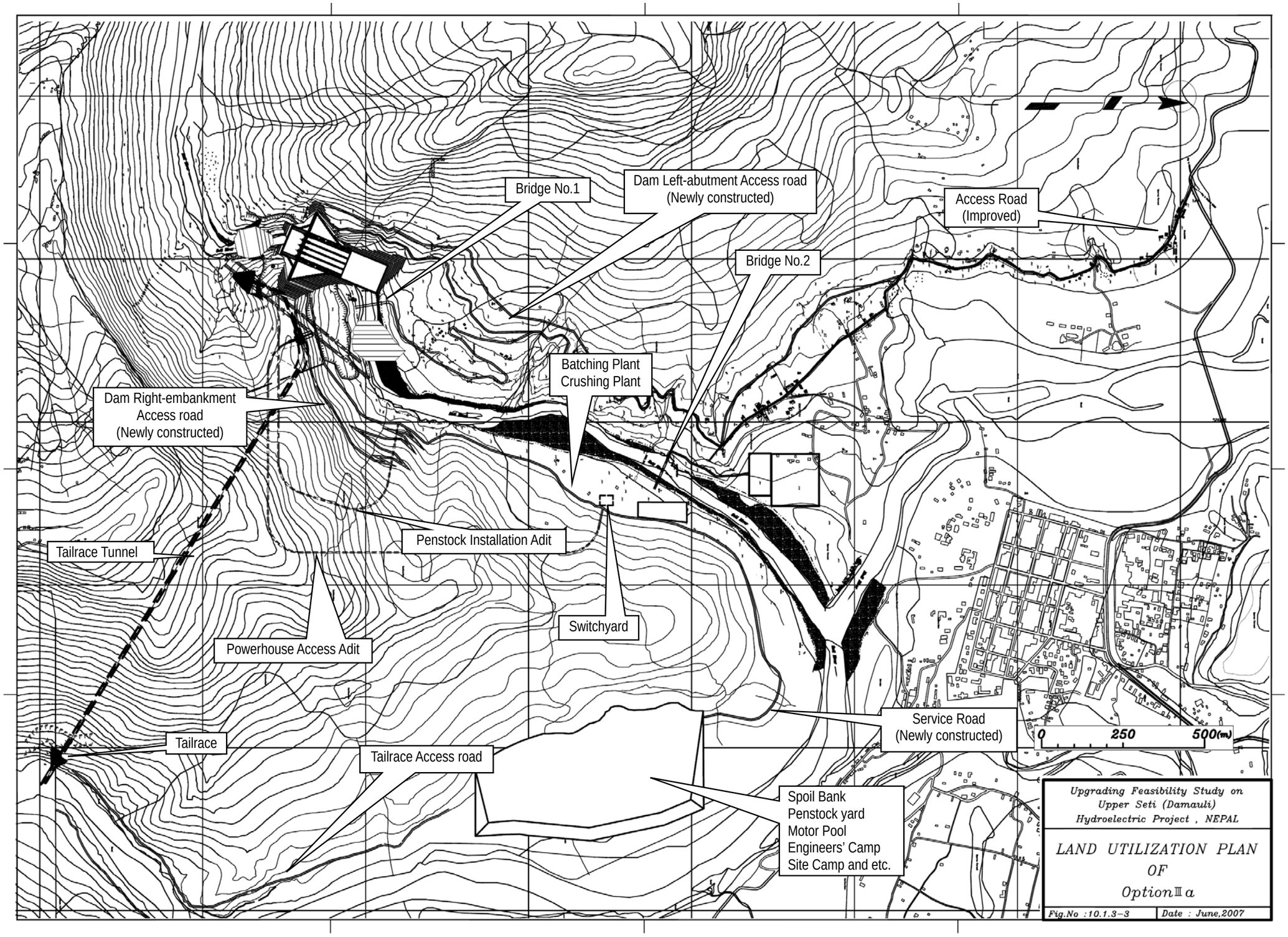
Same as Option I.

(3) Waterway and Powerhouse

Basically, descriptions between the intake and powerhouse are the same in Option II. Regarding the draft chamber, the arch access of the chamber will be excavated from the erection bay after the cavern excavation is completed up to the erection bay elevation. A tailrace tunnel access adit, branching from the powerhouse access adit, will end at the bottom of the draft chamber. The tailrace tunnel access will be connected with the draft chamber arch access via a shaft, following which the chamber will be excavated to the bottom via the bench cut method. Excavated rocks will be allowed to fall through the shaft, and cleared through the tailrace and powerhouse access adits. Since the tailrace tunnel is around 1,500 m long, excavation works will also be conducted from the upstream side upon completion of the chamber excavation works, and the tunnel excavated from the upstream side will be connected with one excavated from the tailrace side respectively.


Powerhouse
Dam
Headrace Tunnel
Intake
Tailrace Tunnel
Tailrace
0
250
500m
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
GENERAL PLAN
OF
Option Ⅲ a
Fig.No :10.1.3-1
Date : June,2007


550
500
450
400
350
300
250
14.7
142.34
109.58
41
14.7
18.6
1435.9
0
100
200(m)
Upgrading Feasibility Studiy on
Upper Seti (Damauli)
Hydroelectric Project , NEAPL
WATERWAY SECTION
OF
Option Ⅲ a
Fig.No :10.1.3-2
Date : June,2007


Bridge No.1
Dam Left-abutment Access road
(Newly constructed)
Access Road
(Improved)
Bridge No.2
Batching Plant
Crushing Plant
Dam Right-embankment
Access road
(Newly constructed)
Penstock Installation Adit
Tailrace Tunnel
Switchyard
Powerhouse Access Adit
Service Road
(Newly constructed)
Tailrace
Tailrace Access road
Spoil Bank
Penstock yard
Motor Pool
Engineers' Camp
Site Camp and etc.
0
250
500(m)
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
LAND UTILIZATION PLAN
OF
OptionⅢa
Fig.No :10.1.3-3
Date : June,2007

10.1.4 Option IIIb

This alternative is the one with the shortest waterway length to the tailrace in comparison with Option IIIa. Here, since the topographical conditions make it difficult to construct the surface type at the end of the tailrace tunnel, an underground type powerhouse should be adopted. Although there is no restriction on the powerhouse location along the waterway, it should be located in the dolomite zone and a surge chamber will be constructed with the long headrace tunnel in mind. As the waterway traverses a high ridge, an open type surge chamber would seem unsuitable. Therefore, the same underground type surge chamber as that of the Middle Marsyangdi project is adopted in this alternative, with the general plan and waterway section shown in **Figs. 10.1.4-1** and **10.1.4-2**.

(1) Road for Construction and Main Service Facilities

The land utilization plan during construction is shown in **Fig. 10.1.4-3**, while that for the dam area is the same as that of Option I. Meanwhile, the access road to the tailrace is the same as that of Option IIIa and branches at a position about 250 m from the downstream service facility area. The branched road 500 m long reaches the flat area, where the river width narrows abruptly and the area will be leveled for the switchyard site, and portals of the penstock installation adit and powerhouse access adit respectively. Beside the two adits, an arch access adit for an underground type surge chamber should also be necessary.

The penstock installation adit reaches the end of the headrace tunnel, with a horizontal length of about 970 m.

The powerhouse access adit reaches the top of the powerhouse cavern, while another adit branching from the access adit will go to the erection bay, as in Option II, making a total horizontal length of about 870 m. As the elevation level of the top of the cavern is EL.312 m and that of the erection bay is EL.292 m, the height difference of the branched adit will be 78 m, and the tunnel inclination will be less than 10%, meaning there will be no problem for the construction works.

The portal elevation of the access adit to the top of the underground type surge chamber is designed to take surging upon load rejection into consideration. The new road will be constructed from the switchyard to the surge chamber access adit portal and its inclination should be considered to be less than 10%, which represents the limit for construction works. The load length, meanwhile, depends on the reservoir Full Supply Level, and will be 810 m horizontally in the case of an FSL of 425 m. The adit diameter should be the same as the headrace tunnel excavation section diameter.

(2) Dam

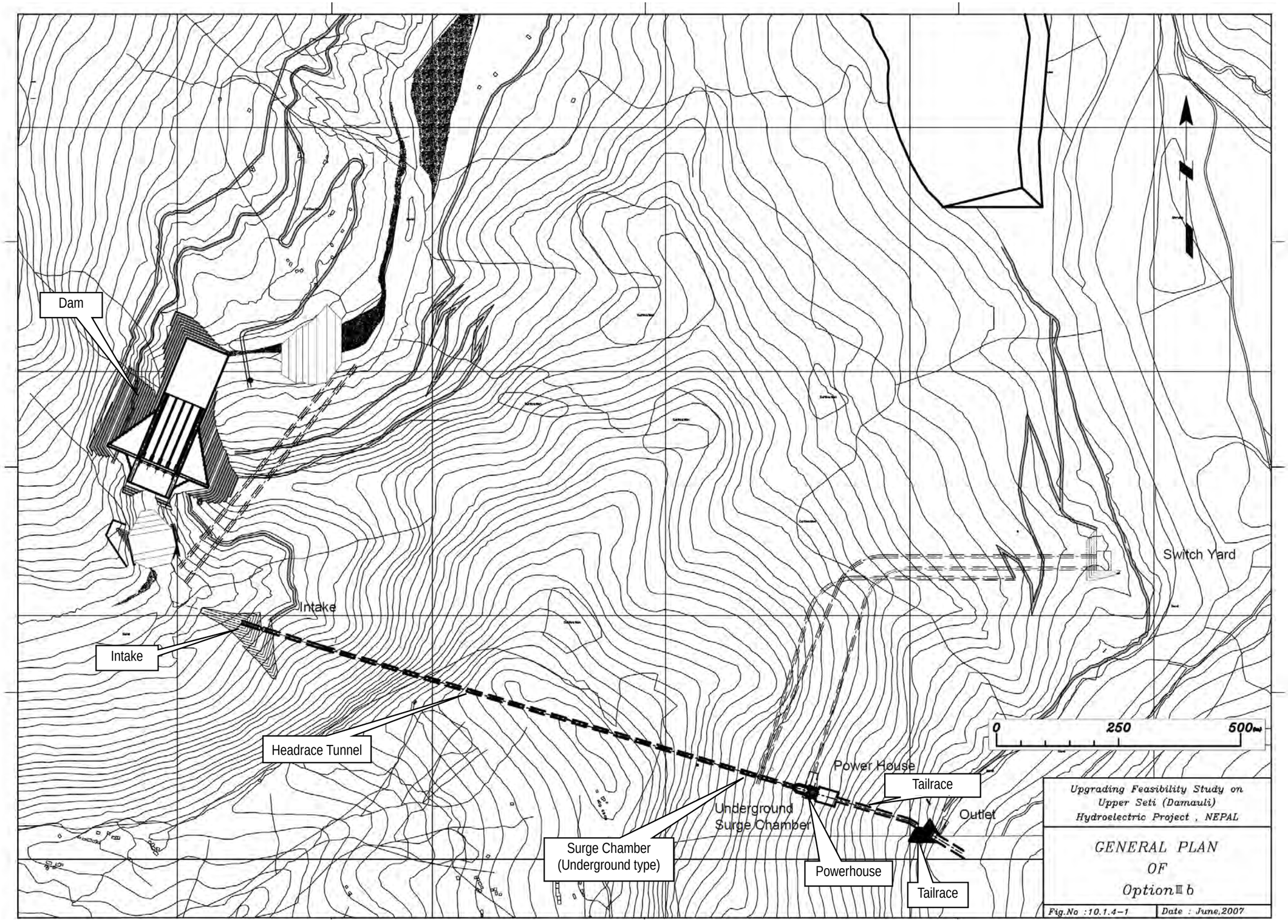
Same as Option I.

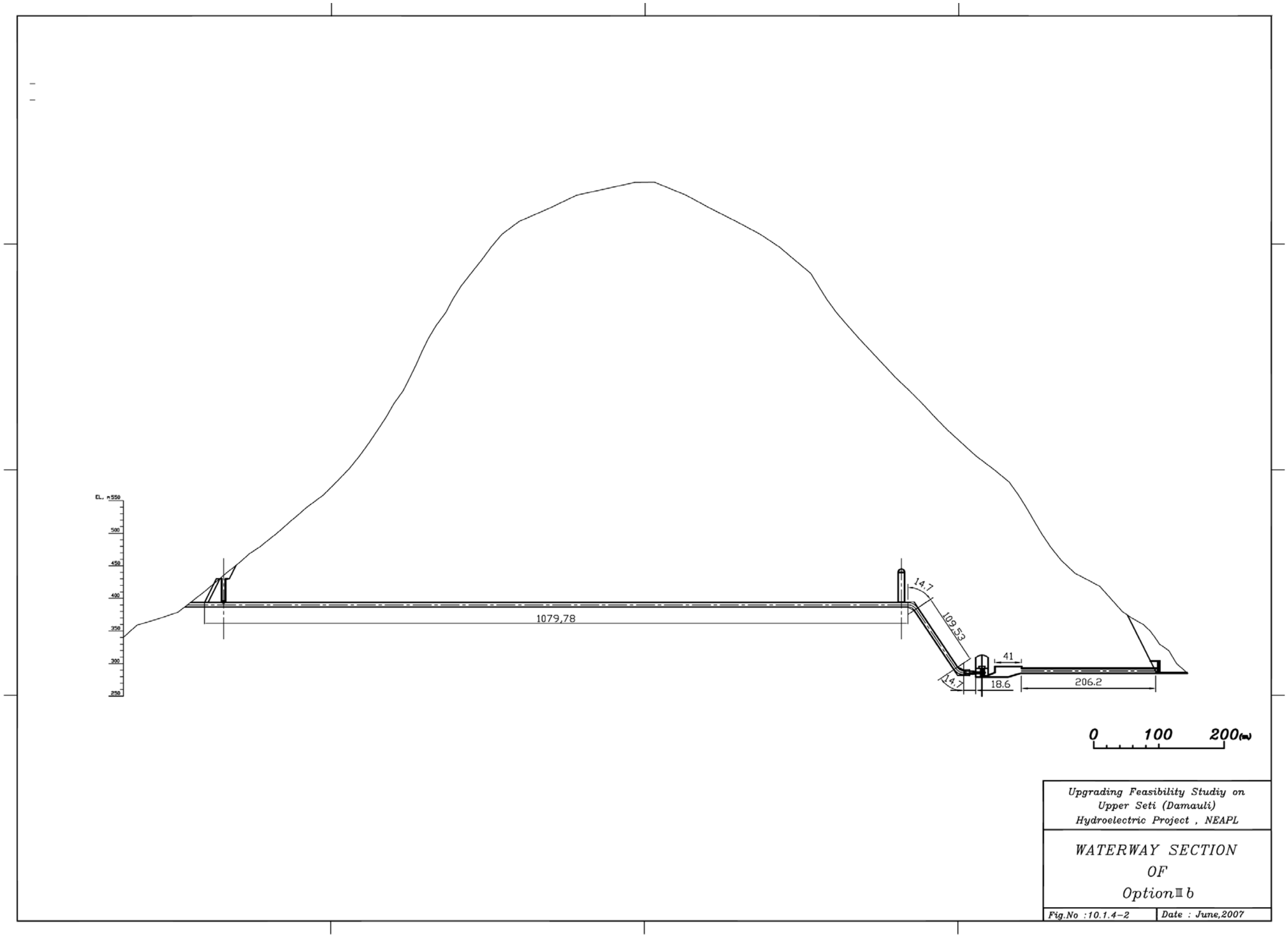
(3) Waterway, Powerhouse

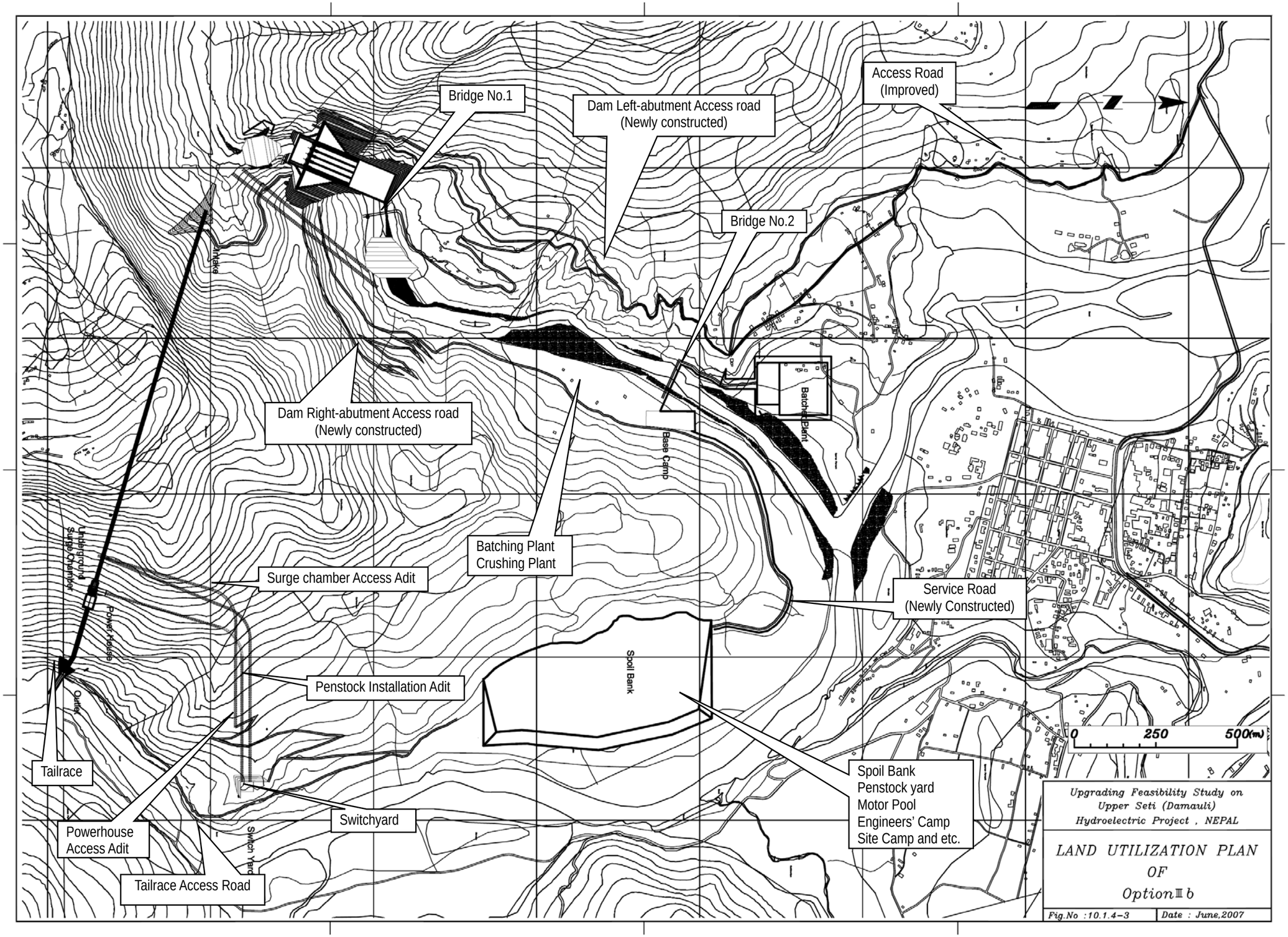
The intake is located about 500 m upstream of the dam crest on the right abutment and after the intake access road is constructed, open excavation works will commence. During the period, the headrace tunnel will be excavated from the end of the penstock installation tunnel to the intake side. Once intake open excavation works are completed, the headrace tunnel excavation works will also commence from the intake side, to a length of about 910 m. Following the tunnel excavation works, concrete lining works and consolidation grouting works for the headrace tunnel, and intake structure concrete works will be executed.

Regarding the surge chamber, the pilot shaft will be excavated by climbers once a significant amount of progress on the headrace tunnel excavation work has been completed. Subsequently, shaft excavation works will be executed, which will allow excavated rocks to fall through the pilot shaft, and then be cleared through the penstock installation adit. Following the shaft excavation work, the shaft will be concrete-lined.

The construction work involved for the penstock inclined shaft, powerhouse and tailrace will be almost identical to that of Option II. A pilot for the inclined shaft will be excavated, initially using a climber or raise borer, with the geological conditions in mind, following which inclined shaft excavation works will be carried out. The excavated rocks will be allowed to fall through the pilot shaft, and then cleared through the powerhouse access adit. With this in mind, excavation works of the inclined shaft 130 m long will be executed once the cavern excavation works are complete and then penstock steel pipes will be installed through the adit, and backfilled by concrete.


Dam
Intake
Intake
Headrace Tunnel
Surge Chamber
(Underground type)
Underground
Surge Chamber
Power House
Powerhouse
Tailrace
Tailrace
Outlet
Switch Yard
0
250
500m
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
GENERAL PLAN
OF
Option Ⅲ b
Fig.No :10.1.4-1
Date : June,2007


EL. m
550
500
450
400
350
300
250
1079,78
14.7
109.53
41
14.7
18.6
206.2
0
100
200(m)
Upgrading Feasibility Studiy on
Upper Seti (Damauli)
Hydroelectric Project , NEAPL
WATERWAY SECTION
OF
Option Ⅲ b
Fig.No :10.1.4-2
Date : June,2007


Bridge No.1
Dam Left-abutment Access road
(Newly constructed)
Access Road
(Improved)
Bridge No.2
Dam Right-abutment Access road
(Newly constructed)
Intake
Batching Plant
Crushing Plant
Base Camp
Surge chamber Access Adit
Service Road
(Newly Constructed)
Underground
Surge Chamber
Power House
Outlet
Spoil Bank
Penstock Installation Adit
Tailrace
Switchyard
Spoil Bank
Penstock yard
Motor Pool
Engineers' Camp
Site Camp and etc.
Powerhouse
Access Adit
Tailrace Access Road
Switch Yard
0 250 500(m)
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
LAND UTILIZATION PLAN
OF
Option Ⅲ b
Fig.No :10.1.4-3
Date : June,2007

10.1.5 Option IV

Through discussion with NEA, this alternative, featuring the construction of an underground type powerhouse in the left abutment of the river, was prepared. To minimize cost, the headrace tunnel length should be as short as possible to avoid the need for surge tank construction, and a draft chamber should be constructed to ensure the tailrace tunnel is non-pressured. However, the waterway length becomes longer than the alternatives in the right abutment, because the river runs and bends to the right. The general plan and waterway section are shown in **Figs. 10.1.5-1** and **10.1.5-2**.

(1) Road for Construction and Main Service Facilities

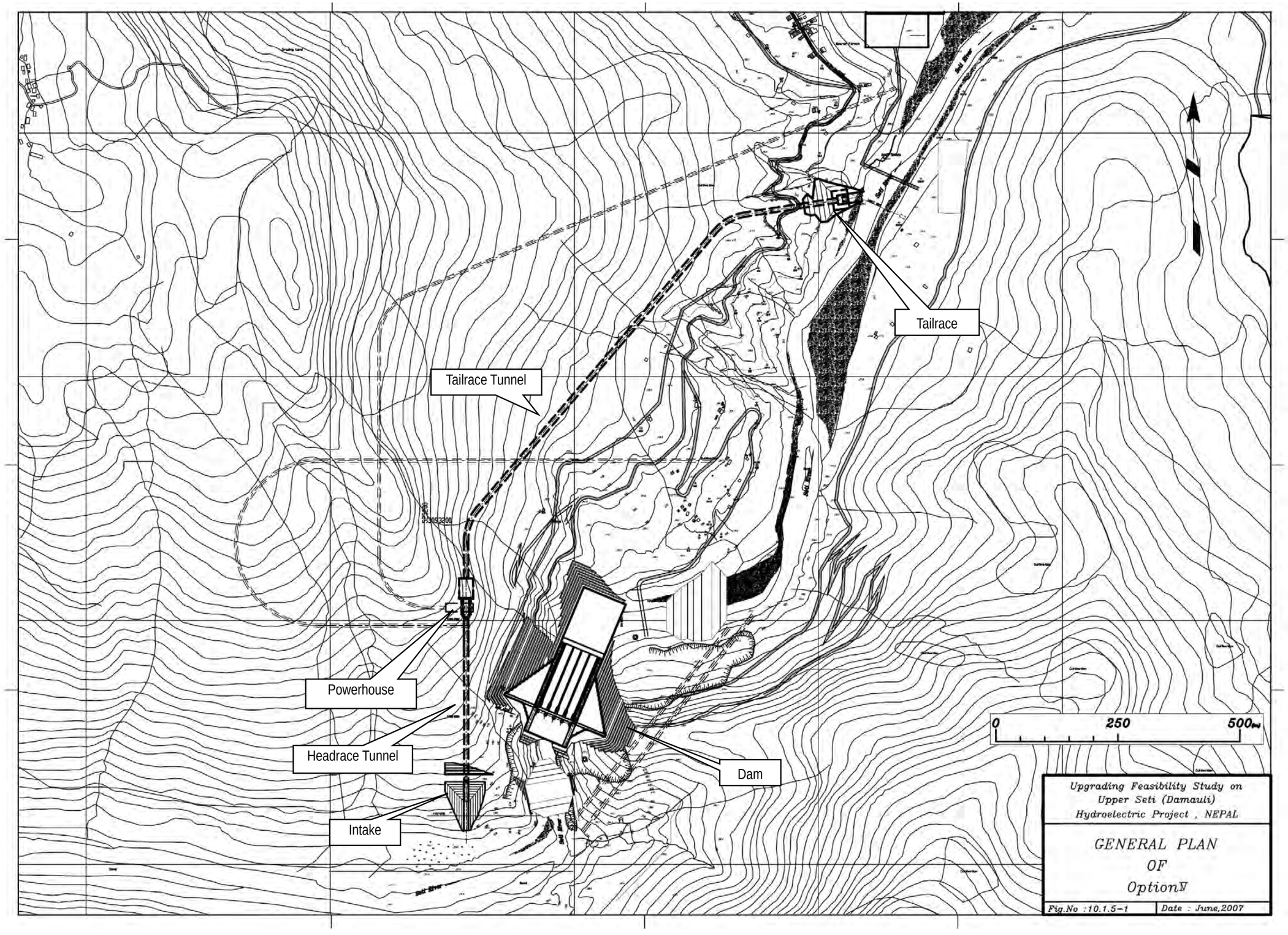
The land utilization plan during construction is shown in **Fig. 10.1.5-3**. The land utilization plan for the dam is same as that of Option I. Access to the tailrace, however, is easier, because it is located near the temporary bridge No. 2. A penstock installation adit and a powerhouse access adit will be necessary, as in Options II and IIIa, but no new access road to each adit portal is necessary, because the road has been already constructed at the left abutment. The geological conditions in the area downstream of the dam along the Seti River, meandering to the right, mainly comprise sedimentations, meaning there is no suitable place for adit portals and switchyard. Consequently, the penstock installation adit portal should be located downstream, where the river runs straight after bending. The adit route will be subject to a considerable detour to ensure it runs through a geologically sound zone in that area, which will make the adit length about 1,700 m. The only suitable place for the powerhouse access adit exists in the vicinity of the batching plant site, which is topologically suitable for the switchyard. Hence, the adit length will be about 1,900 m to ensure it runs through the geologically sound zone in the left abutment area.

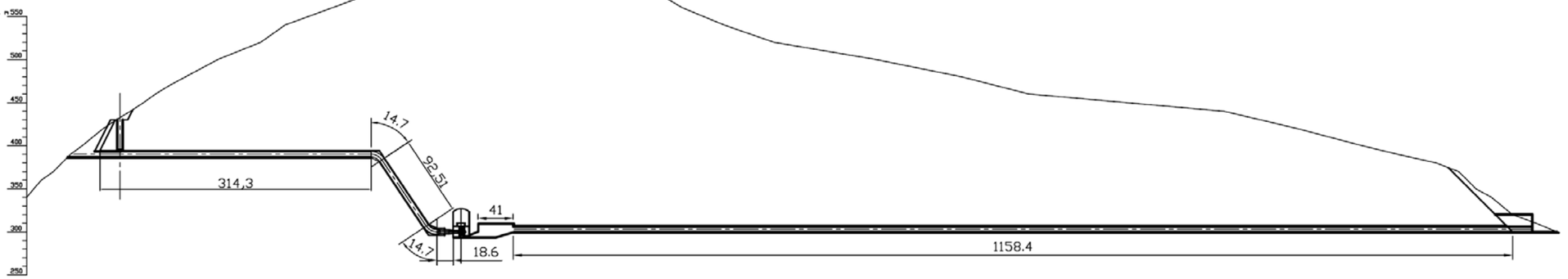
(2) Dam

Same as Option II

(3) Waterway, Powerhouse

The intake is set at about 400 m upstream from the dam axis, while other issues are almost similar to Option II.

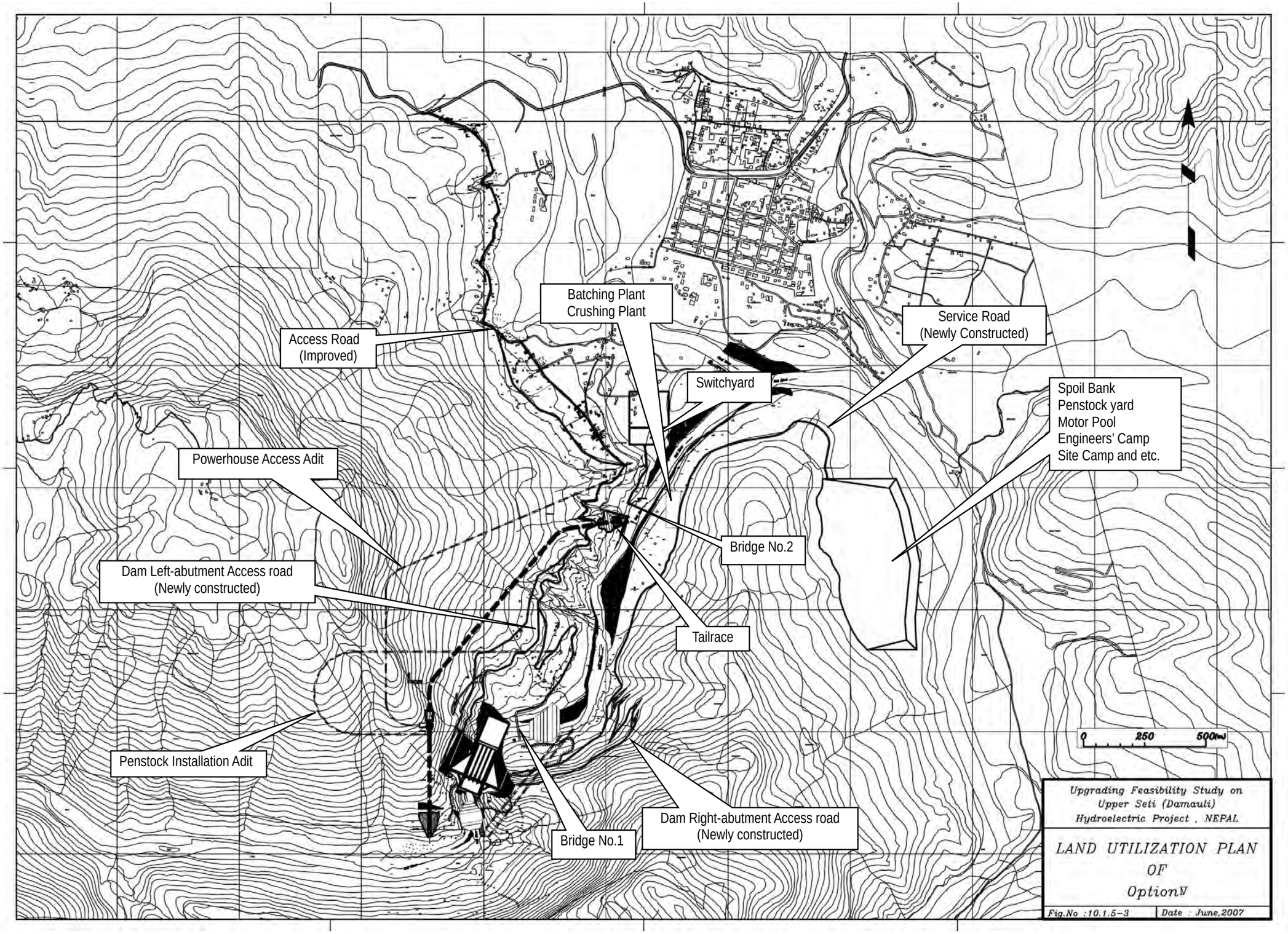

Tailrace
Tailrace Tunnel
Powerhouse
Headrace Tunnel
Intake
Dam
0
250
500m
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
GENERAL PLAN
OF
OptionⅣ
Fig.No :10.1.5-1
Date : June,2007



Upgrading Feasibility Studiy on
Upper Seti (Damauli)
Hydroelectric Project , NEAPL

WATERWAY SECTION
OF
OptionⅣ

Fig.No :10.1.5–2 | *Date : June,2007*


Batching Plant
Crushing Plant
Access Road
(Improved)
Service Road
(Newly Constructed)
Switchyard
Spoil Bank
Penstock yard
Motor Pool
Engineers' Camp
Site Camp and etc.
Powerhouse Access Adit
Bridge No.2
Dam Left-abutment Access road
(Newly constructed)
Tailrace
Penstock Installation Adit
Bridge No.1
Dam Right-abutment Access road
(Newly constructed)
0 250 500(m)
Upgrading Feasibility Study on
Upper Seti (Damauli)
Hydroelectric Project , NEPAL
LAND UTILIZATION PLAN
OF
OptionV
Fig.No :10.1.5-3
Date : June,2007

10.2 Comparative Study of Layout Alternatives

In the alternative study executed by NEA for F/S in 2001 and 2004, FSL was defined at elevation to avoid a considerable environmental impact. Because there is an FSL whereby the number of resettled people increases abruptly if the FSL is higher, NEA's alternative study was conducted only using the specified FSL. In this study, FSL alternatives are set taking topographical and environmental conditions into consideration for the above 5 layout alternatives, in order to conduct a numerically comparative study at each FSL. Economical parameters of all alternatives were compared, and the most economical alternative, which means that generating optimal effects in terms of both costs and benefit, should be chosen as the development planning option.

A flowchart for the comparative study is shown in **Fig. 10.2-1**. The comparative study is composed of 3 parts, i.e. planning, cost estimation, and economical analysis and the procedures of each part are shown as follows:

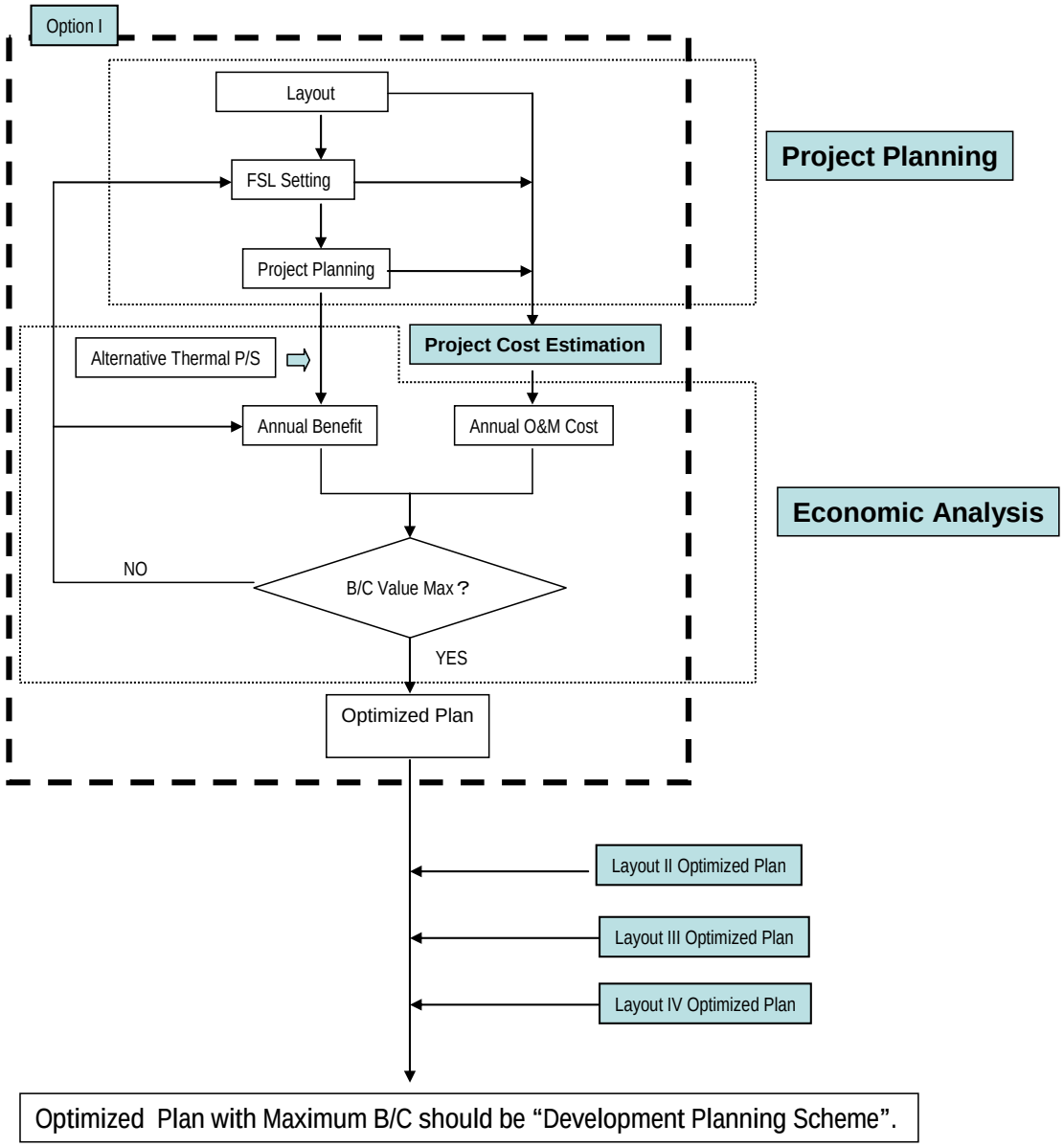


Fig. 10.2-1 Layout Alternatives Comparison Study Flow Chart

10.2.1 Project Planning

The Project Planning Flowchart is shown as **Fig. 10.2.1-1**. The practical procedures on the flowchart are as follows:

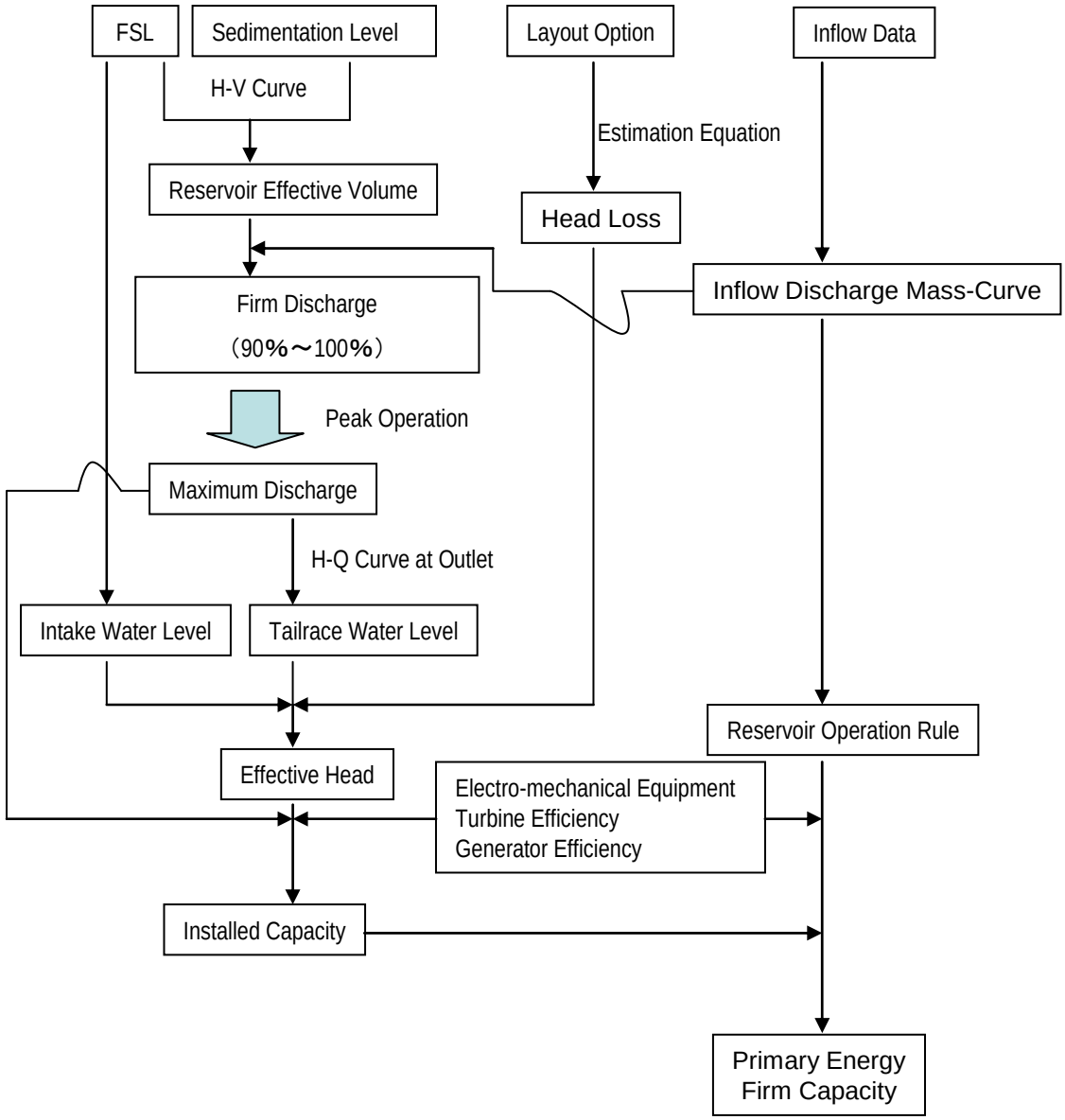


Fig. 10.2.1-1 Planning Flow Chart

(1) FSL Alternatives (FSL: Full Supply Level)

To optimize the project, FSL alternatives are set as follows:

EL.395 m, EL.405 m, EL.410 m, EL.415 m, EL.420 m, EL.425 m, EL.435 m

(2) MOL Estimation (MOL: Minimum Operation Level)

Generally, MOL is defined as shown in **Fig. 10.2.1-2** by the following equation, comprising sedimentation level, base height of the intake structure, waterway diameter, and a certain margin of water depth to prevent air from sucking.

MOL = Sedimentation Level + Intake structure base height + 2 * D

Here, D: Waterway diameter (m)

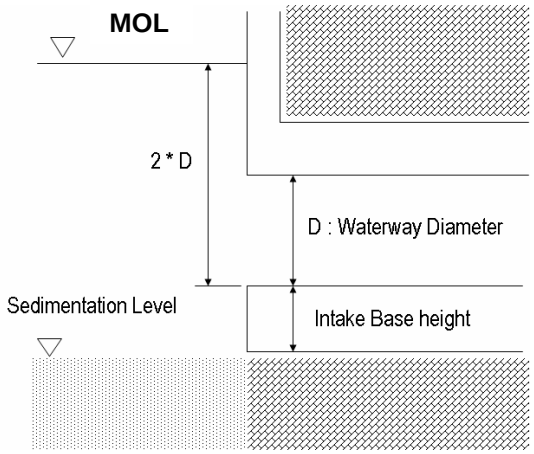


Fig. 10.2.1-2 How to determine the Minimum Operation Level

The Sedimentation Level is defined as follows:

In **Chapter 6**, it is recommended that sediment flushing facilities should be installed to maintain the reservoir function, by flushing in the rainy season, against the high sedimentation of the Seti river, and that the facilities be installed at EL. 320.00 m. The result is as shown in **Table 10.2.1-1**. Because the sediment volume in the reservoir varies, due to the fluctuation of annual discharge, the design sedimentation volume for the reservoir is defined by the average value in the table. Regarding the sedimentation level, it is defined, based on the reservoir H-V curve, by assuming that sedimentation should be distributed horizontally in the reservoir, which is generally considered to be a typical procedure for dam design in Japan. Sedimentation Level is EL. 386.2 m, as shown in **Fig. 10.2.1-3**.

Table 10.2.1-1 Sedimentation Volume in the Reservoir for each FSL

FSL（EL.m）	Maximum sedimentation volume（m^3）
375	115,917,816
395	130,829,357
425	125,726,614
435	138,799,258
Average	127,818,261

(3) Reservoir Effective Capacity Estimation

The effective storage capacity of the reservoir is generally defined as the volume between the FSL and MOL (Minimum Operation Level). As shown in **Fig. 10.2.1-1**, firm discharge should be estimated to determine the maximum discharge for reservoir type hydropower planning. The effective storage capacity of the reservoir should be the input data used to estimate the firm discharge. As this is the primary stage of planning, the effective storage capacity for firm discharge is defined as the volume between the FSL and the Sedimentation Level.

In this study, the H-V curve was re-prepared based on 1/5,000 scale topographical maps prepared with GIS mapping. The H-V curve is shown in **Table 10.2.1-2** and **Fig. 10.2.1-4**.

Table 10.2.1-2 Reservoir Volume and Elevation

Height (m)	Area (km^2)	Volume (MCM)
310.00	0.02	0.00
315.00	0.15	0.42
320.00	0.32	1.59
325.00	0.46	3.54
330.00	0.56	6.10
335.00	0.71	9.29
340.00	1.10	13.82
345.00	1.29	19.81
350.00	1.48	26.74
355.00	1.73	34.77
360.00	2.11	44.38
365.00	2.38	55.60
370.00	2.88	68.74
375.00	3.37	84.35
380.00	3.85	102.40
385.00	4.36	122.93
390.00	4.79	145.78
395.00	5.20	170.74
400.00	5.73	198.06
405.00	6.23	227.95
410.00	6.70	260.25
415.00	7.26	295.14
420.00	7.92	333.08
425.00	8.67	374.57
430.00	9.82	420.79
435.00	11.24	473.45

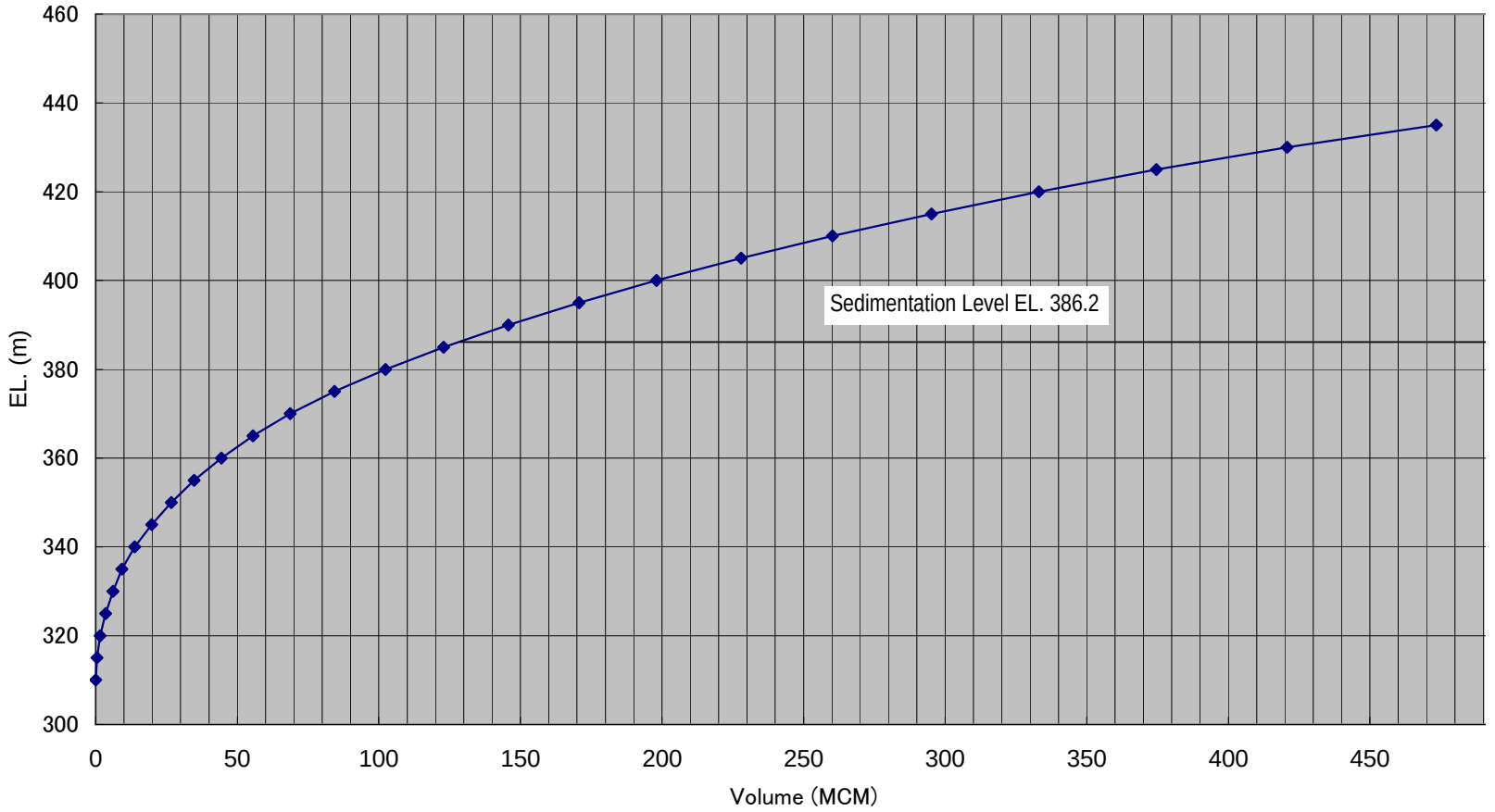


Fig. 10.2.1-3 Reservoir H-V Curve

(4) Discharge for Environmental flow

Because the river discharge in all layout alternatives except Option I decreases between the dam and tailrace, environmental flow should be discharged from an environmental perspective. Even in Option-I, discharge will decrease in the downstream section of the dam, while power is not generated in daytime due to the peak operation of the project.

Although the amount of compensatory flow is determined during the environmental impact assessment, this has not been determined for the current optimization study. Hence, 2.4 m^3/s, which corresponds to the minimum monthly run-off at the dam site, has been applied to the environmental flow, based on the environmental regulations in Nepal.

The environmental flow of 2.4 m^3/s should be discharged while power is not generated in the dry season for Option I, as stated in the Feasibility Study by NEA. For the other layout alternatives, a environmental flow of 2.4 m^3/s should be discharged at all times throughout the year.

(5) Firm Discharge and Maximum Discharge

Firm discharge is estimated using the mass curve method, based on the dam inflow data mentioned in **Chapter 6** and the effective storage volume for each FSL alternative. Generally, firm discharge is estimated by the discharge duration curve, but there is no defined value for periodic probability. Based on empirical knowledge, the value should be some range between 90 and 100%, meaning 90% and 100% firm discharge are estimated.

As described in **Chapter 5**, this project is considered to be an energy supplier for 6 peak hours in the Nepalese power development plan. Therefore, maximum discharge is defined as a value equivalent to 4 times the firm discharge, while the maximum discharge alternatives are defined as the value divided into 10 alternatives between 4 times the value of the 90% firm discharge and 100% firm discharge respectively. The maximum discharge alternatives for each FSL are shown in **Table 10.2.1-3** with firm discharge of 90% and 100% respectively.

Table 10.2.1-3 Firm Discharge for each FSL in the case of Option I

FSL (EL.m)	Effective Volume (MCM)	90% firm discharge (m^3/s)	Peaked for 6 hours (m^3/s)	100% firm discharge (m^3/s)	Peaked for 6 hours (m^3/s)
395	42.42	25.51	102.0	14.58	58.3
405	99.63	29.53	118.1	18.75	75.0
415	116.82	33.73	134.9	23.05	92.2
420	204.75	35.41	141.6	25.47	101.9
425	246.25	39.05	156.2	28.13	112.5
435	345.13	44.63	178.5	33.55	134.2

Table 10.2.1-4 Firm Discharge for each FSL in case of Options II, IIIa, IIIb, and IV

FSL (EL.m)	Effective Volume (MCM)	90% firm discharge (m^3/s)	Peaked for 6 hours (m^3/s)	100% firm discharge (m^3/s)	Peaked for 6 hours (m^3/s)
405	99.63	27.13	108.5	16.35	65.4
410	131.93	28.66	114.6	18.42	73.7
415	166.82	31.33	125.3	20.65	82.6
420	204.75	34.01	136.0	23.07	92.3
425	246.25	36.65	146.6	25.73	102.9
435	345.13	42.23	168.9	31.15	124.6

(6) Intake Water Level and Tailrace Water Level Estimation

At the optimization study level, the Full Supply Level of reservoir is defined as the Intake Water Level, as shown in the F/S report executed by NEA. An optimization study for IWL is shown in **Section 10.5**.

Regarding the Tailrace Water Level (TWL), this is estimated based on H-Q equations of the river section nearest the tailrace alternatives site, which are shown in the F/S report by NEA, under each maximum discharge alternative shown in (4). H-Q equations for the TWL estimation of each layout alternative are shown in **Table 10.2.1-4**.

Table 10.2.1-5 H-Q Equations for the TWL Estimation of each Layout Alternative

Layout alternative	H-Q equation
Option I	$H = 305 + (Q/51.53)^{2/3} * 9.8^{1/3}$
Option II	$H = 306.5 + (Q/50.34)^{1/2.43}$
Option III a	$H = 287.52 + (Q/53.63)^{1/1.769}$
Option III b	ditto
Option IV	$H = 300.79 - 0.99 + (Q/0.5757)^{1/4.8048}$

(7) Effective Head

Effective Head is estimated by the following equation and in the project design, it will be estimated in detail:

Effective Head = IWL − TWL − Loss

Loss = a * Headrace Tunnel Length + b * Penstock Length + c * Tailrace Tunnel Length

Here, the coefficients of a, b, c are defined as shown in **Table 10.2.1-6**.

Table 10.2.1-6 Coefficients in Loss Estimation

a	Pressure Tunnel	1/700
b	Penstock	1/200
c	Pressure Tunnel	1/700
	Non-pressure Tunnel	1/200

(8) Efficiency Curve of the Electro-mechanical Equipment

In consideration of the maximum discharge and effective head, a Vertical axis Francis type turbine is to be adopted. Common turbine efficiency curve and generator efficiency curve are quoted in this study as shown in **Table 10.2.1-7**.

Table 10.2.1-7 Efficiency Curve of the Turbine and Generator

Turbine				Generator	
Q/Qmax	FSL.	I.W.L.	MOL.	P/Ptmax	
0.3	0.684	0.684	0.514	0.4	0.967
0.4	0.780	0.780	0.695	0.6	0.975
0.5	0.841	0.842	0.753	0.8	0.979
0.6	0.878	0.878	0.779	1	0.982
0.7	0.908	0.908	0.816		
0.8	0.934	0.934	0.839		
0.9	0.943	0.943	0.839		
1	0.927	0.928	0.839		

(9) Project Alternatives

Based on the procedures shown in (1) to (7) above, Project alternatives are planned. For estimating the MOL, the waterway diameter is defined as that which makes the flow velocity in waterway 3.7 m/s for Option I, and 4.0 m/s for the other alternatives, based on the existing hydroelectric plants in Japan, for each maximum discharge alternative, and thus MOL is estimated as shown in (2).

Project alternatives are shown in **Table 10.2.1-8 ~ Table 10.2.1-12**.

Table 10.2.1-8 Main Features of Alternatives for Option I

Item	Unit	FSL=395									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	58.3	63.2	68	72.9	77.7	82.6				
FSL	EL.m	395	395	395	395	395	395				
MOL	EL.m	393.6	393.8	394	394.2	394.6	394.8				
Effective Vol.	MCM	7.00	6.00	5.00	4.00	2.00	1.00				
TWL	EL.m	307.3	307.5	307.6	307.7	307.8	307.9				
Loss	m	1	1	1	1	1	1				
Effective Head	m	86.7	86.5	86.4	86.3	86.2	86.1				
Pmax	MW	45	49	52	56	60	63				
Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	75	79.8	84.6	89.4	94.2	99	103.7	108.5	113.3	118.12
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	394.4	394.6	394.8	395.0	395.2	395.4	395.6	395.8	396	396.2
Effective Vol.	MCM	60.2	59.2	58.2	57.2	56.1	55	53.9	52.8	51.7	50.7
TWL	EL.m	307.7	307.9	308	308.1	308.2	308.3	308.4	308.5	308.6	308.7
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	96.3	96.1	96	95.9	95.8	95.7	95.6	95.5	95.4	95.3
Pmax	MW	64	68	72	76	81	85	88	92	96	100
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	83.3	87.8	92.4	96.9	101.5	106	110.6	115.1	119.7	124.2
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	394.8	395	395.2	395.4	395.6	395.8	396	396.2	396.2	396.4
Effective Vol.	MCM	90.5	89.5	88.5	87.5	86.5	85.5	84.5	83.5	83.5	82.5
TWL	EL.m	307.9	308.1	308.2	308.3	308.4	308.5	308.6	308.7	308.8	308.8
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	101.1	100.9	100.8	100.7	100.6	100.5	100.4	100.3	100.2	100.2
Pmax	MW	75	79	83	87	91	95	99	103	107	111
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.2	96.9	101.7	106.4	111.2	115.9	120.7	125.4	130.2	134.92
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	395.2	395.4	395.6	395.8	396	396.2	396.4	396.4	396.6	396.8
Effective Vol.	MCM	123.3	122.2	121.1	120	118.9	117.8	116.8	116.8	115.7	114.6
TWL	EL.m	308.2	308.3	308.4	308.5	308.6	308.7	308.8	308.9	309	309.1
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	105.8	105.7	105.6	105.5	105.4	105.3	105.2	105.1	105	104.9
Pmax	MW	87	91	96	100	105	109	113	118	122	126
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	101.88	106.7	111.6	116.5	121.3	126.2	131	135.9	140.7	145.6
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	395.6	395.8	396	396.2	396.4	396.6	396.6	396.8	397	397.2
Effective Vol.	MCM	159.1	158	156.9	155.8	154.7	153.6	153.6	152.5	151.4	150.3
TWL	EL.m	308.4	308.5	308.6	308.7	308.8	308.9	309	309.1	309.2	309.3
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	110.6	110.5	110.4	110.3	110.2	110.1	110	109.9	109.8	109.7
Pmax	MW	101	105	110	115	119	124	129	133	138	143
Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	112.5	117.4	122.2	127.1	131.9	136.8	141.6	146.5	151.3	156.2
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	396	396.2	396.4	396.6	396.8	397	397	397.2	397.4	397.6
Effective Vol.	MCM	198.4	197.3	196.2	195.1	194	192.9	192.9	191.8	190.7	189.6
TWL	EL.m	308.6	308.7	308.8	308.9	309	309.1	309.2	309.3	309.4	309.5
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	115.4	115.3	115.2	115.1	115	114.9	114.8	114.7	114.6	114.5
Pmax	MW	116	121	126	131	135	140	145	150	155	160
Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	134.2	139.1	144	149	153.9	158.8	163.7	168.7	173.6	178.5
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	396.8	397	397.2	397.4	397.4	397.6	397.8	398	398.2	398.2
Effective Vol.	MCM	292.9	291.8	290.7	289.6	289.6	288.5	287.4	286.3	285.2	285.2
TWL	EL.m	309.1	309.1	309.2	309.3	309.4	309.5	309.6	309.7	309.8	309.9
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	124.9	124.9	124.8	124.7	124.6	124.5	124.4	124.3	124.2	124.1
Pmax	MW	150	155	160	166	171	176	182	187	192	198

Note: The numbers 1 to 10 mean case No. of maximum discharge at the same FSL.

Table 10.2.1-9 Main Features of Alternatives for Option II

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
Effective Vol.	MCM	46.3	44.1	43	40.8	39.7	37.5	35.4	34.3	33.5	31.1
TWL	EL.m	307.6	307.6	307.7	307.7	307.7	307.8	307.8	307.8	307.8	307.9
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	96.2	96.2	96.1	96.1	96.1	96	96	96	96	95.9
Pmax	MW	56	60	64	68	73	76	81	85	89	93
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
Effective Vol.	MCM	75.3	74.2	72	70.9	68.7	67.7	65.5	64.6	63.4	61
TWL	EL.m	307.7	307.7	307.7	307.8	307.8	307.8	307.8	307.9	307.9	307.9
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	101.1	101.1	101.1	101	101	101	101	100.9	100.9	100.9
Pmax	MW	66	71	75	79	83	87	91	95	99	103
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
Effective Vol.	MCM	106.9	105.8	103.6	102.5	100.7	99.5	97.1	95.9	94.7	92.3
TWL	EL.m	307.7	307.8	307.8	307.8	307.8	307.9	307.9	307.9	307.9	308
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	106.1	106	106	106	106	105.9	105.9	105.9	105.9	105.8
Pmax	MW	78	83	87	92	96	100	105	109	114	118
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
Effective Vol.	MCM	141.6	140.5	138.6	137.4	135	133.8	132.6	130.2	129	127.8
TWL	EL.m	307.8	307.8	307.8	307.9	307.9	307.9	307.9	308	308	308
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	111	111	111	110.9	110.9	110.9	110.9	110.8	110.8	110.8
Pmax	MW	91	96	101	106	111	115	120	125	130	134
Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
Effective Vol.	MCM	180.1	177.7	176.5	175.3	172.9	171.7	170.5	168.1	166.9	165.7
TWL	EL.m	307.8	307.9	307.9	307.9	307.9	308	308	308	308	308.1
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	116	115.9	115.9	115.9	115.9	115.8	115.8	115.8	115.8	115.7
Pmax	MW	106	111	116	122	126	131	136	141	146	151
Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
Effective Vol.	MCM	271.8	269.4	268.2	267	265.8	263.4	262.2	261	259.8	258.7
TWL	EL.m	308	308	308	308	308	308.1	308.1	308.1	308.1	308.1
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	125.8	125.8	125.8	125.8	125.8	125.7	125.7	125.7	125.7	125.7
Pmax	MW	140	145	151	156	162	167	173	178	184	189

Note: The numbers 1 to 10 mean case No. of maximum discharge at the same FSL.

Table 10.2.1-10 Main Features of Alternatives for Option IIIa

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
Effective Vol.	MCM	46.3	44.1	43	40.8	39.7	37.5	35.4	34.3	33.5	31.1
TWL	EL.m	288.6	288.7	288.7	288.8	288.8	288.9	288.9	288.9	289	289
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	113	112.9	112.9	112.8	112.8	112.7	112.7	112.7	112.6	112.6
Pmax	MW	66	71	76	80	85	90	95	99	104	109
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
Effective Vol.	MCM	75.3	74.2	72	70.9	68.7	67.7	65.5	64.6	63.4	61
TWL	EL.m	288.7	288.8	288.8	288.8	288.9	288.9	289	289	289	289.1
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	117.9	117.8	117.8	117.8	117.7	117.7	117.6	117.6	117.6	117.5
Pmax	MW	78	82	87	92	97	101	106	111	116	120
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
Effective Vol.	MCM	106.9	105.8	103.6	102.5	100.7	99.5	97.1	95.9	94.7	92.3
TWL	EL.m	288.8	288.8	288.9	288.9	289	289	289	289.1	289.1	289.1
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	122.8	122.8	122.7	122.7	122.6	122.6	122.6	122.5	122.5	122.5
Pmax	MW	90	96	101	106	111	116	122	127	132	137
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
Effective Vol.	MCM	141.6	140.5	138.6	137.4	135	133.8	132.6	130.2	129	127.8
TWL	EL.m	288.9	288.9	289	289	289	289.1	289.1	289.1	289.2	289.2
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	127.7	127.7	127.6	127.6	127.6	127.5	127.5	127.5	127.4	127.4
Pmax	MW	105	111	116	122	127	133	138	144	149	155
Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
Effective Vol.	MCM	180.1	177.7	176.5	175.3	172.9	171.7	170.5	168.1	166.9	165.7
TWL	EL.m	289	289	289	289.1	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	132.6	132.6	132.6	132.5	132.5	132.5	132.4	132.4	132.3	132.3
Pmax	MW	122	128	133	139	145	150	156	162	167	173
Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
Effective Vol.	MCM	271.8	269.4	268.2	267	265.8	263.4	262.2	261	259.8	258.7
TWL	EL.m	289.1	289.2	289.2	289.2	289.3	289.3	289.3	289.4	289.4	289.4
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	142.5	142.4	142.4	142.4	142.3	142.3	142.3	142.2	142.2	142.2
Pmax	MW	158	165	171	177	183	189	196	202	208	214

Note: The numbers 1 to 10 mean case No. of maximum discharge at the same FSL.

Table 10.2.1-11 Main Features of Alternatives for Option IIIb

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	396.4	396.6	397	397.2	397.6	397.8	398.2	398.4	398.6	399
Effective Vol.	MCM	49.6	48.5	46.3	45.2	43	41.9	39.7	38.6	38.3	35.9
TWL	EL.m	288.6	288.7	288.7	288.8	288.8	288.9	288.9	288.9	289	289
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	113.4	113.3	113.3	113.2	113.2	113.1	113.1	113.1	113	113
Pmax	MW	66	71	76	81	85	90	95	100	105	109
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	396.8	397.2	397.4	397.8	398	398.2	398.6	398.8	399	399.2
Effective Vol.	MCM	79.7	77.5	76.4	74.2	73.1	72	69.8	69.4	68.2	67
TWL	EL.m	288.7	288.8	288.8	288.8	288.9	288.9	289	289	289	289.1
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	118.3	118.2	118.2	118.2	118.1	118.1	118	118	118	117.9
Pmax	MW	78	82	87	92	97	102	106	111	116	121
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	397.4	397.8	398	398.4	398.6	398.8	399	399.4	399.6	399.8
Effective Vol.	MCM	111.3	109.1	108	105.8	105.4	104.3	103.1	100.7	99.5	98.3
TWL	EL.m	288.8	288.8	288.9	288.9	289	289	289	289.1	289.1	289.1
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	123.2	123.2	123.1	123.1	123	123	123	122.9	122.9	122.9
Pmax	MW	91	96	101	106	111	117	122	127	132	137
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398	398.4	398.6	398.8	399.2	399.4	399.6	399.8	400.2	400.4
Effective Vol.	MCM	145.9	143.8	143.4	142.2	139.8	138.6	137.4	136.2	133.8	132.6
TWL	EL.m	288.9	288.9	289	289	289	289.1	289.1	289.1	289.2	289.2
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	128.1	128.1	128	128	128	127.9	127.9	127.9	127.8	127.8
Pmax	MW	105	111	116	122	128	133	139	144	149	155
Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	398.6	399	399.2	399.4	399.6	400	400.2	400.4	400.6	400.8
Effective Vol.	MCM	184.9	182.5	181.3	180.1	178.9	176.5	175.3	174.1	172.9	171.7
TWL	EL.m	289	289	289	289.1	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	133	133	133	132.9	132.9	132.9	132.8	132.8	132.7	132.7
Pmax	MW	122	128	134	139	145	151	156	162	168	174
Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	399.8	400	400.2	400.6	400.8	401	401.2	401.4	401.6	401.8
Effective Vol.	MCM	276.6	275.4	274.2	271.8	270.6	269.4	268.2	267	265.8	264.6
TWL	EL.m	289.1	289.2	289.2	289.2	289.3	289.3	289.3	289.4	289.4	289.4
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	142.9	142.8	142.8	142.8	142.7	142.7	142.7	142.6	142.6	142.6
Pmax	MW	159	165	171	178	184	190	196	202	209	215

Note: The numbers 1 to 10 mean case No. of maximum discharge at the same FSL..

Table 10.2.1-12 Main Features of Alternatives for Option IV

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
Effective Vol.	MCM	46.3	44.1	43	40.8	39.7	37.5	35.4	34.3	33.5	31.1
TWL	EL.m	302.5	302.5	302.6	302.6	302.6	302.7	302.7	302.7	302.7	302.8
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	99.3	99.3	99.2	99.2	99.2	99.1	99.1	99.1	99.1	99
Pmax	MW	58	62	66	71	75	79	83	87	92	96
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
Effective Vol.	MCM	75.3	74.2	72	70.9	68.7	67.7	65.5	64.6	63.4	61
TWL	EL.m	302.5	302.6	302.6	302.6	302.7	302.7	302.7	302.8	302.8	302.8
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	104.3	104.2	104.2	104.2	104.1	104.1	104.1	104	104	104
Pmax	MW	69	73	77	81	85	90	94	98	102	106
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
Effective Vol.	MCM	106.9	105.8	103.6	102.5	100.7	99.5	97.1	95.9	94.7	92.3
TWL	EL.m	302.6	302.6	302.7	302.7	302.7	302.8	302.8	302.8	302.8	302.9
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	109.2	109.2	109.1	109.1	109.1	109	109	109	109	108.9
Pmax	MW	80	85	90	94	99	103	108	113	117	122
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
Effective Vol.	MCM	141.6	140.5	138.6	137.4	135	133.8	132.6	130.2	129	127.8
TWL	EL.m	302.7	302.7	302.7	302.8	302.8	302.8	302.8	302.9	302.9	302.9
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	114.1	114.1	114.1	114	114	114	114	113.9	113.9	113.9
Pmax	MW	94	99	104	109	114	119	123	128	133	138
Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
Effective Vol.	MCM	180.1	177.7	176.5	175.3	172.9	171.7	170.5	168.1	166.9	165.7
TWL	EL.m	302.7	302.8	302.8	302.8	302.9	302.9	302.9	302.9	302.9	303
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	119.1	119	119	119	118.9	118.9	118.9	118.9	118.9	118.8
Pmax	MW	109	114	120	125	130	135	140	145	150	155
Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	124.6	12383	12256	12129	12003	11876	11749	11623	11496	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
Effective Vol.	MCM	271.8	269.4	268.2	267	265.8	263.4	262.2	261	259.8	258.7
TWL	EL.m	302.9	302.9	302.9	302.9	303	303	303	303	303	303.1
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	128.9	128.9	128.9	128.9	128.8	128.8	128.8	128.8	128.8	128.7
Pmax	MW	143	149	155	160	166	171	177	183	188	194

Note: The numbers 1 to 10 mean case No. of maximum discharge at the same FSL..

(10) Energy Calculation

As this project is operated for a 6 hour peak period, the annual energy is divided into primary energy, which is produced during peak time, and secondary energy, which is generated during off-peak time, and a firm capacity of 95% is also estimated. Regarding primary energy and secondary energy estimation from 24 hour operation, the conception is shown in **Fig 10.2.1-4**.

Primary energy, secondary energy, and the 95% firm capacity of each project alternative in (8) are shown in **Tables 10.2.1-13** to **10.2.1-17**, while simulation outputs are shown in the Appendix.

The reservoir operation rule is as shown in **Fig. 10.2.1-5**, whereby water is reserved during the rainy season, and utilized during the dry season, based on considerations shown in **Chapter 6**, and energy is calculated based on this operation rule and project specification.

Energy generated with reservoir operation rule, and with the sediment flushing shown in **Chapter 6** taken into consideration, will be estimated for the selected optimum plan later.

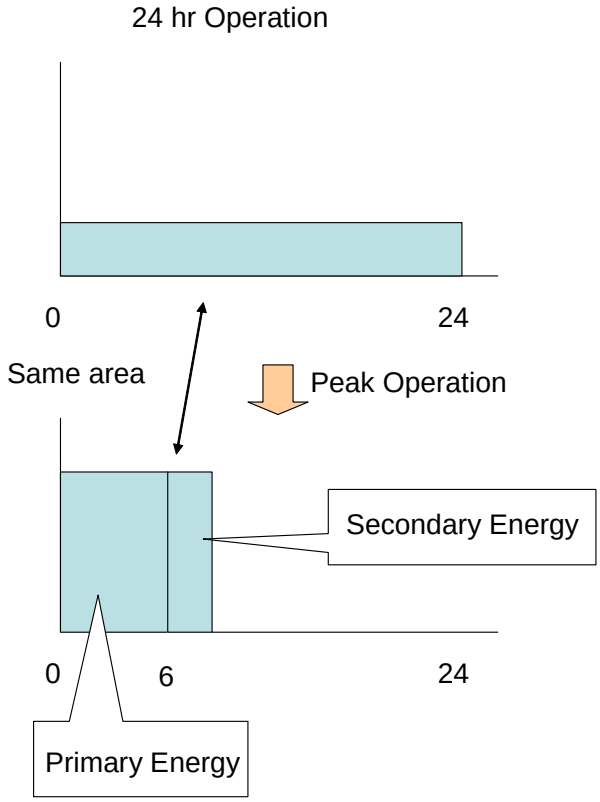


Fig. 10.2.1-4 Image of primary energy and secondary energy estimation

Table 10.2.1-13 Reservoir Simulation Result for Option I

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061016 395-1 output_.xls	395	395	393.60	307.30	58.30	45	0.951	40.350	95.220	184.250	279.470
2	061016 395-2 output_.xls	395	395	393.80	307.50	63.20	49	0.951	43.770	102.820	190.110	292.930
3	061016 395-3 output_.xls	395	395	394.00	307.60	68.00	52	0.951	46.600	109.720	194.360	304.080
4	061016 395-4 output_.xls	395	395	394.20	307.70	72.90	56	0.951	48.770	117.200	200.170	317.370
5	061016 395-5 output_.xls	395	395	394.60	307.80	77.70	60	0.951	46.710	124.110	205.430	329.540
6	061016 395-6 output_.xls	395	395	394.80	307.90	82.60	63	0.951	46.130	130.520	209.560	340.080
7	061016 405-1 output_.xls	405	405	394.40	307.70	75.00	64	0.951	50.520	130.480	232.400	362.880
8	061016 405-2 output_.xls	405	405	394.60	307.90	79.80	68	0.951	53.780	138.180	236.940	375.120
9	061016 405-3 output_.xls	405	405	394.80	308.00	84.60	72	0.951	57.120	145.830	241.280	387.110
10	061016 405-4 output_.xls	405	405	395.00	308.10	89.40	76	0.951	58.580	153.230	245.280	398.510
11	061016 405-5 output_.xls	405	405	395.20	308.20	94.20	81	0.951	61.870	160.560	250.280	410.840
12	061016 405-6 output_.xls	405	405	395.40	308.30	99.00	85	0.951	62.730	167.340	254.300	421.640
13	061016 405-7 output_.xls	405	405	395.60	308.40	103.70	88	0.951	58.470	173.320	257.370	430.690
14	061016 405-8 output_.xls	405	405	395.80	308.50	108.50	92	0.951	55.310	179.380	261.320	440.700
15	061016 405-9 output_.xls	405	405	396.00	308.60	113.30	96	0.951	48.850	184.870	265.120	449.990
16	061016 405-10 output_.xls	405	405	396.20	308.70	118.12	100	0.951	43.030	190.240	268.850	459.090
17	061019 410-1 output_.xls	410	410	394.80	307.90	83.30	75	0.951	55.520	149.170	257.650	406.820
18	061019 410-2 output_.xls	410	410	395.00	308.10	87.80	79	0.951	58.550	156.460	261.510	417.970
19	061019 410-3 output_.xls	410	410	395.20	308.20	92.40	83	0.951	61.500	163.800	265.140	428.940
20	061019 410-4 output_.xls	410	410	395.40	308.30	96.90	87	0.951	62.180	170.900	268.840	439.740
21	061019 410-5 output_.xls	410	410	395.60	308.40	101.50	91	0.951	65.280	177.770	272.510	450.280
22	061019 410-6 output_.xls	410	410	395.80	308.50	106.00	95	0.951	68.330	184.210	276.250	460.460
23	061019 410-7 output_.xls	410	410	396.00	308.60	110.60	99	0.951	70.020	190.380	279.560	469.940
24	061019 410-8 output_.xls	410	410	396.20	308.70	115.10	103	0.951	59.480	195.950	282.930	478.880
25	061019 410-9 output_.xls	410	410	396.20	308.80	119.70	107	0.951	53.800	201.230	286.430	487.660
26	061019 410-10 output_.xls	410	410	396.40	308.80	124.20	111	0.951	50.670	206.320	290.300	496.620
27	061016 415-1 output_.xls	415	415	395.20	308.20	92.20	87	0.951	60.810	169.140	283.150	452.290
28	061016 415-2 output_.xls	415	415	395.40	308.30	96.90	91	0.951	62.650	176.730	286.530	463.260
29	061016 415-3 output_.xls	415	415	395.60	308.40	101.70	96	0.951	64.240	184.680	291.150	475.830
30	061016 415-4 output_.xls	415	415	395.80	308.50	106.40	100	0.951	66.910	191.970	294.330	486.300
31	061016 415-5 output_.xls	415	415	396.00	308.60	111.20	105	0.951	70.090	199.080	298.050	497.130
32	061016 415-6 output_.xls	415	415	396.20	308.70	115.90	109	0.951	73.210	205.280	301.220	506.500
33	061016 415-7 output_.xls	415	415	396.40	308.80	120.70	113	0.951	72.090	211.180	303.900	515.080
34	061016 415-8 output_.xls	415	415	396.40	308.90	125.40	118	0.951	62.610	216.940	307.640	524.580
35	061016 415-9 output_.xls	415	415	396.60	309.00	130.20	122	0.951	58.080	222.400	311.060	533.460
36	061016 415-10 output_.xls	415	415	396.80	309.10	134.92	126	0.951	52.050	227.100	314.350	541.450
37	061020 420-1 output_.xls	420	420	395.60	308.40	101.88	101	0.951	64.550	191.200	310.650	501.850
38	061020 420-2 output_.xls	420	420	395.80	308.50	106.70	105	0.951	65.660	198.960	313.870	512.830
39	061020 420-3 output_.xls	420	420	396.00	308.60	111.60	110	0.951	68.810	206.780	317.460	524.240
40	061020 420-4 output_.xls	420	420	396.20	308.70	116.50	115	0.951	71.980	214.140	320.540	534.680
41	061020 420-5 output_.xls	420	420	396.40	308.80	121.30	119	0.951	75.110	220.520	323.280	543.800
42	061020 420-6 output_.xls	420	420	396.60	308.90	126.20	124	0.951	78.310	226.960	326.890	553.850
43	061020 420-7 output_.xls	420	420	396.60	309.00	131.00	129	0.951	74.550	232.710	330.230	562.940
44	061020 420-8 output_.xls	420	420	396.80	309.10	135.90	133	0.951	61.160	238.280	333.170	571.450
45	061020 420-9 output_.xls	420	420	397.00	309.20	140.70	138	0.951	59.490	243.630	337.120	580.750
46	061020 420-10 output_.xls	420	420	397.20	309.30	145.60	143	0.951	54.960	248.250	340.820	589.070
47	061016 425-1 output_.xls	425	425	396.00	308.60	112.50	116	0.951	68.050	215.250	339.010	554.260
48	061016 425-2 output_.xls	425	425	396.20	308.70	117.40	121	0.951	71.000	223.050	341.990	565.040
49	061016 425-3 output_.xls	425	425	396.40	308.80	122.20	126	0.951	74.060	230.190	344.960	575.150
50	061016 425-4 output_.xls	425	425	396.60	308.90	127.10	131	0.951	77.200	237.290	347.790	585.080
51	061016 425-5 output_.xls	425	425	396.80	309.00	131.90	135	0.951	80.290	243.190	350.370	593.560
52	061016 425-6 output_.xls	425	425	397.00	309.10	136.80	140	0.951	78.340	249.210	353.570	602.780
53	061016 425-7 output_.xls	425	425	397.00	309.20	141.60	145	0.951	73.670	254.710	357.180	611.890
54	061016 425-8 output_.xls	425	425	397.20	309.30	146.50	150	0.951	59.800	260.220	360.530	620.750
55	061016 425-9 output_.xls	425	425	397.40	309.40	151.30	155	0.951	59.330	265.330	363.510	628.840
56	061016 425-10 output_.xls	425	425	397.60	309.50	156.20	160	0.951	52.700	269.140	367.460	636.600
57	061016 435-1 output_.xls	435	435	396.80	309.10	134.20	150	0.951	78.120	265.740	398.560	664.300
58	061016 435-2 output_.xls	435	435	397.00	309.10	139.10	155	0.951	81.260	273.310	401.270	674.580
59	061016 435-3 output_.xls	435	435	397.20	309.20	144.00	160	0.951	84.310	279.930	403.560	683.490
60	061016 435-4 output_.xls	435	435	397.40	309.30	149.00	166	0.951	87.430	286.340	406.620	692.960
61	061016 435-5 output_.xls	435	435	397.40	309.40	153.90	171	0.951	83.370	291.740	409.150	700.890
62	061016 435-6 output_.xls	435	435	397.60	309.50	158.80	176	0.951	72.850	296.790	411.990	708.780
63	061016 435-7 output_.xls	435	435	397.80	309.60	163.70	182	0.951	69.280	301.710	415.630	717.340
64	061016 435-8 output_.xls	435	435	398.00	309.70	168.70	187	0.951	66.560	305.860	418.910	724.770
65	061016 435-9 output_.xls	435	435	398.20	309.80	173.60	192	0.951	57.040	309.100	422.600	731.700
66	061016 435-10 output_.xls	435	435	398.20	309.90	178.50	198	0.951	54.750	312.300	426.650	738.950

Table 10.2.1-14 Reservoir Simulation Result for Option II

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061016 405-1 output_.xls	405	405	397.00	307.60	65.40	56	0.951	45.750	115.440	217.020	332.460
2	061016 405-2 output_.xls	405	405	397.40	307.60	70.20	60	0.951	49.400	123.600	222.140	345.750
3	061016 405-3 output_.xls	405	405	397.60	307.70	75.00	64	0.951	52.870	131.560	227.200	358.760
4	061016 405-4 output_.xls	405	405	398.00	307.70	79.80	68	0.951	56.160	139.560	231.800	371.350
5	061016 405-5 output_.xls	405	405	398.20	307.70	84.60	73	0.951	58.730	147.490	237.350	384.830
6	061016 405-6 output_.xls	405	405	398.60	307.80	89.30	76	0.951	59.650	154.170	240.460	394.630
7	061016 405-7 output_.xls	405	405	399.00	307.80	94.10	81	0.951	54.380	161.420	246.030	407.450
8	061016 405-8 output_.xls	405	405	399.20	307.80	98.90	85	0.951	49.710	168.040	250.720	418.760
9	061016 405-9 output_.xls	405	405	399.40	307.80	103.70	89	0.951	44.190	174.270	255.320	429.590
10	061016 405-10 output_.xls	405	405	399.80	307.90	108.50	93	0.951	43.620	180.100	259.200	439.300
11	061019 410-1 output_.xls	410	410	397.60	307.70	73.70	66	0.951	51.180	133.900	241.720	375.610
12	061019 410-2 output_.xls	410	410	397.80	307.70	78.20	71	0.951	54.460	142.010	247.550	389.560
13	061019 410-3 output_.xls	410	410	398.20	307.70	82.80	75	0.951	58.000	150.020	252.050	402.070
14	061019 410-4 output_.xls	410	410	398.40	307.80	87.30	79	0.951	60.040	157.390	255.970	413.360
15	061019 410-5 output_.xls	410	410	398.80	307.80	91.90	83	0.951	62.750	164.940	259.950	424.890
16	061019 410-6 output_.xls	410	410	399.00	307.80	96.40	87	0.951	66.040	171.940	264.040	435.980
17	061019 410-7 output_.xls	410	410	399.40	307.80	101.00	91	0.951	66.120	178.920	267.990	446.910
18	061019 410-8 output_.xls	410	410	399.60	307.90	105.50	95	0.951	58.780	185.120	271.790	456.910
19	061019 410-9 output_.xls	410	410	399.80	307.90	110.10	99	0.951	55.810	191.130	275.540	466.670
20	061019 410-10 output_.xls	410	410	400.20	307.90	114.60	103	0.951	49.100	196.560	279.340	475.910
21	061016 415-1 output_.xls	415	415	398.20	307.70	82.60	78	0.951	57.090	154.520	268.860	423.380
22	061016 415-2 output_.xls	415	415	398.40	307.80	87.30	83	0.951	60.440	162.730	273.580	436.320
23	061016 415-3 output_.xls	415	415	398.80	307.80	92.10	87	0.951	63.360	171.050	277.570	448.610
24	061016 415-4 output_.xls	415	415	399.00	307.80	96.80	92	0.951	64.720	179.120	282.020	461.140
25	061016 415-5 output_.xls	415	415	399.40	307.80	101.60	96	0.951	68.380	187.020	285.840	472.860
26	061016 415-6 output_.xls	415	415	399.60	307.90	106.30	100	0.951	71.700	193.850	289.100	482.950
27	061016 415-7 output_.xls	415	415	400.00	307.90	111.10	105	0.951	74.820	201.130	293.430	494.560
28	061016 415-8 output_.xls	415	415	400.20	307.90	115.80	109	0.951	63.500	207.220	296.570	503.790
29	061016 415-9 output_.xls	415	415	400.40	307.90	120.60	114	0.951	59.850	213.600	301.130	514.720
30	061016 415-10 output_.xls	415	415	400.80	308.00	125.30	118	0.951	50.290	218.790	304.500	523.290
31	061020 420-1 output_.xls	420	420	398.80	307.80	92.30	91	0.951	63.270	176.910	296.310	473.220
32	061020 420-2 output_.xls	420	420	399.00	307.80	97.20	96	0.951	64.620	185.640	301.080	486.720
33	061020 420-3 output_.xls	420	420	399.40	307.80	102.00	101	0.951	67.060	194.200	305.430	499.630
34	061020 420-4 output_.xls	420	420	399.60	307.90	106.90	106	0.951	70.430	202.290	309.000	511.290
35	061020 420-5 output_.xls	420	420	400.00	307.90	111.70	111	0.951	74.080	209.900	312.510	522.410
36	061020 420-6 output_.xls	420	420	400.20	307.90	116.60	115	0.951	77.590	216.810	315.500	532.310
37	061020 420-7 output_.xls	420	420	400.40	307.90	121.40	120	0.951	76.990	223.620	319.410	543.030
38	061020 420-8 output_.xls	420	420	400.80	308.00	126.30	125	0.951	63.990	230.050	323.110	553.160
39	061020 420-9 output_.xls	420	420	401.00	308.00	131.10	130	0.951	61.940	235.990	327.080	563.070
40	061020 420-10 output_.xls	420	420	401.20	308.00	136.00	134	0.951	56.710	241.230	330.820	572.050
41	061016 425-1 output_.xls	425	425	399.40	307.80	102.90	106	0.951	67.720	201.750	325.970	527.720
42	061016 425-2 output_.xls	425	425	399.80	307.90	107.80	111	0.951	69.790	210.310	329.360	539.670
43	061016 425-3 output_.xls	425	425	400.00	307.90	112.60	116	0.951	73.140	218.440	332.790	551.230
44	061016 425-4 output_.xls	425	425	400.20	307.90	117.50	122	0.951	76.570	226.570	336.920	563.490
45	061016 425-5 output_.xls	425	425	400.60	307.90	122.30	126	0.951	80.210	233.700	339.630	573.330
46	061016 425-6 output_.xls	425	425	400.80	308.00	127.20	131	0.951	83.360	240.290	342.980	583.270
47	061016 425-7 output_.xls	425	425	401.00	308.00	132.00	136	0.951	76.930	246.690	346.470	593.160
48	061016 425-8 output_.xls	425	425	401.40	308.00	136.90	141	0.951	62.610	252.940	350.210	603.150
49	061016 425-9 output_.xls	425	425	401.60	308.00	141.70	146	0.951	62.090	258.880	354.010	612.890
50	061016 425-10 output_.xls	425	425	401.80	308.10	146.60	151	0.951	57.310	263.760	357.850	621.610
51	061016 435-1 output_.xls	435	435	400.60	308.00	124.60	140	0.951	78.360	254.590	388.240	642.820
52	061016 435-2 output_.xls	435	435	401.00	308.00	129.50	145	0.951	81.990	262.840	390.590	653.430
53	061016 435-3 output_.xls	435	435	401.20	308.00	134.40	151	0.951	85.370	270.840	394.140	664.980
54	061016 435-4 output_.xls	435	435	401.40	308.00	139.40	156	0.951	88.840	277.990	396.780	674.770
55	061016 435-5 output_.xls	435	435	401.60	308.00	144.30	162	0.951	92.190	284.960	400.330	685.290
56	061016 435-6 output_.xls	435	435	402.00	308.10	149.20	167	0.951	78.420	290.870	402.740	693.610
57	061016 435-7 output_.xls	435	435	402.20	308.10	154.10	173	0.951	73.050	296.810	406.650	703.460
58	061016 435-8 output_.xls	435	435	402.40	308.10	159.10	178	0.951	65.480	302.140	409.870	712.010
59	061016 435-9 output_.xls	435	435	402.60	308.10	164.00	184	0.951	61.970	306.490	414.850	721.340
60	061016 435-10 output_.xls	435	435	402.80	308.10	168.90	189	0.951	57.300	310.720	418.740	729.460

Table 10.2.1-15 Reservoir Simulation Result for Option IIIa

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061016 405-1 output_.xls	405	405	397.00	288.60	65.40	66	0.951	54.760	136.430	255.870	392.300
2	061016 405-2 output_.xls	405	405	397.40	288.70	70.20	71	0.951	59.020	146.020	261.920	407.940
3	061016 405-3 output_.xls	405	405	397.60	288.70	75.00	76	0.951	63.210	155.630	268.200	423.830
4	061016 405-4 output_.xls	405	405	398.00	288.80	79.80	80	0.951	67.040	164.750	272.880	437.630
5	061016 405-5 output_.xls	405	405	398.20	288.80	84.60	85	0.951	70.180	173.870	278.680	452.550
6	061016 405-6 output_.xls	405	405	398.60	288.90	89.30	90	0.951	70.870	182.240	283.910	466.150
7	061016 405-7 output_.xls	405	405	399.00	288.90	94.10	95	0.951	64.870	190.450	289.280	479.730
8	061016 405-8 output_.xls	405	405	399.20	288.90	98.90	99	0.951	59.470	197.980	293.950	491.930
9	061016 405-9 output_.xls	405	405	399.40	289.00	103.70	104	0.951	52.920	205.330	299.520	504.850
10	061016 405-10 output_.x	405	405	399.80	289.00	108.50	109	0.951	52.280	212.510	304.680	517.190
11	061019 410-1 output_.xls	410	410	397.60	288.70	73.70	78	0.951	61.350	157.720	283.950	441.670
12	061019 410-2 output_.xls	410	410	397.80	288.80	78.20	82	0.951	65.190	166.570	288.910	455.480
13	061019 410-3 output_.xls	410	410	398.20	288.80	82.80	87	0.951	69.350	176.060	294.440	470.500
14	061019 410-4 output_.xls	410	410	398.40	288.80	87.30	92	0.951	71.820	185.030	299.380	484.410
15	061019 410-5 output_.xls	410	410	398.80	288.90	91.90	97	0.951	75.200	193.700	303.840	497.540
16	061019 410-6 output_.xls	410	410	399.00	288.90	96.40	101	0.951	79.100	201.830	308.060	509.880
17	061019 410-7 output_.xls	410	410	399.40	289.00	101.00	106	0.951	78.480	210.030	312.930	522.960
18	061019 410-8 output_.xls	410	410	399.60	289.00	105.50	111	0.951	70.000	217.580	317.680	535.260
19	061019 410-9 output_.xls	410	410	399.80	289.00	110.10	116	0.951	66.720	224.750	322.330	547.080
20	061019 410-10 output_.x	410	410	400.20	289.10	114.60	120	0.951	58.680	230.870	326.210	557.080
21	061016 415-1 output_.xls	415	415	398.20	288.80	82.60	90	0.951	68.440	180.470	312.100	492.570
22	061016 415-2 output_.xls	415	415	398.40	288.80	87.30	96	0.951	72.500	190.440	318.350	508.790
23	061016 415-3 output_.xls	415	415	398.80	288.90	92.10	101	0.951	75.680	200.130	322.960	523.090
24	061016 415-4 output_.xls	415	415	399.00	288.90	96.80	106	0.951	77.850	209.500	327.650	537.150
25	061016 415-5 output_.xls	415	415	399.40	289.00	101.60	111	0.951	82.080	218.570	331.830	550.400
26	061016 415-6 output_.xls	415	415	399.60	289.00	106.30	116	0.951	86.110	226.990	336.260	563.260
27	061016 415-7 output_.xls	415	415	400.00	289.00	111.10	122	0.951	88.670	235.450	341.020	576.470
28	061016 415-8 output_.xls	415	415	400.20	289.10	115.80	127	0.951	75.710	242.700	345.020	587.720
29	061016 415-9 output_.xls	415	415	400.40	289.10	120.60	132	0.951	71.440	249.940	349.610	599.540
30	061016 415-10 output_.x	415	415	400.80	289.10	125.30	137	0.951	60.160	256.440	354.270	610.710
31	061020 420-1 output_.xls	420	420	398.80	288.90	92.30	105	0.951	75.670	206.150	343.300	549.460
32	061020 420-2 output_.xls	420	420	399.00	288.90	97.20	111	0.951	77.500	216.410	348.880	565.290
33	061020 420-3 output_.xls	420	420	399.40	289.00	102.00	116	0.951	80.810	226.000	352.720	578.720
34	061020 420-4 output_.xls	420	420	399.60	289.00	106.90	122	0.951	84.920	235.780	357.270	593.040
35	061020 420-5 output_.xls	420	420	400.00	289.00	111.70	127	0.951	89.220	244.600	360.900	605.500
36	061020 420-6 output_.xls	420	420	400.20	289.10	116.60	133	0.951	93.300	252.870	365.090	617.960
37	061020 420-7 output_.xls	420	420	400.40	289.10	121.40	138	0.951	91.470	260.710	368.900	629.620
38	061020 420-8 output_.xls	420	420	400.80	289.10	126.30	144	0.951	76.410	268.520	373.430	641.950
39	061020 420-9 output_.xls	420	420	401.00	289.20	131.10	149	0.951	73.830	275.200	377.580	652.770
40	061020 420-10 output_.x	420	420	401.20	289.20	136.00	155	0.951	67.590	281.710	382.790	664.500
41	061016 425-1 output_.xls	425	425	399.40	289.00	102.90	122	0.951	81.130	234.210	375.940	610.150
42	061016 425-2 output_.xls	425	425	399.80	289.00	107.80	128	0.951	84.260	244.440	379.960	624.400
43	061016 425-3 output_.xls	425	425	400.00	289.00	112.60	133	0.951	88.250	253.830	383.320	637.150
44	061016 425-4 output_.xls	425	425	400.20	289.10	117.50	139	0.951	92.260	261.010	387.310	648.320
45	061016 425-5 output_.xls	425	425	400.60	289.10	122.30	145	0.951	96.560	267.610	391.230	658.840
46	061016 425-6 output_.xls	425	425	400.80	289.10	127.20	150	0.951	97.500	272.460	394.610	667.070
47	061016 425-7 output_.xls	425	425	401.00	289.20	132.00	156	0.951	91.530	283.930	398.710	682.640
48	061016 425-8 output_.xls	425	425	401.40	289.20	136.90	162	0.951	74.720	293.260	403.180	696.440
49	061016 425-9 output_.xls	425	425	401.60	289.30	141.70	167	0.951	74.040	300.790	406.760	707.550
50	061016 425-10 output_.x	425	425	401.80	289.30	146.60	173	0.951	68.420	306.910	411.640	718.550
51	061016 435-1 output_.xls	435	435	400.60	289.10	124.60	158	0.951	95.140	293.480	442.460	735.950
52	061016 435-2 output_.xls	435	435	401.00	289.20	129.50	165	0.951	99.320	303.280	445.900	749.180
53	061016 435-3 output_.xls	435	435	401.20	289.20	134.40	171	0.951	103.360	309.440	449.200	758.640
54	061016 435-4 output_.xls	435	435	401.40	289.20	139.40	177	0.951	107.500	313.950	452.620	766.570
55	061016 435-5 output_.xls	435	435	401.60	289.30	144.30	183	0.951	108.880	318.670	455.560	774.230
56	061016 435-6 output_.xls	435	435	402.00	289.30	149.20	189	0.951	93.350	328.980	458.840	787.820
57	061016 435-7 output_.xls	435	435	402.20	289.30	154.10	196	0.951	87.070	339.000	463.320	802.320
58	061016 435-8 output_.xls	435	435	402.40	289.40	159.10	202	0.951	77.790	349.200	467.240	816.450
59	061016 435-9 output_.xls	435	435	402.60	289.40	164.00	208	0.951	73.700	354.140	472.100	826.240
60	061016 435-10 output_.x	435	435	402.80	289.40	168.90	214	0.951	68.380	359.260	476.880	836.140

Table 10.2.1-16 Reservoir Simulation Result for Option IIIb

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061016 405-1 output_.xls	405	405	396.40	288.60	65.40	66	0.951	54.560	136.550	256.870	393.420
2	061016 405-2 output_.xls	405	405	396.60	288.70	70.20	71	0.951	58.650	146.230	263.530	409.750
3	061016 405-3 output_.xls	405	405	397.00	288.70	75.00	76	0.951	62.970	155.910	269.670	425.580
4	061016 405-4 output_.xls	405	405	397.20	288.80	79.80	81	0.951	67.100	165.220	275.200	440.420
5	061016 405-5 output_.xls	405	405	397.60	288.80	84.60	85	0.951	69.850	174.080	279.580	453.660
6	061016 405-6 output_.xls	405	405	397.80	288.90	89.30	90	0.951	73.870	182.570	285.090	467.660
7	061016 405-7 output_.xls	405	405	398.20	288.90	94.10	95	0.951	68.270	190.960	290.680	481.640
8	061016 405-8 output_.xls	405	405	398.40	288.90	98.90	100	0.951	61.090	198.940	296.130	495.060
9	061016 405-9 output_.xls	405	405	398.60	289.00	103.70	105	0.951	55.140	206.130	301.230	507.360
10	061016 405-10 output_.x	405	405	399.00	289.00	108.50	109	0.951	51.980	213.000	305.370	518.370
11	061019 410-1 output_.xls	410	410	396.80	288.70	73.70	78	0.951	60.980	157.850	285.670	443.520
12	061019 410-2 output_.xls	410	410	397.20	288.80	78.20	82	0.951	64.950	166.650	289.930	456.580
13	061019 410-3 output_.xls	410	410	397.40	288.80	82.80	87	0.951	68.940	176.070	295.610	471.690
14	061019 410-4 output_.xls	410	410	397.80	288.80	87.30	92	0.951	72.050	185.270	300.680	485.950
15	061019 410-5 output_.xls	410	410	398.00	288.90	91.90	97	0.951	74.640	194.020	305.430	499.450
16	061019 410-6 output_.xls	410	410	398.20	288.90	96.40	102	0.951	78.510	202.380	310.150	512.520
17	061019 410-7 output_.xls	410	410	398.60	289.00	101.00	106	0.951	82.630	210.260	313.970	524.230
18	061019 410-8 output_.xls	410	410	398.80	289.00	105.50	111	0.951	75.670	218.000	319.000	537.000
19	061019 410-9 output_.xls	410	410	399.00	289.00	110.10	116	0.951	66.370	225.330	323.760	549.080
20	061019 410-10 output_.x	410	410	399.20	289.10	114.60	121	0.951	65.090	231.640	328.010	559.660
21	061016 415-1 output_.xls	415	415	397.40	288.80	82.60	91	0.951	68.030	180.950	314.780	495.730
22	061016 415-2 output_.xls	415	415	397.80	288.80	87.30	96	0.951	72.240	190.740	319.820	510.560
23	061016 415-3 output_.xls	415	415	398.00	288.90	92.10	101	0.951	75.210	200.200	324.350	524.550
24	061016 415-4 output_.xls	415	415	398.40	288.90	96.80	106	0.951	77.680	209.640	328.720	538.360
25	061016 415-5 output_.xls	415	415	398.60	289.00	101.60	111	0.951	81.460	218.690	332.980	551.680
26	061016 415-6 output_.xls	415	415	398.80	289.00	106.30	117	0.951	85.460	227.530	338.520	566.050
27	061016 415-7 output_.xls	415	415	399.00	289.00	111.10	122	0.951	89.570	235.730	342.830	578.560
28	061016 415-8 output_.xls	415	415	399.40	289.10	115.80	127	0.951	76.850	243.080	346.520	589.600
29	061016 415-9 output_.xls	415	415	399.60	289.10	120.60	132	0.951	71.050	250.350	350.580	600.930
30	061016 415-10 output_.x	415	415	399.80	289.10	125.30	137	0.951	64.990	256.850	355.160	612.000
31	061020 420-1 output_.xls	420	420	398.00	288.90	92.30	105	0.951	75.190	206.150	344.570	550.730
32	061020 420-2 output_.xls	420	420	398.40	288.90	97.20	111	0.951	77.180	216.640	350.210	566.850
33	061020 420-3 output_.xls	420	420	398.60	289.00	102.00	116	0.951	80.190	225.980	354.010	579.990
34	061020 420-4 output_.xls	420	420	398.80	289.00	106.90	122	0.951	84.280	235.900	358.830	594.720
35	061020 420-5 output_.xls	420	420	399.20	289.00	111.70	128	0.951	88.550	245.030	362.980	608.010
36	061020 420-6 output_.xls	420	420	399.40	289.10	116.60	133	0.951	92.600	253.170	366.600	619.770
37	061020 420-7 output_.xls	420	420	399.60	289.10	121.40	139	0.951	95.040	261.220	370.860	632.080
38	061020 420-8 output_.xls	420	420	399.80	289.10	126.30	144	0.951	78.170	268.660	374.960	643.610
39	061020 420-9 output_.xls	420	420	400.20	289.20	131.10	149	0.951	75.130	275.520	378.560	654.080
40	061020 420-10 output_.x	420	420	400.40	289.20	136.00	155	0.951	68.820	282.220	384.090	666.310
41	061016 425-1 output_.xls	425	425	398.60	289.00	102.90	122	0.951	80.610	234.300	377.520	611.810
42	061016 425-2 output_.xls	425	425	399.00	289.00	107.80	128	0.951	83.650	244.630	381.810	626.440
43	061016 425-3 output_.xls	425	425	399.20	289.00	112.60	134	0.951	87.600	254.170	385.640	639.800
44	061016 425-4 output_.xls	425	425	399.40	289.10	117.50	139	0.951	91.570	261.030	388.670	649.700
45	061016 425-5 output_.xls	425	425	399.60	289.10	122.30	145	0.951	95.560	268.830	392.960	661.790
46	061016 425-6 output_.xls	425	425	400.00	289.10	127.20	151	0.951	99.930	273.010	396.950	669.960
47	061016 425-7 output_.xls	425	425	400.20	289.20	132.00	156	0.951	91.100	284.110	399.900	684.010
48	061016 425-8 output_.xls	425	425	400.40	289.20	136.90	162	0.951	81.010	293.440	404.570	698.010
49	061016 425-9 output_.xls	425	425	400.60	289.30	141.70	168	0.951	73.480	301.380	408.800	710.170
50	061016 425-10 output_.x	425	425	400.80	289.30	146.60	174	0.951	71.270	307.480	413.460	720.930
51	061016 435-1 output_.xls	435	435	399.80	289.10	124.60	159	0.951	94.410	293.910	445.100	739.010
52	061016 435-2 output_.xls	435	435	400.00	289.20	129.50	165	0.951	98.290	303.280	447.940	751.220
53	061016 435-3 output_.xls	435	435	400.20	289.20	134.40	171	0.951	102.290	309.460	450.850	760.310
54	061016 435-4 output_.xls	435	435	400.60	289.20	139.40	178	0.951	106.670	314.390	454.760	769.150
55	061016 435-5 output_.xls	435	435	400.80	289.30	144.30	184	0.951	110.610	319.150	457.780	776.930
56	061016 435-6 output_.xls	435	435	401.00	289.30	149.20	190	0.951	94.740	329.480	461.130	790.610
57	061016 435-7 output_.xls	435	435	401.20	289.30	154.10	196	0.951	88.340	339.230	464.850	804.080
58	061016 435-8 output_.xls	435	435	401.40	289.40	159.10	202	0.951	84.750	349.420	468.530	817.950
59	061016 435-9 output_.xls	435	435	401.60	289.40	164.00	209	0.951	75.420	354.710	474.000	828.720
60	061016 435-10 output_.x	435	435	401.80	289.40	168.90	215	0.951	68.090	359.750	478.910	838.660

Table 10.2.1-17 Reservoir Simulation Result for Option IV

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061016 405-1 output_.xls	405	405	397.00	302.50	65.40	58	0.951	47.470	119.480	224.480	343.960
2	061016 405-2 output_.xls	405	405	397.40	302.50	70.20	62	0.951	51.250	127.800	229.560	357.360
3	061016 405-3 output_.xls	405	405	397.60	302.60	75.00	66	0.951	54.840	135.990	234.470	370.460
4	061016 405-4 output_.xls	405	405	398.00	302.60	79.80	71	0.951	58.260	144.590	240.280	384.870
5	061016 405-5 output_.xls	405	405	398.20	302.60	84.60	75	0.951	60.930	152.500	245.070	397.570
6	061016 405-6 output_.xls	405	405	398.60	302.70	89.30	79	0.951	61.970	159.690	249.320	409.010
7	061016 405-7 output_.xls	405	405	399.00	302.70	94.10	83	0.951	56.700	166.780	253.600	420.380
8	061016 405-8 output_.xls	405	405	399.20	302.70	98.90	87	0.951	51.960	173.490	258.070	431.570
9	061016 405-9 output_.xls	405	405	399.40	302.70	103.70	92	0.951	46.300	180.270	263.650	443.920
10	061016 405-10 output_.x	405	405	399.80	302.80	108.50	96	0.951	45.730	186.310	267.690	454.000
11	061019 410-1 output_.xls	410	410	397.60	302.50	73.70	69	0.951	53.220	138.780	250.610	389.390
12	061019 410-2 output_.xls	410	410	397.80	302.60	78.20	73	0.951	56.560	146.670	255.350	402.020
13	061019 410-3 output_.xls	410	410	398.20	302.60	82.80	77	0.951	60.210	154.930	259.910	414.840
14	061019 410-4 output_.xls	410	410	398.40	302.60	87.30	81	0.951	62.430	162.660	263.820	426.490
15	061019 410-5 output_.xls	410	410	398.80	302.70	91.90	85	0.951	65.180	170.160	267.430	437.590
16	061019 410-6 output_.xls	410	410	399.00	302.70	96.40	90	0.951	68.590	177.660	272.330	449.990
17	061019 410-7 output_.xls	410	410	399.40	302.70	101.00	94	0.951	68.690	184.890	276.540	461.440
18	061019 410-8 output_.xls	410	410	399.60	302.80	105.50	98	0.951	61.320	191.320	280.400	471.710
19	061019 410-9 output_.xls	410	410	399.80	302.80	110.10	102	0.951	58.330	197.510	284.120	481.630
20	061019 410-10 output_.x	410	410	400.20	302.80	114.60	106	0.951	51.430	203.090	287.860	490.950
21	061016 415-1 output_.xls	415	415	398.20	302.60	82.60	80	0.951	59.340	159.330	276.530	435.860
22	061016 415-2 output_.xls	415	415	398.40	302.60	87.30	85	0.951	62.880	168.090	281.920	450.010
23	061016 415-3 output_.xls	415	415	398.80	302.70	92.10	90	0.951	65.850	176.670	286.230	462.900
24	061016 415-4 output_.xls	415	415	399.00	302.70	96.80	94	0.951	67.330	184.740	290.070	474.810
25	061016 415-5 output_.xls	415	415	399.40	302.70	101.60	99	0.951	71.120	193.150	294.750	487.900
26	061016 415-6 output_.xls	415	415	399.60	302.80	106.30	103	0.951	74.550	200.210	297.910	498.120
27	061016 415-7 output_.xls	415	415	400.00	302.80	111.10	108	0.951	77.670	207.660	302.170	509.820
28	061016 415-8 output_.xls	415	415	400.20	302.80	115.80	113	0.951	66.270	214.260	306.180	520.440
29	061016 415-9 output_.xls	415	415	400.40	302.80	120.60	117	0.951	62.560	220.500	309.740	530.230
30	061016 415-10 output_.x	415	415	400.80	302.90	125.30	122	0.951	52.700	226.190	314.160	540.350
31	061020 420-1 output_.xls	420	420	398.80	302.70	92.30	94	0.951	65.810	182.690	305.770	488.460
32	061020 420-2 output_.xls	420	420	399.00	302.70	97.20	99	0.951	67.300	191.650	310.410	502.060
33	061020 420-3 output_.xls	420	420	399.40	302.70	102.00	104	0.951	69.850	200.380	314.480	514.860
34	061020 420-4 output_.xls	420	420	399.60	302.80	106.90	109	0.951	73.350	208.710	317.990	526.700
35	061020 420-5 output_.xls	420	420	400.00	302.80	111.70	114	0.951	77.120	216.600	321.570	538.170
36	061020 420-6 output_.xls	420	420	400.20	302.80	116.60	119	0.951	80.760	223.940	325.280	549.230
37	061020 420-7 output_.xls	420	420	400.40	302.90	121.40	123	0.951	79.970	230.480	328.050	558.540
38	061020 420-8 output_.xls	420	420	400.80	302.90	126.30	128	0.951	66.870	237.310	331.890	569.200
39	061020 420-9 output_.xls	420	420	401.00	302.90	131.10	133	0.951	64.770	243.540	336.140	579.680
40	061020 420-10 output_.x	420	420	401.20	302.90	136.00	138	0.951	59.380	249.220	340.700	589.920
41	061016 425-1 output_.xls	425	425	399.40	302.70	102.90	109	0.951	70.570	208.020	335.460	543.480
42	061016 425-2 output_.xls	425	425	399.80	302.80	107.80	114	0.951	72.750	216.820	338.720	555.530
43	061016 425-3 output_.xls	425	425	400.00	302.80	112.60	120	0.951	76.220	225.470	342.870	568.340
44	061016 425-4 output_.xls	425	425	400.20	302.80	117.50	125	0.951	79.780	233.650	346.370	580.020
45	061016 425-5 output_.xls	425	425	400.60	302.90	122.30	130	0.951	83.450	241.030	349.610	590.640
46	061016 425-6 output_.xls	425	425	400.80	302.90	127.20	135	0.951	86.400	248.060	353.180	601.230
47	061016 425-7 output_.xls	425	425	401.00	302.90	132.00	140	0.951	80.170	254.630	356.570	611.210
48	061016 425-8 output_.xls	425	425	401.40	302.90	136.90	145	0.951	65.510	261.070	360.260	621.330
49	061016 425-9 output_.xls	425	425	401.60	302.90	141.70	150	0.951	64.990	267.180	364.010	631.190
50	061016 425-10 output_.x	425	425	401.80	303.00	146.60	155	0.951	60.060	272.220	367.820	640.040
51	061016 435-1 output_.xls	435	435	400.60	302.90	124.60	143	0.951	81.850	262.040	398.030	660.070
52	061016 435-2 output_.xls	435	435	401.00	302.90	129.50	149	0.951	85.610	270.880	401.380	672.260
53	061016 435-3 output_.xls	435	435	401.20	302.90	134.40	155	0.951	89.130	279.000	404.500	683.500
54	061016 435-4 output_.xls	435	435	401.40	302.90	139.40	160	0.951	92.730	286.470	407.360	693.830
55	061016 435-5 output_.xls	435	435	401.60	303.00	144.30	166	0.951	95.730	293.410	410.560	703.980
56	061016 435-6 output_.xls	435	435	402.00	303.00	149.20	171	0.951	81.870	299.760	413.150	712.900
57	061016 435-7 output_.xls	435	435	402.20	303.00	154.10	177	0.951	76.380	305.880	417.070	722.950
58	061016 435-8 output_.xls	435	435	402.40	303.00	159.10	183	0.951	68.530	311.680	421.130	732.820
59	061016 435-9 output_.xls	435	435	402.60	303.00	164.00	188	0.951	64.960	315.900	425.180	741.080
60	061016 435-10 output_.x	435	435	402.80	303.10	168.90	194	0.951	60.050	320.330	429.790	750.120

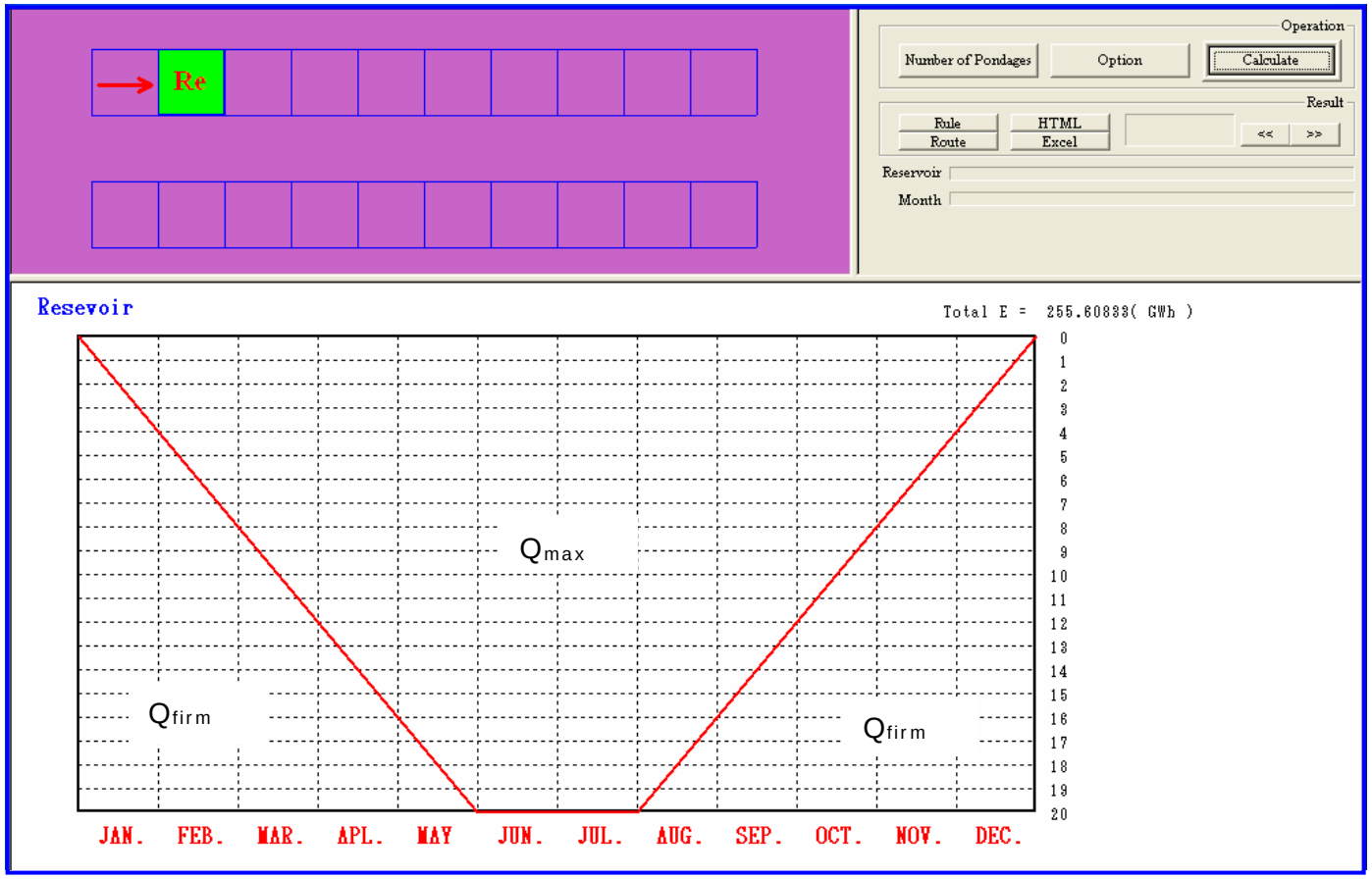


Fig. 10.2.1-5 Reservoir Operation Rule in Energy Calculation

10.2.2 Project Cost Estimation

The Project Cost for the optimization study is estimated based on the format shown in **Table 10.2.2-1**, while the cost estimation procedure is as shown in the note of each table, which is a simple method often applied in study at this level in Japan. Other procedures not shown in the note are shown as follows:

Table 10.2.2-1 Project Cost Summary Table

Item	Cost	Note
1. Preparation and Land Acquisition (1) Access Road (2) Compensation & Resettlement (3) Camps & Facilities		
2. Environmental Mitigation cost		
3. Civil Work (1) Care of river (2) Dm (3) Spillway (4) Intake (5) Headrace (6) Surge Tank (7) Penstock (8) Powerhouse (9) Tailrace channel (10) Tailrace (11) Miscellaneous		((1)~(10)) * 0.05
4. Hydraulic equipment (1) Gate and Screen (2) Penstock		
5. Electro-mechanical equipment		Turbine and Generator, Transformer, etc.
6. Transmission line		
Direct Cost		1 + 2 + 3 + 4 + 5 + 6
7. Administration and Engineering service		(Direct Cost) * 0.15
8. Contingency		(Direct Cost) * 0.1
9. Interest during Construction		(1+2+3+4+5+6+7+8)*0.4*i*T
Total Cost		1+2+3+4+5+6+7+8+9

(1) Environmental Mitigation Cost

In this study, the environmental mitigation cost estimated in **Chapter 9** is used. This is composed of mitigation costs for the physical and biological environment, resettlement cost, the cost of the social action program, and cost slope protection for cliffs along the reservoir area affected by the water level fluctuation. They are summarized in **Table 10.2.2-2**, while the variation in the environmental mitigation cost caused by FSL is shown in **Fig. 10.2.2-1**.

Table 10.2.2-2 Summary of Environmental Cost

Summary of Environmental Cost

No.	Item	Unit	FSL (EL. m)						
			435	425	415	405	395	385	375
1	Cost for Physical Environment	Million NRs	168.72	168.72	168.72	168.72	168.72	168.72	168.72
2	Cost for Biological Environment	Million NRs	568.21	512.85	461.77	417.95	374.68	335.38	291.80
3	Cost for Resettlement Plan	Million NRs	3,105.26	1,744.62	1,127.30	917.92	827.00	751.52	708.43
4	Social Action Program	Million NRs	409.77	332.83	236.10	211.88	210.84	207.93	188.80
5	Sub-total (1 to 4)	Million NRs	4,251.96	2,759.02	1,993.89	1,716.47	1,581.24	1,463.55	1,357.75
		Million USD	59.89	38.86	28.08	24.18	22.27	20.61	19.12
6	Slope Protection in Bhimad Bajar	Million USD	2.10	2.10	2.10	2.10	2.10	2.10	2.10
7	Total (5+6)	Million USD	61.99	40.96	30.18	26.28	24.37	22.71	21.22

1 USD = 71 NRs

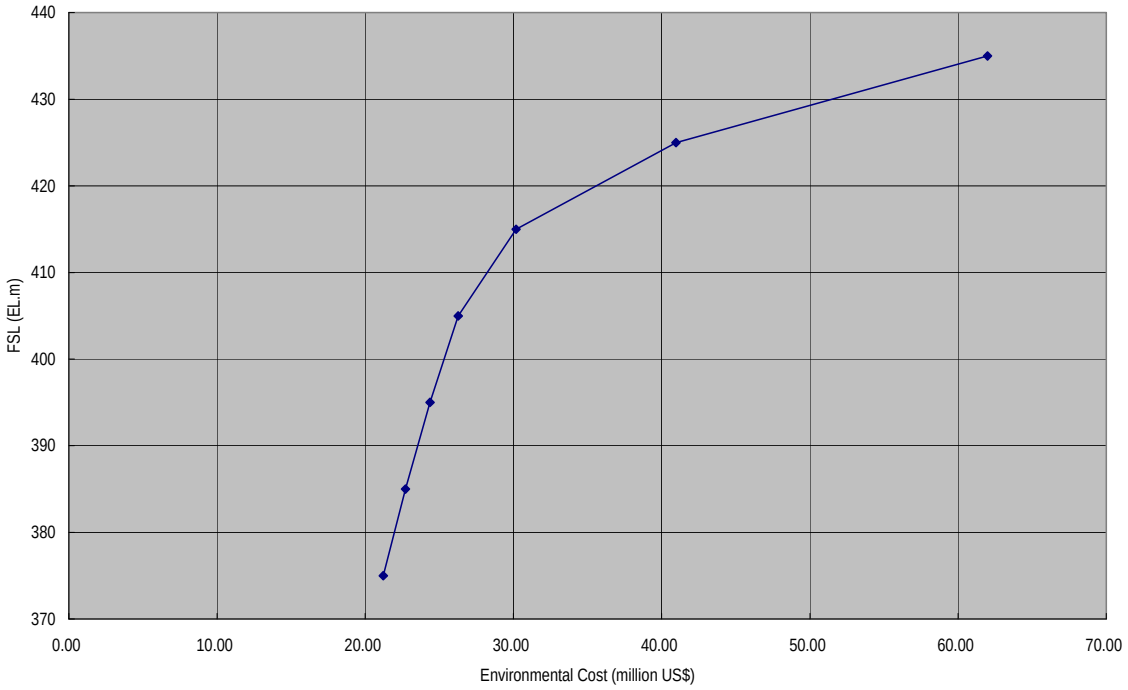


Fig. 10.2.2-1 Relation between the FSL and Environmental mitigation Cost

(2) Civil Work and Hydraulic Equipment

Civil work cost and hydraulic equipment cost are summarized as shown in **Table 10.2.2-3 ~ 10.2.2-4**. Each item is estimated as follows:

1) Work quantity

Based on the typical general cost estimation method in Japan, quantities are estimated by equations composed of the characteristic parameters of each structure.

a) Dam

Based on the geological consideration in **Chapter 7**, a concrete gravity type is adopted for the dam in this project. In this stage, the adoption of a ski-jump type dissipator is considered, and a spillway chute which has sufficient capacity for the design flood discharge is set at the center part of dam crest, of which the abutment should be excavated with a 1:0.3 inclination and a berm for every 10 m. Based on these conditions, the excavation volume and dam concrete volume are estimated, corresponding to each FSL alternative shown in **10.2.1 (1)**.

Items in the category of "Others" represent 20% of the above total cost for grouting, coffer dams, and other works.

b) Intake

The excavation volume (Ve), concrete volume (Vc), weight of the reinforcement bars (Wr), and the weight of the gate and screen (Wg and Ws) are calculated by the following equations:

$$Ve = 130 \times [\{(ha+D) \times Q\}^{1/2} \times n^{1/3}]^{1.27}$$
$$Vc = 56.5 \times [\{(ha+D) \times Q\}^{1/2} \times n^{1/3}]^{1.23}$$
$$Wr = 0.04 \times Vc$$
$$Wg = 0.9 \times (ha+D)^{1/9} \times Q$$
$$Ws = 0.5 \times (ha+D)^{1/9} \times Q$$

Where

ha : Available drawdown (m)
Q : Maximum plant discharge (m^3/s)
D : Inner diameter of waterway (m)
n : Number of waterway channels

The cost of other work items, such as a coffering and trashrack, and rake, etc. not included in the main items obtained above is estimated to comprise 20% of the cost of the main items.

c) Headrace

A circular fully lined pressure tunnel is adopted. The excavation volume of the pressure tunnel (Ve), concrete volume (Vc), and weight of the reinforcement bars (Wr) are calculated by the following equations:

$$Ve = 3.2 \times (R+t_0)^2 \times L \times n$$

$Vc = \{3.2 \times (R+t0)2-\pi R2\} \times L \times n$

$Wr = 0.04 \times Vc$

Where

R : Tunnel radius (m)

t_0 : Lining concrete thickness (m)

L : Total length of waterway channels (m)

n : Number of waterway channels

The cost of other items of works, such as grouting, adit, etc. not included in the main items stated above is estimated at 15% of the cost of the main items.

d) Surge tank (only for Option IIIb)

The excavation volume (Ve), concrete volume (Vc), and weight of the reinforcement bars (Wr) are calculated in accordance with the following equations:

$Ve = 38 \times q \times (ha+L)^{1/4} \times n$

$Vc = 11 \times q \times (ha+L)^{1/4} \times n$

$Wr = 0.05 \times Vc$

Where

q : Design discharge (m^3/s), equivalent to the maximum plant discharge when the waterway has only one channel.

L : Total length of waterway (m)

ha : Available drawdown of the regulating pond or reservoir (m)

n : Number of waterway channels

A surge tank is not provided when the length of waterway is less than 500 m.

The cost of other items of works, such as a steel lining not included in the main items stated above, is estimated at 20% of the cost of the main items.

e) Penstock

An excavation volume (Ve) and concrete volume (Vc) are obtained by the following equation, assuming a constant thickness of filling concrete of 60 cm.

$Ve = \pi/4 \times (Dm + 2t)^2 \times L$

$Vc = \pi/4 \times \{(Dm + 2t)^2 - Dm^2\} \times L$

$Wr = 0.012 \times Vc$

Here

D_m : Average inner diameter of steel pipe (m)

t : Thickness of filling concrete (m)

L : Total length of penstock (m)

The weight of the steel penstock pipes (Wp) is calculated by the following equations:

$$Wp = 7.85 \times \pi \times Dm \times tm \times 1.1 \times L \times n$$

$$tm = 0.0313 \times H \times Dm + 2$$

Where

Wp: Weight of the steel conduit (ton)

t_m : Thickness of the steel conduit (mm)

H : Design head (m) (= high water level – tailwater level)

An allowable tensile stress of 1,600 kgf/cm^2 is used for steel conduits.

f) Powerhouse (Underground type)

The excavation volume (Ve), concrete volume (Vc), and weight of the reinforcement bars (Wr) are obtained by the following equations:

$$Ve = 27A + 1.3 \times A \times d$$

$$Vc = 15 \times A$$

$$Wr = 0.06 \times A$$

Where

$$A = 20 \times Q^{1/2} \times He^{1/3}$$

Where

Q : Maximum plant discharge (m^3/s)

He : Effective head (m)

A : Area of powerhouse (m^2)

d : Height of powerhouse (m)

The cost of the powerhouse building and transformer chamber is included in 50% of "Others".

g) Tailrace tunnel

The quantities of work are calculated according to the calculation method of the headrace.

h) Tailrace outlet

The excavation volume (Ve), concrete volume (Vc), and weight of reinforcement bars (Wr) are obtained by the following equations:

$$Ve = 395 \times (R \times Q)^{0.479}$$

$$Vc = 40.4 \times (R \times Q)^{0.684}$$

$$Wr = 0.278 \times Vc^{0.610}$$

Where

Q : Maximum plant discharge (m^3/s)

R : Tunnel radius (m)

The cost of other items of works, such as coffering and trashrack, rake, etc. not included in the main items obtained above, is estimated at 25% of the cost of the main items.

i) Access tunnel to powerhouse

The excavation volume (Ve), concrete volume (Vc), and weight of the reinforcement bars (Wr) of the access tunnel are obtained by the following equations: The maximum gradient of the access tunnel is 1:10.

$Ve = 45 \times L$

$Vc = 10 \times L$

$Wr = 0.03 \times Vc$

j) Adit

Same as the Headrace, where '$t_0 = 0$. L is defined as the Adit length.

k) Miscellaneous works

The cost of the miscellaneous works, such as the disposal area and landscaping work, is estimated at 5% of the total cost of civil works (from a) through j)).

Table 10.2.2-3 Civil Engineering Work Cost

Item	Unit	Unit cost	Quantity	Cost	Calculation method
a) Dam					a)=a).1+a).2
a).1 Care of river	LS			a).2 の 2%	a).1=a).2×0.02
a).2 Dam	m^3				a).2=1)+2)+3)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Others	LS			20%	3)=(1)+2))×0.2
b) Intake					b)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			25%	4)=(1)+2)+3))×0.25
c) Headrace					c)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Rebar	Ton				3)
4) Others	LS			15%	4)=(1)+2)+3))×0.15
d) Surge Tank					d)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			55%	4)=(1)+2)+3))×0.55
e) Penstock					e)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			20%	4)=(1)+2)+3))×0.2
f) Powerhouse					f)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			50%	4)=(1)+2)+3))×0.5
g) Tailrace					g)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			15%-30%	4)=(1)+2)+3))×0.15~0.30
h) Tailrace Outlet					h)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			25%	4)=(1)+2)+3))×0.25
i) Access tunnel to PH					i)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Re-bar	Ton				3)
4) Others	LS			20%	4)=(1)+2)+3))×0.2
j) Adit					j)=1)+2)+3)+4)
1) Excavation	m^3				1)
2) Concrete	m^3				2)
3) Rebar	Ton				3)
4) Others	LS			15%	4)=(1)+2)+3))×0.15
k) Miscellaneous	LS				k)=∑(a)~j))×0.05
Subtotal					

Table 10.2.2-4 Hydraulic Equipment Cost

Item	Unit	Unit Cost	Quantity	Cost
1. Dam & Spillway Gate	 Ton			
2. Intake Gate Screen	 Ton Ton			
3. Penstock (Steel pipe)	Ton			
4. Tailrace gate	Ton			
5. Others	LS			20%
Subtotal				

2) Unit cost

Unit cost is quoted, in comparison with recent major hydropower projects in Nepal and other projects in neighboring countries.

(3) Electro-mechanical Equipment

Regarding the cost of electro-mechanical equipment, it is quoted based on past records in Feasibility Studies conducted by JICA in Nepal and neighboring countries.

(4) Transmission Line

The transmission line cost is estimated by the unit cost shown in **Chapter 5** and the length shown in **Chapter 11**.

(5) Interest during Construction

The interest during construction is based on the equation shown in **Table 10.2.2-1**, where i=10%, and T=5 years, based on past records of hydropower construction works of equivalent scale.

(6) Cost Estimation Result

The project cost of the project alternatives is shown in **Table 10.2.2-5**.

Table 10.2.2-5 Project Cost (Option I FSL=395m)

Project Cost Summary 1,000USD

Item	FSL=395									
	1	2	3	4	5	6				
1. Preparation & Compensation	2,845	2,855	2,865	2,873	2,882	2,891				
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	24,370	24,370	24,370	24,370	24,370	24,370				
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053				
(2) Dam	129,365	129,818	130,271	130,673	131,075	131,477				
(3) Intake	47	70	88	103	114	126				
(4) Power Tunnel	0	0	0	0	0	0				
(5) Penstock	0	0	0	0	0	0				
(6) Power House	0	0	0	0	0	0				
(7) Tailrace Tunnel	0	0	0	0	0	0				
(8) Tailrace	0	0	0	0	0	0				
(9) Others	6,773	6,797	6,821	6,841	6,862	6,883				
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,630	2,652	2,673	2,696	2,718	2,741				
(2) Penstocks	163	175	187	199	210	222				
5. Electro-Mechanical Works	23,057	24,426	25,424	26,725	27,996	28,934				
6. Transmission Line	5,298	5,298	10,170	10,170	10,170	10,170				
Direct Cost	200,601	202,513	208,921	210,702	212,451	213,866				
7. Administration Fee	30,090	30,377	31,338	31,605	31,868	32,080				
8. Contingency	20,060	20,251	20,892	21,070	21,245	21,387				
9. Interest During Construction	50,150	50,628	52,230	52,676	53,113	53,466				
Total	300,902	303,770	313,382	316,054	318,676	320,798				

Note: The numbers 1 to 6 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8.

Table 10.2.2-6 Project Cost (Option I FSL=405m)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,199	3,209	3,220	3,229	3,238	3,247	3,256	3,264	3,273	3,281
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	146,177	146,641	147,105	147,510	147,916	148,321	148,727	149,074	149,479	149,826
(3) Intake	92	138	175	207	235	261	285	307	328	348
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	7,616	7,642	7,667	7,689	7,710	7,732	7,753	7,772	7,793	7,811
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,746	2,769	2,793	2,816	2,839	2,863	2,885	2,909	2,932	2,955
(2) Penstocks	222	234	247	259	272	284	296	309	321	333
5. Electro-Mechanical Works	28,167	29,351	30,504	31,637	33,024	34,116	34,928	35,993	37,044	38,081
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	230,722	232,488	234,213	235,850	237,738	239,327	240,634	242,130	243,672	245,138
7. Administration Fee	34,608	34,873	35,132	35,378	35,661	35,899	36,095	36,319	36,551	36,771
8. Contingency	23,072	23,249	23,421	23,585	23,774	23,933	24,063	24,213	24,367	24,514
9. Interest During Construction	57,680	58,122	58,553	58,963	59,434	59,832	60,158	60,532	60,918	61,284
Total	346,083	348,732	351,320	353,775	356,606	358,991	360,950	363,195	365,508	367,707

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8.

Table 10.2.2-7 Project Cost (Option I FSL=410m)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,388	3,398	3,408	3,417	3,427	3,435	3,444	3,452	3,461	3,469
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	155,176	155,610	156,045	156,417	156,852	157,224	157,596	157,969	158,341	158,712
(3) Intake	109	165	209	247	281	312	341	368	395	419
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	8,067	8,091	8,115	8,136	8,159	8,179	8,200	8,219	8,239	8,259
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,801	2,823	2,846	2,869	2,892	2,915	2,938	2,960	2,984	3,006
(2) Penstocks	254	266	278	291	303	315	327	339	351	364
5. Electro-Mechanical Works	30,810	31,919	33,001	34,066	35,116	36,151	37,174	38,183	39,180	40,152
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	245,057	246,726	248,356	249,896	251,483	252,985	254,472	255,944	257,403	258,835
7. Administration Fee	36,759	37,009	37,253	37,484	37,722	37,948	38,171	38,392	38,611	38,825
8. Contingency	24,506	24,673	24,836	24,990	25,148	25,299	25,447	25,594	25,740	25,883
9. Interest During Construction	61,264	61,681	62,089	62,474	62,871	63,246	63,618	63,986	64,351	64,709
Total	367,586	370,089	372,534	374,843	377,224	379,478	381,708	383,915	386,105	388,252

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8

Table 10.2.2-8 Project Cost (Option I FSL=415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,585	3,596	3,607	3,618	3,627	3,636	3,646	3,655	3,664	3,673
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	164,540	165,005	165,469	165,934	166,332	166,731	167,195	167,593	167,991	168,389
(3) Intake	125	188	239	283	322	358	392	424	454	482
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	8,536	8,562	8,588	8,614	8,635	8,657	8,682	8,704	8,725	8,746
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,858	2,882	2,907	2,931	2,956	2,981	3,005	3,030	3,055	3,079
(2) Penstocks	289	302	316	329	343	356	369	382	395	408
5. Electro-Mechanical Works	33,509	34,541	35,808	36,810	38,041	39,015	39,979	41,165	42,105	43,036
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	259,844	261,479	263,337	264,921	266,659	268,136	269,671	271,355	272,791	274,216
7. Administration Fee	38,977	39,222	39,501	39,738	39,999	40,220	40,451	40,703	40,919	41,132
8. Contingency	25,984	26,148	26,334	26,492	26,666	26,814	26,967	27,136	27,279	27,422
9. Interest During Construction	64,961	65,370	65,834	66,230	66,665	67,034	67,418	67,839	68,198	68,554
Total	389,766	392,219	395,006	397,382	399,989	402,204	404,506	407,033	409,187	411,324

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8

Table 10.2.2-9 Project Cost (Option I FSL=420m)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,793	3,805	3,816	3,826	3,836	3,847	3,857	3,867	3,876	3,884
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	174,412	174,908	175,405	175,830	176,256	176,752	177,177	177,602	178,027	178,381
(3) Intake	139	210	267	316	360	401	439	475	508	540
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	9,030	9,059	9,086	9,110	9,133	9,160	9,183	9,207	9,229	9,249
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,920	2,945	2,971	2,997	3,022	3,048	3,074	3,100	3,125	3,151
(2) Penstocks	329	343	357	372	385	400	413	427	441	455
5. Electro-Mechanical Works	36,476	37,445	38,639	39,815	40,747	41,896	43,030	43,930	45,040	46,137
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	278,891	280,508	282,334	284,059	285,533	287,296	288,966	290,399	292,039	293,590
7. Administration Fee	41,834	42,076	42,350	42,609	42,830	43,094	43,345	43,560	43,806	44,039
8. Contingency	27,889	28,051	28,233	28,406	28,553	28,730	28,897	29,040	29,204	29,359
9. Interest During Construction	69,723	70,127	70,583	71,015	71,383	71,824	72,242	72,600	73,010	73,398
Total	418,336	420,762	423,501	426,088	428,299	430,944	433,449	435,599	438,059	440,385

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8

Table 10.2.2-10 Project Cost (Option I FSL=425m)

Project Cost Summary 1,000USD

Item	FSL=425									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,012	4,023	4,035	4,046	4,056	4,067	4,077	4,086	4,096	4,107
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	184,820	185,274	185,804	186,257	186,711	187,165	187,618	187,996	188,450	188,903
(3) Intake	153	230	293	347	396	440	483	522	559	594
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	9,551	9,578	9,607	9,633	9,658	9,683	9,708	9,729	9,753	9,778
4. Hydro-Mechanical Works										
(1) Gate & Screen	2,987	3,013	3,039	3,065	3,091	3,118	3,144	3,170	3,196	3,222
(2) Penstocks	374	389	403	418	432	447	461	476	490	504
5. Electro-Mechanical Works	39,446	40,586	41,710	42,821	43,703	44,790	45,866	46,930	47,983	49,025
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	298,525	300,275	302,074	303,770	305,230	306,892	308,539	310,091	311,709	313,316
7. Administration Fee	44,779	45,041	45,311	45,565	45,784	46,034	46,281	46,514	46,756	46,997
8. Contingency	29,853	30,028	30,207	30,377	30,523	30,689	30,854	31,009	31,171	31,332
9. Interest During Construction	74,631	75,069	75,518	75,942	76,307	76,723	77,135	77,523	77,927	78,329
Total	447,788	450,413	453,111	455,655	457,845	460,338	462,809	465,136	467,564	469,974

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8

Table 10.2.2-11 Project Cost (Option I FSL=435m)

Project Cost Summary 1,000USD

Item	FSL=435									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,476	4,489	4,502	4,512	4,524	4,536	4,546	4,558	4,567	4,577
(1) Access Road										
(2) Compensation										
(3) Others										
2. Environmental Mitigation	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	206,936	207,450	207,964	208,393	208,907	209,421	209,850	210,364	210,792	211,220
(3) Intake	178	268	341	404	461	514	563	608	652	694
(4) Power Tunnel	0	0	0	0	0	0	0	0	0	0
(5) Penstock	0	0	0	0	0	0	0	0	0	0
(6) Power House	0	0	0	0	0	0	0	0	0	0
(7) Tailrace Tunnel	0	0	0	0	0	0	0	0	0	0
(8) Tailrace	0	0	0	0	0	0	0	0	0	0
(9) Others	10,658	10,689	10,718	10,742	10,771	10,799	10,823	10,851	10,875	10,898
4. Hydro-Mechanical Works										
(1) Gate & Screen	3,125	3,153	3,180	3,207	3,235	3,262	3,289	3,317	3,344	3,371
(2) Penstocks	472	488	504	520	535	551	567	583	598	614
5. Electro-Mechanical Works	45,613	46,623	47,635	48,834	49,825	50,807	51,971	52,935	53,891	55,024
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	349,671	351,372	353,056	354,825	356,471	358,103	359,821	361,428	362,931	364,612
7. Administration Fee	52,451	52,706	52,958	53,224	53,471	53,715	53,973	54,214	54,440	54,692
8. Contingency	34,967	35,137	35,306	35,482	35,647	35,810	35,982	36,143	36,293	36,461
9. Interest During Construction	87,418	87,843	88,264	88,706	89,118	89,526	89,955	90,357	90,733	91,153
Total	524,507	527,058	529,583	532,237	534,707	537,154	539,731	542,141	544,397	546,918

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-8

Table 10.2.2-12 Project Cost (Option II FSL=405m)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	2,856	2,870	2,882	2,895	2,907	2,920	2,933	2,944	2,955	2,968
(1) Access Road										
(2) Compensation										
(3) Others										
2. Environmental Mitigation	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360
(3) Intake	796	823	852	876	902	923	943	967	989	1,006
(4) Power Tunnel	2,685	2,860	2,950	3,133	3,226	3,418	3,615	3,715	3,817	4,025
(5) Penstock	869	911	952	993	1,033	1,073	1,112	1,151	1,190	1,229
(6) Power House	10,172	10,539	10,889	11,232	11,565	11,878	12,193	12,500	12,800	13,088
(7) Tailrace Tunnel	795	836	857	900	921	965	1,009	1,032	1,054	1,101
(8) Tailrace	300	322	339	361	378	400	422	440	458	481
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	6,800	6,834	6,861	6,894	6,921	6,952	6,984	7,010	7,035	7,066
4. Hydro-Mechanical Works	17,174	17,379	17,582	17,785	17,989	18,185	18,386	18,589	18,791	18,988
5. Electro-Mechanical Works	25,773	26,988	28,187	29,351	30,776	31,626	33,001	34,081	35,144	36,203
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	225,056	227,196	229,187	231,256	233,455	235,174	237,434	239,263	241,068	242,990
7. Administration Fee	33,758	34,079	34,378	34,688	35,018	35,276	35,615	35,890	36,160	36,449
8. Contingency	22,506	22,720	22,919	23,126	23,345	23,517	23,743	23,926	24,107	24,299
9. Interest During Construction	56,264	56,799	57,297	57,814	58,364	58,794	59,358	59,816	60,267	60,748
Total	337,585	340,795	343,780	346,883	350,182	352,762	356,151	358,895	361,603	364,485

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-13 Project Cost (Option II FSL=410m)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,028	3,039	3,052	3,063	3,077	3,087	3,100	3,110	3,121	3,134
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062
(3) Intake	1,030	1,063	1,093	1,124	1,151	1,181	1,205	1,233	1,260	1,281
(4) Power Tunnel	2,950	3,040	3,226	3,321	3,515	3,615	3,817	3,920	4,025	4,238
(5) Penstock	941	980	1,018	1,056	1,094	1,131	1,169	1,205	1,242	1,278
(6) Power House	10,979	11,309	11,637	11,945	12,255	12,552	12,848	13,127	13,410	13,681
(7) Tailrace Tunnel	857	878	921	943	987	1,009	1,054	1,077	1,101	1,148
(8) Tailrace	335	352	373	390	412	429	451	468	485	508
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	7,209	7,236	7,268	7,293	7,325	7,350	7,382	7,406	7,431	7,461
4. Hydro-Mechanical Works	17,660	17,860	18,064	18,262	18,464	18,663	18,864	19,061	19,263	19,459
5. Electro-Mechanical Works	28,289	29,703	30,810	31,909	32,979	34,032	35,069	36,104	37,112	38,107
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	238,765	240,948	242,950	244,794	246,747	248,536	250,447	252,198	253,936	255,781
7. Administration Fee	35,815	36,142	36,443	36,719	37,012	37,280	37,567	37,830	38,090	38,367
8. Contingency	23,876	24,095	24,295	24,479	24,675	24,854	25,045	25,220	25,394	25,578
9. Interest During Construction	59,691	60,237	60,738	61,198	61,687	62,134	62,612	63,049	63,484	63,945
Total	358,147	361,422	364,426	367,191	370,120	372,804	375,670	378,297	380,905	383,672

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-14 Project Cost (Option II FSL=415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,208	3,220	3,234	3,245	3,258	3,269	3,283	3,293	3,304	3,317
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	51,040	51,040	51,040	51,040	51,040	51,040	51,040	51,040	51,040	51,040
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131
(3) Intake	1,271	1,310	1,346	1,383	1,415	1,450	1,481	1,514	1,547	1,574
(4) Power Tunnel	3,226	3,321	3,515	3,615	3,817	3,920	4,131	4,238	4,347	4,568
(5) Penstock	1,017	1,056	1,096	1,134	1,173	1,211	1,250	1,287	1,325	1,362
(6) Power House	11,811	12,139	12,468	12,782	13,095	13,390	13,689	13,976	14,263	14,533
(7) Tailrace Tunnel	921	943	987	1,009	1,054	1,077	1,124	1,148	1,171	1,220
(8) Tailrace	373	390	412	430	452	470	493	511	529	552
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	7,639	7,666	7,699	7,725	7,758	7,784	7,816	7,842	7,867	7,898
4. Hydro-Mechanical Works	18,188	18,403	18,623	18,838	19,057	19,270	19,488	19,703	19,922	20,132
5. Electro-Mechanical Works	31,122	32,451	33,487	34,761	35,763	36,763	37,981	38,941	40,126	41,073
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	274,143	276,265	278,233	280,289	282,211	283,973	286,103	287,820	289,767	291,597
7. Administration Fee	41,121	41,440	41,735	42,043	42,332	42,596	42,915	43,173	43,465	43,740
8. Contingency	27,414	27,627	27,823	28,029	28,221	28,397	28,610	28,782	28,977	29,160
9. Interest During Construction	68,536	69,066	69,558	70,072	70,553	70,993	71,526	71,955	72,442	72,899
Total	411,214	414,398	417,350	420,433	423,317	425,960	429,155	431,730	434,651	437,396

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-15 Project Cost (Option II FSL=420m)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,398	3,410	3,424	3,435	3,449	3,460	3,471	3,485	3,495	3,506
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578
(3) Intake	1,523	1,568	1,607	1,649	1,685	1,726	1,764	1,798	1,834	1,871
(4) Power Tunnel	3,515	3,615	3,817	3,920	4,131	4,238	4,347	4,568	4,681	4,795
(5) Penstock	1,097	1,138	1,177	1,216	1,255	1,293	1,331	1,370	1,407	1,445
(6) Power House	12,675	13,007	13,324	13,636	13,939	14,241	14,532	14,818	15,096	15,376
(7) Tailrace Tunnel	987	1,009	1,054	1,077	1,124	1,148	1,171	1,220	1,244	1,269
(8) Tailrace	413	431	454	472	495	513	531	555	574	592
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	8,091	8,119	8,152	8,179	8,212	8,238	8,264	8,297	8,322	8,348
4. Hydro-Mechanical Works	18,769	19,002	19,228	19,458	19,684	19,915	20,142	20,369	20,595	20,825
5. Electro-Mechanical Works	33,981	35,217	36,432	37,638	38,815	39,743	40,889	42,032	43,148	44,030
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	271,793	273,858	276,011	278,024	280,131	281,860	283,786	285,854	287,740	289,401
7. Administration Fee	40,769	41,079	41,402	41,704	42,020	42,279	42,568	42,878	43,161	43,410
8. Contingency	27,179	27,386	27,601	27,802	28,013	28,186	28,379	28,585	28,774	28,940
9. Interest During Construction	67,948	68,464	69,003	69,506	70,033	70,465	70,946	71,464	71,935	72,350
Total	407,690	410,787	414,017	417,036	420,196	422,789	425,679	428,781	431,610	434,101

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-16 Project Cost (Option II FSL=425m)

Project Cost Summary 1,000USD

Item	FSL=425									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,598	3,612	3,623	3,635	3,648	3,659	3,670	3,684	3,695	3,706
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413
(3) Intake	1,791	1,834	1,880	1,925	1,964	2,007	2,048	2,085	2,125	2,164
(4) Power Tunnel	3,817	4,025	4,131	4,238	4,457	4,568	4,681	4,911	5,028	5,146
(5) Penstock	1,184	1,223	1,262	1,301	1,338	1,377	1,414	1,452	1,489	1,527
(6) Power House	13,581	13,896	14,202	14,508	14,801	15,091	15,373	15,655	15,928	16,196
(7) Tailrace Tunnel	1,054	1,101	1,124	1,148	1,195	1,220	1,244	1,294	1,319	1,344
(8) Tailrace	456	479	497	516	539	558	576	600	619	638
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	8,566	8,600	8,627	8,654	8,687	8,713	8,739	8,772	8,797	8,823
4. Hydro-Mechanical Works	19,416	19,652	19,886	20,124	20,356	20,592	20,824	21,061	21,293	21,527
5. Electro-Mechanical Works	37,077	38,247	39,389	40,739	41,626	42,734	43,817	44,887	45,943	47,002
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	285,718	287,848	289,799	291,964	293,791	295,697	297,566	299,580	301,414	303,251
7. Administration Fee	42,858	43,177	43,470	43,795	44,069	44,355	44,635	44,937	45,212	45,488
8. Contingency	28,572	28,785	28,980	29,196	29,379	29,570	29,757	29,958	30,141	30,325
9. Interest During Construction	71,430	71,962	72,450	72,991	73,448	73,924	74,391	74,895	75,354	75,813
Total	428,577	431,772	434,699	437,946	440,687	443,546	446,349	449,370	452,121	454,877

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-17 Project Cost (Option II FSL=435m)

Project Cost Summary 1,000USD

Item	FSL=435									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,023	4,037	4,049	4,060	4,071	4,085	4,096	4,107	4,118	4,129
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292
(3) Intake	2,348	2,396	2,447	2,497	2,546	2,590	2,637	2,684	2,729	2,774
(4) Power Tunnel	4,457	4,681	4,795	4,911	5,028	5,266	5,387	5,510	5,633	5,758
(5) Penstock	1,356	1,395	1,433	1,471	1,509	1,546	1,584	1,622	1,658	1,695
(6) Power House	15,354	15,653	15,946	16,240	16,523	16,797	17,070	17,345	17,610	17,871
(7) Tailrace Tunnel	1,195	1,244	1,269	1,294	1,319	1,370	1,396	1,422	1,448	1,474
(8) Tailrace	545	569	588	607	626	650	669	689	708	727
(9)P/S Access Tunnel	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973	10,973
(10) Others	9,579	9,613	9,640	9,667	9,693	9,727	9,753	9,779	9,805	9,831
4. Hydro-Mechanical Works	20,795	21,045	21,296	21,552	21,802	22,049	22,299	22,554	22,803	23,053
5. Electro-Mechanical Works	43,455	44,485	45,707	46,712	47,904	48,900	50,066	51,028	52,171	53,113
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	341,585	343,596	345,646	347,488	349,499	351,457	353,434	355,216	357,161	358,903
7. Administration Fee	51,238	51,539	51,847	52,123	52,425	52,719	53,015	53,282	53,574	53,835
8. Contingency	34,159	34,360	34,565	34,749	34,950	35,146	35,343	35,522	35,716	35,890
9. Interest During Construction	85,396	85,899	86,412	86,872	87,375	87,864	88,359	88,804	89,290	89,726
Total	512,378	515,394	518,469	521,233	524,249	527,186	530,151	532,824	535,742	538,355

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-9.

Table 10.2.2-18 Project Cost (Option IIIa FSL=405m)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,115	3,141	3,159	3,185	3,202	3,228	3,254	3,272	3,289	3,315
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360
(3) Intake	796	823	852	876	902	923	943	967	989	1,006
(4) Power Tunnel	3,105	3,302	3,403	3,609	3,715	3,930	4,151	4,264	4,378	4,611
(5) Penstock	775	812	848	884	920	954	989	1,024	1,058	1,093
(6) Power House	10,733	11,116	11,490	11,849	12,200	12,530	12,863	13,187	13,499	13,808
(7) Tailrace Tunnel	11,105	11,678	11,969	12,559	12,859	13,468	14,089	14,403	14,721	15,366
(8) Tailrace	300	322	339	361	378	400	422	440	458	481
(9)P/S Access Tunnel	12,101	12,101	12,101	12,101	12,101	12,101	12,101	12,101	12,101	12,101
(10) Others	7,416	7,478	7,521	7,583	7,624	7,686	7,749	7,790	7,831	7,894
4. Hydro-Mechanical Works	17,194	17,400	17,607	17,811	18,017	18,216	18,419	18,624	18,827	19,029
5. Electro-Mechanical Works	27,257	28,628	29,959	31,012	32,294	33,560	34,794	35,766	36,974	38,152
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	239,759	242,662	245,110	247,692	250,075	252,859	255,636	257,700	259,988	262,717
7. Administration Fee	35,964	36,399	36,766	37,154	37,511	37,929	38,345	38,655	38,998	39,408
8. Contingency	23,976	24,266	24,511	24,769	25,008	25,286	25,564	25,770	25,999	26,272
9. Interest During Construction	59,940	60,666	61,277	61,923	62,519	63,215	63,909	64,425	64,997	65,679
Total	359,639	363,993	367,664	371,537	375,113	379,288	383,454	386,549	389,981	394,075

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-19 Project Cost (Option IIIa FSL=410m)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,324	3,341	3,367	3,384	3,410	3,427	3,454	3,471	3,488	3,514
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062
(3) Intake	1,030	1,063	1,093	1,124	1,151	1,181	1,205	1,233	1,260	1,281
(4) Power Tunnel	3,403	3,506	3,715	3,821	4,040	4,151	4,378	4,494	4,611	4,850
(5) Penstock	838	872	907	940	973	1,006	1,039	1,071	1,104	1,135
(6) Power House	11,556	11,900	12,245	12,573	12,897	13,209	13,516	13,814	14,112	14,393
(7) Tailrace Tunnel	11,969	12,263	12,859	13,162	13,777	14,089	14,721	15,042	15,366	16,023
(8) Tailrace	335	352	373	390	412	429	451	468	485	508
(9)P/S Access Tunnel	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032
(10) Others	7,914	7,955	8,017	8,058	8,120	8,161	8,223	8,263	8,304	8,367
4. Hydro-Mechanical Works	17,675	17,876	18,081	18,282	18,485	18,685	18,887	19,087	19,291	19,486
5. Electro-Mechanical Works	30,045	31,075	32,328	33,557	34,774	35,726	36,908	38,062	39,198	40,107
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	255,636	257,749	260,531	262,839	265,585	267,608	270,328	272,550	274,766	277,211
7. Administration Fee	38,345	38,662	39,080	39,426	39,838	40,141	40,549	40,883	41,215	41,582
8. Contingency	25,564	25,775	26,053	26,284	26,558	26,761	27,033	27,255	27,477	27,721
9. Interest During Construction	63,909	64,437	65,133	65,710	66,396	66,902	67,582	68,138	68,691	69,303
Total	383,454	386,624	390,796	394,258	398,377	401,413	405,492	408,826	412,149	415,817

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-20 Project Cost (Option IIIa FSL=415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,523	3,540	3,567	3,585	3,611	3,629	3,656	3,673	3,691	3,718
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131
(3) Intake	1,271	1,310	1,346	1,383	1,415	1,450	1,481	1,514	1,547	1,574
(4) Power Tunnel	3,715	3,821	4,040	4,151	4,378	4,494	4,730	4,850	4,972	5,220
(5) Penstock	905	940	975	1,009	1,043	1,077	1,111	1,144	1,177	1,210
(6) Power House	12,401	12,749	13,091	13,421	13,746	14,060	14,374	14,671	14,972	15,261
(7) Tailrace Tunnel	12,859	13,162	13,777	14,089	14,721	15,042	15,693	16,023	16,355	17,030
(8) Tailrace	373	390	412	430	452	470	493	511	529	552
(9)P/S Access Tunnel	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032
(10) Others	8,387	8,429	8,493	8,535	8,599	8,640	8,705	8,746	8,788	8,853
4. Hydro-Mechanical Works	18,195	18,413	18,632	18,849	19,068	19,284	19,503	19,717	19,937	20,151
5. Electro-Mechanical Works	32,612	34,049	35,233	36,388	37,536	38,657	39,981	41,080	42,153	43,213
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	270,806	273,369	276,130	278,404	281,135	283,369	286,292	288,494	290,687	293,347
7. Administration Fee	40,621	41,005	41,420	41,761	42,170	42,505	42,944	43,274	43,603	44,002
8. Contingency	27,081	27,337	27,613	27,840	28,114	28,337	28,629	28,849	29,069	29,335
9. Interest During Construction	67,701	68,342	69,033	69,601	70,284	70,842	71,573	72,124	72,672	73,337
Total	406,209	410,054	414,195	417,606	421,703	425,054	429,438	432,741	436,031	440,020

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-21 Project Cost (Option IIIa FSL=420m)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,731	3,749	3,776	3,794	3,822	3,840	3,858	3,885	3,903	3,921
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578
(3) Intake	1,523	1,568	1,607	1,649	1,685	1,726	1,764	1,798	1,834	1,871
(4) Power Tunnel	4,040	4,151	4,378	4,494	4,730	4,850	4,972	5,220	5,346	5,474
(5) Penstock	976	1,012	1,046	1,081	1,115	1,149	1,183	1,217	1,250	1,283
(6) Power House	13,281	13,629	13,958	14,289	14,606	14,919	15,223	15,527	15,816	16,108
(7) Tailrace Tunnel	13,777	14,089	14,721	15,042	15,693	16,023	16,355	17,030	17,372	17,717
(8) Tailrace	413	431	454	472	495	513	531	555	574	592
(9)P/S Access Tunnel	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032
(10) Others	8,884	8,927	8,991	9,034	9,099	9,142	9,185	9,250	9,293	9,335
4. Hydro-Mechanical Works	18,768	19,001	19,227	19,459	19,685	19,916	20,143	20,373	20,597	20,828
5. Electro-Mechanical Works	35,679	37,029	38,144	39,451	40,524	41,804	42,847	44,082	45,111	46,316
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	290,474	292,988	295,704	298,168	300,856	303,283	305,462	308,340	310,496	312,847
7. Administration Fee	43,571	43,948	44,356	44,725	45,128	45,492	45,819	46,251	46,574	46,927
8. Contingency	29,047	29,299	29,570	29,817	30,086	30,328	30,546	30,834	31,050	31,285
9. Interest During Construction	72,619	73,247	73,926	74,542	75,214	75,821	76,365	77,085	77,624	78,212
Total	435,712	439,481	443,557	447,252	451,284	454,925	458,193	462,509	465,745	469,271

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-22 Project Cost (Option IIIa FSL=425m)

Project Cost Summary 1,000USD

Item	FSL=425									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,950	3,978	3,996	4,014	4,042	4,060	4,078	4,106	4,124	4,142
(1) Access Road										
(2) Compensation										
(3) Others										
2. Environmental Mitigation	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413
(3) Intake	1,791	1,834	1,880	1,925	1,964	2,007	2,048	2,085	2,125	2,164
(4) Power Tunnel	4,378	4,611	4,730	4,850	5,095	5,220	5,346	5,603	5,733	5,866
(5) Penstock	1,053	1,088	1,121	1,156	1,189	1,223	1,256	1,290	1,322	1,355
(6) Power House	14,200	14,534	14,854	15,170	15,477	15,784	16,075	16,370	16,651	16,936
(7) Tailrace Tunnel	14,721	15,366	15,693	16,023	16,691	17,030	17,372	18,064	18,415	18,769
(8) Tailrace	456	479	497	516	539	558	576	600	619	638
(9)P/S Access Tunnel	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032	13,032
(10) Others	9,405	9,470	9,514	9,557	9,623	9,666	9,709	9,776	9,818	9,861
4. Hydro-Mechanical Works	19,402	19,640	19,874	20,110	20,342	20,580	20,811	21,048	21,278	21,515
5. Electro-Mechanical Works	38,948	40,217	41,260	42,504	43,721	44,722	45,921	47,093	48,071	49,218
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	310,931	313,844	316,045	318,451	321,310	323,477	325,818	328,662	330,783	333,091
7. Administration Fee	46,640	47,077	47,407	47,768	48,197	48,522	48,873	49,299	49,617	49,964
8. Contingency	31,093	31,384	31,604	31,845	32,131	32,348	32,582	32,866	33,078	33,309
9. Interest During Construction	77,733	78,461	79,011	79,613	80,328	80,869	81,455	82,165	82,696	83,273
Total	466,396	470,767	474,067	477,677	481,965	485,215	488,727	492,993	496,175	499,637

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-23 Project Cost (Option IIIa FSL=435m)

Project Cost Summary 1,000USD

Item	FSL=435									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,577	4,606	4,624	4,644	4,662	4,691	4,710	4,729	4,748	4,767
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292
(3) Intake	2,348	2,396	2,447	2,497	2,546	2,590	2,637	2,684	2,729	2,774
(4) Power Tunnel	5,095	5,346	5,474	5,603	5,733	5,999	6,135	6,271	6,409	6,549
(5) Penstock	1,205	1,239	1,272	1,307	1,340	1,373	1,406	1,439	1,472	1,504
(6) Power House	17,113	17,443	17,769	18,097	18,408	18,718	19,023	19,324	19,620	19,911
(7) Tailrace Tunnel	16,691	17,372	17,717	18,064	18,415	19,126	19,486	19,848	20,214	20,583
(8) Tailrace	545	569	588	607	626	650	669	689	708	727
(9)P/S Access Tunnel	19,601	19,601	19,601	19,601	19,601	19,601	19,601	19,601	19,601	19,601
(10) Others	10,897	10,966	11,011	11,056	11,101	11,170	11,215	11,260	11,305	11,350
4. Hydro-Mechanical Works	20,754	21,001	21,251	21,505	21,752	22,000	22,249	22,501	22,749	22,998
5. Electro-Mechanical Works	45,190	46,529	47,652	48,762	49,872	50,958	52,211	53,286	54,338	55,380
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	371,522	374,570	376,910	379,248	381,561	384,382	386,846	389,137	391,397	393,647
7. Administration Fee	55,728	56,186	56,536	56,887	57,234	57,657	58,027	58,371	58,710	59,047
8. Contingency	37,152	37,457	37,691	37,925	38,156	38,438	38,685	38,914	39,140	39,365
9. Interest During Construction	92,880	93,643	94,227	94,812	95,390	96,095	96,711	97,284	97,849	98,412
Total	557,283	561,856	565,365	568,871	572,341	576,572	580,269	583,705	587,096	590,470

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-10.

Table 10.2.2-24 Project Cost (Option IIIb FSL=405m)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,035	3,051	3,077	3,098	3,124	3,145	3,172	3,192	3,212	3,240
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	26,276	26,276	26,276	26,276	26,276	26,276	26,276	26,276	26,276	26,276
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360
(3) Intake	807	838	864	892	916	941	962	986	1,010	1,027
(4) Power Tunnel	6,545	6,739	7,137	7,339	7,752	7,962	8,391	8,609	8,830	9,280
(5) Penstock	850	891	932	972	1,012	1,051	1,090	1,129	1,168	1,206
(6) Power House	8,617	8,925	9,225	9,513	9,795	10,060	10,327	10,587	10,838	11,086
(7) Tailrace Tunnel	1,507	1,585	1,624	1,704	1,745	1,828	1,912	1,955	1,998	2,085
(8) Tailrace	300	322	339	361	378	400	422	440	458	481
(9)P/S Access Tunnel	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378
(10) Surge Tank	5,729	6,065	6,481	6,821	7,245	7,583	8,014	8,362	8,711	9,152
(11) Others	7,227	6,975	7,018	7,051	7,094	7,127	7,171	7,202	7,233	7,278
4. Hydro-Mechanical Works	17,325	17,541	17,756	17,971	18,185	18,394	18,607	18,822	19,034	19,245
5. Electro-Mechanical Works	27,225	28,594	29,924	31,234	32,256	33,521	34,753	35,965	37,167	38,107
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	235,403	237,762	240,612	243,193	245,738	248,249	251,059	253,486	255,895	258,423
7. Administration Fee	35,310	35,664	36,092	36,479	36,861	37,237	37,659	38,023	38,384	38,763
8. Contingency	23,540	23,776	24,061	24,319	24,574	24,825	25,106	25,349	25,589	25,842
9. Interest During Construction	58,851	59,441	60,153	60,798	61,434	62,062	62,765	63,371	63,974	64,606
Total	353,104	356,643	360,918	364,790	368,606	372,373	376,589	380,229	383,842	387,635

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11.

Table 10.2.2-25 Project Cost (Option IIIb FSL=410m)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,221	3,240	3,261	3,287	3,308	3,327	3,354	3,373	3,393	3,413
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,229	28,229	28,229	28,229	28,229	28,229	28,229	28,229	28,229	28,229
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062
(3) Intake	1,044	1,074	1,108	1,136	1,167	1,197	1,223	1,251	1,278	1,305
(4) Power Tunnel	6,937	7,339	7,544	7,962	8,175	8,391	8,830	9,054	9,280	9,509
(5) Penstock	921	959	997	1,035	1,072	1,109	1,146	1,182	1,219	1,254
(6) Power House	9,277	9,554	9,831	10,094	10,354	10,604	10,851	11,091	11,330	11,556
(7) Tailrace Tunnel	1,624	1,664	1,745	1,786	1,870	1,912	1,998	2,041	2,085	2,174
(8) Tailrace	335	352	373	390	412	429	451	468	485	508
(9)P/S Access Tunnel	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378
(10) Surge Tank	6,337	6,739	7,070	7,480	7,815	8,145	8,571	8,905	9,246	9,583
(11) Others	7,670	7,395	7,428	7,470	7,503	7,533	7,578	7,608	7,638	7,671
4. Hydro-Mechanical Works	17,827	18,036	18,251	18,461	18,674	18,883	19,094	19,303	19,516	19,723
5. Electro-Mechanical Works	30,011	31,039	32,291	33,519	34,735	35,921	36,866	38,018	39,154	40,285
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	250,097	252,284	254,793	257,512	259,977	262,344	264,854	267,187	269,518	271,873
7. Administration Fee	37,515	37,843	38,219	38,627	38,996	39,352	39,728	40,078	40,428	40,781
8. Contingency	25,010	25,228	25,479	25,751	25,998	26,234	26,485	26,719	26,952	27,187
9. Interest During Construction	62,524	63,071	63,698	64,378	64,994	65,586	66,214	66,797	67,380	67,968
Total	375,146	378,426	382,190	386,268	389,965	393,517	397,281	400,780	404,277	407,810

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11

Table 10.2.2-26 Project Cost (Option IIIb FSL=415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,423	3,442	3,464	3,490	3,512	3,532	3,553	3,580	3,600	3,621
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,183	30,183	30,183	30,183	30,183	30,183	30,183	30,183	30,183	30,183
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131
(3) Intake	1,284	1,321	1,360	1,394	1,431	1,466	1,502	1,531	1,565	1,596
(4) Power Tunnel	7,544	7,962	8,175	8,609	8,830	9,054	9,280	9,740	9,974	10,211
(5) Penstock	996	1,035	1,074	1,112	1,151	1,189	1,227	1,264	1,301	1,338
(6) Power House	9,955	10,235	10,509	10,774	11,035	11,288	11,540	11,778	12,020	12,252
(7) Tailrace Tunnel	1,745	1,786	1,870	1,912	1,998	2,041	2,130	2,174	2,220	2,311
(8) Tailrace	373	390	412	430	452	470	493	511	529	552
(9)P/S Access Tunnel	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378
(10) Surge Tank	7,064	7,485	7,831	8,260	8,610	8,955	9,308	9,749	10,105	10,457
(11) Others	8,150	7,840	7,874	7,917	7,951	7,982	8,016	8,060	8,091	8,124
4. Hydro-Mechanical Works	18,371	18,597	18,828	19,053	19,283	19,509	19,740	19,962	20,192	20,417
5. Electro-Mechanical Works	32,818	34,012	35,194	36,349	37,495	38,837	39,938	41,035	42,107	43,166
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	265,639	268,020	270,507	273,216	275,664	278,239	280,641	283,299	285,619	287,961
7. Administration Fee	39,846	40,203	40,576	40,982	41,350	41,736	42,096	42,495	42,843	43,194
8. Contingency	26,564	26,802	27,051	27,322	27,566	27,824	28,064	28,330	28,562	28,796
9. Interest During Construction	66,410	67,005	67,627	68,304	68,916	69,560	70,160	70,825	71,405	71,990
Total	398,458	402,030	405,761	409,824	413,495	417,358	420,961	424,948	428,429	431,942

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11

Table 10.2.2-27 Project Cost (Option IIIb FSL=420m)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,635	3,655	3,676	3,697	3,725	3,746	3,767	3,788	3,816	3,837
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,571	35,571	35,571	35,571	35,571	35,571	35,571	35,571	35,571	35,571
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578
(3) Intake	1,537	1,578	1,621	1,664	1,701	1,741	1,780	1,819	1,851	1,888
(4) Power Tunnel	8,175	8,609	8,830	9,054	9,509	9,740	9,974	10,211	10,692	10,937
(5) Penstock	1,076	1,115	1,154	1,193	1,231	1,270	1,308	1,346	1,383	1,421
(6) Power House	10,661	10,941	11,205	11,471	11,725	11,977	12,221	12,465	12,696	12,931
(7) Tailrace Tunnel	1,870	1,912	1,998	2,041	2,130	2,174	2,220	2,311	2,358	2,404
(8) Tailrace	413	431	454	472	495	513	531	555	574	592
(9)P/S Access Tunnel	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378	10,378
(10) Surge Tank	7,848	8,288	8,638	8,995	9,439	9,800	10,157	10,520	10,977	11,344
(11) Others	8,655	8,307	8,342	8,374	8,421	8,453	8,485	8,519	8,563	8,595
4. Hydro-Mechanical Works	18,971	19,213	19,450	19,693	19,930	20,170	20,408	20,650	20,883	21,125
5. Electro-Mechanical Works	35,642	36,990	38,105	39,410	40,694	41,760	43,009	44,036	45,063	46,267
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	285,233	287,790	290,222	292,814	295,750	298,095	300,608	302,970	305,607	308,092
7. Administration Fee	42,785	43,169	43,533	43,922	44,363	44,714	45,091	45,445	45,841	46,214
8. Contingency	28,523	28,779	29,022	29,281	29,575	29,810	30,061	30,297	30,561	30,809
9. Interest During Construction	71,308	71,948	72,556	73,204	73,938	74,524	75,152	75,742	76,402	77,023
Total	427,850	431,685	435,334	439,221	443,626	447,143	450,912	454,455	458,410	462,138

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11.

Table 10.2.2-28 Project Cost (Option IIIb FSL=425m)

Project Cost Summary 1,000USD

Item	FSL=425									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,770	3,790	3,810	3,831	3,852	3,880	3,900	3,922	3,942	3,963
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	40,959	40,959	40,959	40,959	40,959	40,959	40,959	40,959	40,959	40,959
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413
(3) Intake	1,804	1,848	1,894	1,939	1,983	2,022	2,064	2,106	2,146	2,186
(4) Power Tunnel	8,830	9,280	9,509	9,740	9,974	10,450	10,692	10,937	11,184	11,434
(5) Penstock	1,161	1,201	1,239	1,277	1,315	1,353	1,390	1,428	1,464	1,502
(6) Power House	10,661	10,911	11,152	11,389	11,619	11,850	12,068	12,290	12,501	12,715
(7) Tailrace Tunnel	1,998	2,085	2,130	2,174	2,265	2,311	2,358	2,452	2,499	2,547
(8) Tailrace	456	479	497	516	539	558	576	600	619	638
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	8,693	9,141	9,496	9,856	10,213	10,674	11,034	11,402	11,765	12,135
(11) Others	8,977	8,588	8,620	8,652	8,685	8,730	8,761	8,795	8,826	8,857
4. Hydro-Mechanical Works	19,635	19,884	20,128	20,376	20,620	20,867	21,109	21,357	21,598	21,846
5. Electro-Mechanical Works	38,909	40,177	41,425	42,462	43,677	44,876	45,875	47,046	48,215	49,358
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	301,390	303,880	306,394	308,707	311,238	314,066	316,322	318,828	321,253	323,674
7. Administration Fee	45,208	45,582	45,959	46,306	46,686	47,110	47,448	47,824	48,188	48,551
8. Contingency	30,139	30,388	30,639	30,871	31,124	31,407	31,632	31,883	32,125	32,367
9. Interest During Construction	75,347	75,970	76,598	77,177	77,810	78,517	79,080	79,707	80,313	80,919
Total	452,084	455,820	459,591	463,061	466,857	471,099	474,483	478,243	481,879	485,511

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11.

Table 10.2.2-29 Project Cost (Option IIIb FSL=435m)

Project Cost Summary 1,000USD

Item	FSL=435									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,244	4,255	4,276	4,305	4,326	4,348	4,369	4,390	4,411	4,432
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	61,987	61,987	61,987	61,987	61,987	61,987	61,987	61,987	61,987	61,987
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292
(3) Intake	2,362	2,414	2,465	2,512	2,561	2,609	2,657	2,704	2,750	2,795
(4) Power Tunnel	10,211	10,450	10,692	11,184	11,434	11,686	11,942	12,199	12,460	12,723
(5) Penstock	1,333	1,371	1,408	1,447	1,484	1,521	1,558	1,596	1,633	1,669
(6) Power House	12,015	12,246	12,476	12,706	12,924	13,142	13,356	13,567	13,775	13,979
(7) Tailrace Tunnel	2,265	2,358	2,404	2,452	2,499	2,596	2,644	2,694	2,743	2,793
(8) Tailrace	545	569	588	607	626	650	669	689	708	727
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	10,450	10,815	11,182	11,656	12,027	12,398	12,771	13,151	13,527	13,903
(11) Others	10,105	9,617	9,649	9,694	9,726	9,761	9,793	9,825	9,857	9,889
4. Hydro-Mechanical Works	21,054	21,313	21,575	21,840	22,099	22,360	22,620	22,883	23,144	23,404
5. Electro-Mechanical Works	45,339	46,485	47,607	48,900	50,007	51,090	52,162	53,236	54,461	55,500
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	354,323	356,295	358,724	361,704	364,114	366,562	368,942	371,335	373,868	376,215
7. Administration Fee	53,148	53,444	53,809	54,256	54,617	54,984	55,341	55,700	56,080	56,432
8. Contingency	35,432	35,629	35,872	36,170	36,411	36,656	36,894	37,134	37,387	37,621
9. Interest During Construction	88,581	89,074	89,681	90,426	91,028	91,641	92,236	92,834	93,467	94,054
Total	531,485	534,442	538,085	542,556	546,170	549,844	553,413	557,003	560,802	564,322

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-11

Table 10.2.2-30 Project Cost (Option IV FSL=405m)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	2,972	2,994	3,008	3,030	3,045	3,067	3,089	3,104	3,118	3,140
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360
(3) Intake	796	823	852	876	902	923	943	967	989	1,006
(4) Power Tunnel	4,843	5,146	5,301	5,618	5,779	6,110	6,449	6,622	6,797	7,155
(5) Penstock	724	759	794	827	861	894	926	959	991	1,023
(6) Power House	7,710	7,988	8,254	8,514	8,766	9,003	9,242	9,475	9,702	9,921
(7) Tailrace Tunnel	7,310	7,687	7,878	8,267	8,464	8,865	9,274	9,481	9,690	10,114
(8) Tailrace	300	322	339	361	378	400	422	440	458	481
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	7,076	7,128	7,163	7,215	7,250	7,302	7,355	7,389	7,424	7,477
4. Hydro-Mechanical Works	16,941	17,129	17,318	17,505	17,693	17,874	18,060	18,247	18,434	18,616
5. Electro-Mechanical Works	26,106	27,295	28,469	29,892	31,006	32,112	33,189	34,249	35,551	36,589
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	231,070	233,563	235,667	238,396	240,438	242,842	245,241	247,224	249,447	251,815
7. Administration Fee	34,661	35,034	35,350	35,759	36,066	36,426	36,786	37,084	37,417	37,772
8. Contingency	23,107	23,356	23,567	23,840	24,044	24,284	24,524	24,722	24,945	25,181
9. Interest During Construction	57,768	58,391	58,917	59,599	60,109	60,710	61,310	61,806	62,362	62,954
Total	346,605	350,344	353,501	357,595	360,657	364,262	367,862	370,837	374,171	377,722

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

Table 10.2.2-31 Project Cost (Option IV FSL=410m)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,154	3,168	3,190	3,205	3,227	3,241	3,263	3,277	3,292	3,314
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062
(3) Intake	1,030	1,063	1,093	1,124	1,151	1,181	1,205	1,233	1,260	1,281
(4) Power Tunnel	5,301	5,458	5,779	5,943	6,278	6,449	6,797	6,975	7,155	7,521
(5) Penstock	784	816	848	880	911	942	973	1,003	1,034	1,064
(6) Power House	8,320	8,567	8,816	9,052	9,285	9,509	9,733	9,945	10,159	10,365
(7) Tailrace Tunnel	7,878	8,072	8,464	8,664	9,068	9,274	9,690	9,901	10,114	10,547
(8) Tailrace	335	352	373	390	412	429	451	468	485	508
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	7,510	7,544	7,596	7,630	7,683	7,716	7,770	7,803	7,838	7,892
4. Hydro-Mechanical Works	17,387	17,570	17,758	17,942	18,127	18,311	18,497	18,678	18,865	19,045
5. Electro-Mechanical Works	28,840	29,955	31,042	32,110	33,171	34,462	35,477	36,490	37,479	38,454
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	245,483	247,511	249,905	251,884	254,258	256,458	258,802	260,719	262,626	264,935
7. Administration Fee	36,822	37,127	37,486	37,783	38,139	38,469	38,820	39,108	39,394	39,740
8. Contingency	24,548	24,751	24,990	25,188	25,426	25,646	25,880	26,072	26,263	26,494
9. Interest During Construction	61,371	61,878	62,476	62,971	63,564	64,114	64,700	65,180	65,656	66,234
Total	368,224	371,267	374,857	377,826	381,386	384,687	388,203	391,079	393,938	397,403

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

Table 10.2.2-32 Project Cost (Option IV FSL=415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,345	3,360	3,383	3,397	3,420	3,435	3,458	3,473	3,487	3,511
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131
(3) Intake	1,271	1,310	1,346	1,383	1,415	1,450	1,481	1,514	1,547	1,574
(4) Power Tunnel	5,779	5,943	6,278	6,449	6,797	6,975	7,337	7,521	7,708	8,087
(5) Penstock	847	880	913	945	977	1,009	1,041	1,072	1,103	1,134
(6) Power House	8,944	9,195	9,441	9,679	9,916	10,140	10,366	10,583	10,800	11,005
(7) Tailrace Tunnel	8,464	8,664	9,068	9,274	9,690	9,901	10,329	10,547	10,766	11,210
(8) Tailrace	373	390	412	430	452	470	493	511	529	552
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	7,965	8,000	8,054	8,089	8,143	8,178	8,233	8,268	8,303	8,359
4. Hydro-Mechanical Works	17,867	18,067	18,268	18,467	18,668	18,865	19,066	19,264	19,465	19,659
5. Electro-Mechanical Works	31,350	32,645	33,926	34,926	36,156	37,137	38,331	39,508	40,436	41,595
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	260,169	262,417	265,052	267,001	269,600	271,523	274,099	276,223	278,109	280,650
7. Administration Fee	39,025	39,363	39,758	40,050	40,440	40,728	41,115	41,433	41,716	42,098
8. Contingency	26,017	26,242	26,505	26,700	26,960	27,152	27,410	27,622	27,811	28,065
9. Interest During Construction	65,042	65,604	66,263	66,750	67,400	67,881	68,525	69,056	69,527	70,163
Total	390,253	393,626	397,578	400,501	404,400	407,285	411,148	414,335	417,163	420,975

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

Table 10.2.2-33 Project Cost (Option IV FSL=420m)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,546	3,561	3,584	3,599	3,623	3,638	3,653	3,676	3,691	3,707
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578
(3) Intake	1,523	1,568	1,607	1,649	1,685	1,726	1,764	1,798	1,834	1,871
(4) Power Tunnel	6,278	6,449	6,797	6,975	7,337	7,521	7,708	8,087	8,281	8,476
(5) Penstock	914	948	980	1,013	1,045	1,077	1,109	1,140	1,172	1,203
(6) Power House	9,594	9,845	10,085	10,322	10,551	10,780	10,999	11,216	11,427	11,639
(7) Tailrace Tunnel	9,068	9,274	9,690	9,901	10,329	10,547	10,766	11,210	11,435	11,662
(8) Tailrace	413	431	454	472	495	513	531	555	574	592
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	8,443	8,479	8,534	8,570	8,625	8,661	8,697	8,753	8,789	8,825
4. Hydro-Mechanical Works	18,397	18,610	18,819	19,031	19,238	19,451	19,659	19,869	20,077	20,289
5. Electro-Mechanical Works	34,407	35,619	36,811	37,995	39,150	40,289	41,188	42,311	43,408	44,492
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	279,383	281,584	284,160	286,326	288,878	291,002	292,874	295,417	297,488	299,555
7. Administration Fee	41,907	42,238	42,624	42,949	43,332	43,650	43,931	44,313	44,623	44,933
8. Contingency	27,938	28,158	28,416	28,633	28,888	29,100	29,287	29,542	29,749	29,956
9. Interest During Construction	69,846	70,396	71,040	71,581	72,219	72,750	73,218	73,854	74,372	74,889
Total	419,075	422,376	426,241	429,488	433,317	436,503	439,311	443,125	446,231	449,333

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

Table 10.2.2-34 Project Cost (Option IV FSL=425m)

Project Cost Summary 1,000USD

Item	FSL=425									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,757	3,780	3,795	3,811	3,834	3,850	3,865	3,889	3,904	3,920
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960	40,960
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413	132,413
(3) Intake	1,791	1,834	1,880	1,925	1,964	2,007	2,048	2,085	2,125	2,164
(4) Power Tunnel	6,797	7,155	7,337	7,521	7,896	8,087	8,281	8,674	8,874	9,077
(5) Penstock	986	1,019	1,051	1,083	1,114	1,146	1,177	1,209	1,240	1,271
(6) Power House	10,275	10,514	10,746	10,977	11,196	11,418	11,632	11,845	12,051	12,254
(7) Tailrace Tunnel	9,690	10,114	10,329	10,547	10,987	11,210	11,435	11,891	12,121	12,354
(8) Tailrace	456	479	497	516	539	558	576	600	619	638
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	8,945	9,001	9,037	9,073	9,130	9,166	9,202	9,260	9,296	9,333
4. Hydro-Mechanical Works	18,983	19,200	19,415	19,634	19,846	20,064	20,278	20,495	20,709	20,924
5. Electro-Mechanical Works	37,443	38,593	39,938	41,042	42,143	43,219	44,281	45,331	46,370	47,410
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	299,149	301,715	304,050	306,153	308,674	310,750	312,800	315,306	317,334	319,370
7. Administration Fee	44,872	45,257	45,608	45,923	46,301	46,613	46,920	47,296	47,600	47,905
8. Contingency	29,915	30,172	30,405	30,615	30,867	31,075	31,280	31,531	31,733	31,937
9. Interest During Construction	74,787	75,429	76,013	76,538	77,169	77,688	78,200	78,826	79,334	79,842
Total	448,724	452,573	456,075	459,230	463,012	466,125	469,201	472,958	476,002	479,055

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

Table 10.2.2-35 Project Cost (Option IV FSL=435m)

Project Cost Summary 1,000USD

Item	FSL=435									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	4,206	4,230	4,246	4,262	4,277	4,302	4,318	4,334	4,350	4,365
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990	61,990
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292	149,292
(3) Intake	2,348	2,396	2,447	2,497	2,546	2,590	2,637	2,684	2,729	2,774
(4) Power Tunnel	7,896	8,281	8,476	8,674	8,874	9,281	9,488	9,697	9,909	10,122
(5) Penstock	1,129	1,161	1,193	1,225	1,256	1,287	1,318	1,350	1,380	1,411
(6) Power House	11,609	11,835	12,057	12,279	12,490	12,700	12,907	13,115	13,315	13,509
(7) Tailrace Tunnel	10,987	11,435	11,662	11,891	12,121	12,589	12,826	13,065	13,306	13,548
(8) Tailrace	545	569	588	607	626	650	669	689	708	727
(9)P/S Access Tunnel	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430	10,430
(10) Others	10,014	10,073	10,110	10,147	10,184	10,244	10,281	10,319	10,356	10,393
4. Hydro-Mechanical Works	20,231	20,460	20,689	20,924	21,151	21,379	21,608	21,841	22,070	22,296
5. Electro-Mechanical Works	43,718	44,935	46,135	47,124	48,309	49,276	50,425	51,560	52,497	53,624
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	350,618	353,308	355,537	357,564	359,770	362,233	364,411	366,587	368,553	370,704
7. Administration Fee	52,593	52,996	53,331	53,635	53,965	54,335	54,662	54,988	55,283	55,606
8. Contingency	35,062	35,331	35,554	35,756	35,977	36,223	36,441	36,659	36,855	37,070
9. Interest During Construction	87,655	88,327	88,884	89,391	89,942	90,558	91,103	91,647	92,138	92,676
Total	525,927	529,962	533,305	536,346	539,655	543,350	546,617	549,880	552,830	556,056

Note: The numbers 1 to 10 correspond to case No. of maximum discharge (Qmax) of each FSL in Table 10.2.1-12.

10.2.3 Economic Evaluation

(1) Evaluation Method

The project alternatives shown in **Tables 10.2.1-7 ~ 10.2.1-11** are evaluated using a method comparing Benefit and Cost. Regarding Benefit (B), it is estimated in the form of benefit generated by an alternative thermal power plant of equivalent scale to the Project. Regarding Cost (C), it is estimated as the annual Operation & Maintenance cost due to the project. In comparison with B/C values among the project alternatives, the project alternative with maximum B/C should be adopted as the optimal plan.

(2) Selection of an Alternative Thermal Power Plan

In consideration of recent global environmental problems, a gas turbine power plant, which exhausts less CO_2 than a normal diesel power plant, was chosen as an alternative thermal power plant. An example of a Gas Turbine Power plant is shown in **Fig. 10.2.3-1**.

Fig. 10.2.3-1 Example of a Gas Turbine Power Plant

As a 6 hour peak operation is assumed to be conducted for this project, the kW and kWh values of a gas turbine power plant in Nepal are estimated based on the construction cost of the plant under specification for 6 hours' operation, with recent fuel cost and operational records of NEA facilities, as shown in **Table 10.2.3-1**. The references of each value in the table are as follows:

- The Values of Station service, Forced outage, Scheduled outage, and Transmission loss for the thermal power plant are based on Kulekhani III F/S.
- The Values of Heat rate and Construction cost are base on World Bank's report "Power Generation Technology Assessment 2005".
- Fuel Cost is based on Nepalnews.com.

Table 10.2.3-1 Basis of the kW and kWh Values of an Alternative Thermal Power Plant

	Item	Unit	Value		Remarks
a	Targeted Firm Peak output of Hydropower	MW	100		
b	Effective Output of Hydropower	MW	92.12		ax(1-H1)x(1-H2)x(1-H3)X(1-H4)
c	Effective Output of Thermalpower	MW	92.12		same as b
d	Installed Capacity of Alternative Thermalpower	MW	138.22		c/((1-T1)x(1-T2)x(1-T3)X(1-T4))
e	Targeted Annual Energy Geneation of Hydropower	GWh	219		Daily 6hr peak operation
f	Effective energy of Hydropower	GWh	211.37		ex(1-H1)x(1-H4)
g	Energy Generation of Alternative Thermalpower	GWh	211.37		Same value as f
h	Annual Energy Geneation of Thermalpower	GWh	215.66		g/((1-T1)x(1-T4))
	Type of Thermalpower		Diesel		
			Hydro	Thermal	
	Station Service Use	%	3.0%	1.5%	H1(hydro), T1(thermal)
	Forced Outrage	%	1.0%	20.0%	H2(hydro), T2(thermal)
	Scheduled Outrage	%	3.6%	15.0%	H3(hydro), T3(thermal)
	Transmiaaion loss	%	0.5%	0.5%	H4(hydro), T4(thermal)
i	Installed Capacity	MW	138.22		value of d
j	Annual Energy Generation	GWh	215.66		value of h
k	Annual Plant Factor	%	17.8%		j /(kx8,760) x100
l	Heat rate	kcal/kWh	2,529		860/thermal efficiency (=34%)
m	Fuel Price		7.35262E-05		
	Fuel Price	US$/l	0.671		Diesel oil
	Fuel specific gravity	kg/l	0.832		Ditto
	Calorific value	kcal/l	9126		
n	Unit Construction Cost	US$/kW	520		interest during construction not include
o	Construction Cost	10^6 US$	71.88		i x n
p	Service Life	year	15		
q	Interest Rate	%	10.00%		
r	Capital Recovery Factor		0.13		((1+q)^p x q)/((1+q)^p-1)
s	O&M Cost Ratio	%	3.00%		
			Fixed	Variable	
t	Interest and Depreciation	10^6 US$	9.45		o x r
u	O&M Cost	10^6 US$	2.16		o x s
v	Fuel Cost	10^6 US$		40.11	j x l x m
w	Total of Fixed Costs	10^6 US$	11.61		t + u
x	Total of Variable Costs	10^6 US$		40.11	v
	kW Value for Targeted Firm Peakout	US$/kW	116.06		x / a
	kWh Value for Targeted Firm Peakout	US$/kWh		0.18	y / e

Unfortunately, NEA lacks official values for the Station Service, Forced Outage, Scheduled Outage, and Transmission loss. Therefore, these values are reconsidered based on the generation records for 2004 as shown in the NEA Annual Report 2005.

The operation hours of power plants in Nepal for 2004 are listed in **Table 10.2.3-2.** In comparison with the values for the Forced Outage Ratio and Scheduled Outage ratio shown in **Table 10.2.3-2**, it is confirmed that all the generators in each power plant have extremely remarkable Idle Time values. For this reason, the kW and kWh values are re-estimated by changing the Forced Outage into Idle Time to reflect the real power plant operation conditions and the result is shown in **Table 10.2.3-3**. Due to the extremely short operation hours of

thermal power plants in Nepal for peak power supply, the kW value of alternative thermal power plant becomes excessive. Although thermal power plants are said to be operated relatively infrequently for the peak power supply to save fuel cost, this result proves this fact in figures. To reflect these circumstances, the kW and kWh values shown in **Table 10.2.3-3** are adopted for project optimization to reflect such situations.

Table 10.2.3-2 Generation hour records in NEPAL 2004

NEPAL ELECTRICITY AUTHORITY

GENERATION

Generation Availability in F/Y 2062/63 (2005/6)

S.N.	Name of Power Station	Unit Capacity in MW	No. of Units	Installed Capacity in MW (P)	Weightage of the center (Wi)	Running Hours	Idle Hours	Planned Outage	Total Hours of this Year	Plant Availability $(A_i)=\left(1-\frac{Planned\ Outage\ (Hrs)}{Total\ Hours\ of\ This\ Year}\right)\times 100$	Generator Availability (WI × AI)
1	Kaligandaki "A"	48	3	144	0.319	17,454.24	8,566.19	331.57	26,352.00	98.74	31.506
2	Marsyangdi	23	3	69	0.153	20,436.24	5,845.30	175.46	26,352.00	99.33	15.187
3	Kulekhani-I	30	2	60	0.133	6,152.27	11,287.42	128.31	17,568.00	99.27	13.198
4	Kulekhani-II	16	2	32	0.071	5,403.41	12,045.05	119.54	17,568.00	99.32	7.042
5	Trishuli	3.5 & 3	6+1	24	0.047	48,695.00	12,575.00	218.00	61,488.00	99.65	4.637
6	Gandak	5	3	15	0.033	9,558.25	17,045.69	1,148.06	26,352.00	95.64	3.179
7	Modi Khola	7.4	2	14.80	0.033	7,979.17	9,496.24	92.59	17,568.00	99.47	3.262
8	Devighat	4.7	3	14.10	0.031	23,011.31	23,972.78	170.22	26,352.00	99.35	3.104
9	Sunkoshi	3.35	3	10.05	0.022	17,384.34	6,796.14	171.52	26,352.00	99.35	2.212
10	Puwa khola	3.1	2	6.20	0.014	11,242.12	6,323.41	2.47	17,568.00	99.99	1.374
11	Chatara	1.6	3	3.20	0.007	8,373.00	7,954.00	1,241.00	17,568.00	92.94	0.659
12	Panauti	0.8	3	2.40	0.005	6,717.00	19,503.79	731.21	26,352.00	97.23	0.517
13	Seti	0.5	3	1.50	0.003	20,948.00	5,122.00	296.00	26,352.00	98.88	0.329
14	Fewa	0.25	4	1.00	0.002	22,413.00	20,396.00	1,537.00	35,136.00	95.63	0.212
15	Sundarijal	0.32	2	0.64	0.001	7,890.00	8,784.00	894.00	17,568.00	94.91	0.135
	Hydropower Sub-total					233,657.35	175,713.01	7,256.95	386,496.00		
16	Multifuel	6.5	6	39	0.086	2,601.67	43,404.00	8,520.00	52,704.00	83.83	7.245
17	Hetauda Diesle	2.5&1.47	4+3	14	0.032	2,939.65	50,622.50	10,520.00	61,488.00	82.89	2.647
	Thermal Sub-total					5,541.32	94,026.50	19,040.00	114,192.00		
	Total			451.30		239,198.67	269,739.51	26,296.95	500,688.00	96.26	96.45

	Hydro	Thermal	Total
Planned outrage ratio	1.88%	16.67%	5.25%
Idle time ratio	45.46%	82.34%	53.87%

Table 10.2.3-3 kW and kWh Values of Alternative Thermal Power Plant by Generation records

	Item	Unit	Value		Remarks
a	Targeted Firm Peak output of Hydropower	MW	100		
b	Effective Output of Hydropower	MW	51.65		ax(1-H1)x(1-H2)x(1-H3)X(1-H4)
c	Effective Output of Thermalpower	MW	51.65		same as b
d	Installed Capacity of Alternative Thermalpower	MW	358.24		c/((1-T1)x(1-T2)x(1-T3)X(1-T4))
e	Targeted Annual Energy Geneation of Hydropower	GWh	219		Daily 6hr peak operation
f	Effective energy of Hydropower	GWh	211.37		ex(1-H1)x(1-H4)
g	Energy Generation of Alternative Thermalpower	GWh	211.37		Same value as f
h	Annual Energy Geneation of Thermalpower	GWh	215.66		g/((1-T1)x(1-T4))
	Type of Thermalpower		Diesel		
			Hydro	Thermal	
	Station Service Use	%	3.0%	1.5%	H1(hydro), T1(thermal)
	Idle Time	%	45.5%	82.3%	H2(hydro), T2(thermal)
	Scheduled Outrage	%	1.9%	16.7%	H3(hydro), T3(thermal)
	Transmiaaion loss	%	0.5%	0.5%	H4(hydro), T4(thermal)
i	Installed Capacity	MW	358.24		value of d
j	Annual Energy Generation	GWh	215.66		value of h
k	Annual Plant Factor	%	6.9%		j /(kx8,760) x100
l	Heat rate	kcal/kWh	2,529		860/thermal efficiency (=34%)
m	Fuel Price		7.35262E-05		
	Fuel Price	US$/l	0.671		Diesel oil
	Fuel specific gravity	kg/l	0.832		Ditto
	Calorific value	kcal/l	9126		
n	Unit Construction Cost	US$/kW	520		interest during construction not include
o	Construction Cost	10^6 US$	186.28		i x n
p	Service Life	year	15		
q	Interest Rate	%	10.00%		
r	Capital Recovery Factor		0.13		((1+q)^p x q)/((1+q)^p-1)
s	O&M Cost Ratio	%	3.00%		
			Fixed	Variable	
t	Interest and Depreciation	10^6 US$	24.49		o x r
u	O&M Cost	10^6 US$	5.59		o x s
v	Fuel Cost	10^6 US$		40.11	j x l x m
w	Total of Fixed Costs	10^6 US$	30.08		t + u
x	Total of Variable Costs	10^6 US$		40.11	v
	kW Value for Targeted Firm Peakout	US$/kW	300.80		x / a
	kWh Value for Targeted Firm Peakout	US$/kWh		0.18	y / e

(3) Benefit and Cost of hydropower

The annual benefit by hydropower plant is estimated by the following equations, based on fixed and variable costs and as shown in **Table 10.2.3-3**.

$$B = B_1 + B_2$$

$$B_1 = Ph \times b_1$$

$$B_2 = E \times b_2$$

Where,

B : Annual benefit by hydropower

B_1 : kW benefit by hydropower plant

B_2 : kWh benefit by hydropower plant
Ph : Peak firm capacity of project alternative
b_1 : kW value of alternative thermal power plant
b_2 : kWh value of alternative thermal power plant

The annual cost of hydropower plant (C) is estimated by the following equation.

$C = Ch \times \alpha$

Where,

C : Annual cost of hydropower plant
Ch : Project cost of hydropower plant
A : Annual cost ratio

The annual cost ratio is calculated by the following equation.

α = Coefficient for investment recovery + ratio of Operation & Maintenance Cost

Coefficient for investment recovery = $i \times (1 + i)^t / \{(1 + i)^t - 1\}$

Where,

i : interest rate
t : Project life of hydropower = 50 years

Where i = 10%, ratio of O&M cost =1%, α = 0.1009 + 0.01 = 0.11

10.3 Result of Layout Alternative Comparison Study

The result of a layout alternative comparison study by the method shown in **10.2** is as shown in **Table 10.3-1** to **10.3-31**. The relation between the B/C value and the installed capacity (Pmax) of each layout alternative is as shown in figures as follows:

Consequently, the project alternative whose FSL = 425 m, maximum discharge = 127.2 m^3/sec, installed capacity = 151 MW of layout Option IIIb has the highest B/C among a total of 310 project alternatives.

The main features of this project are as follows:

Reservoir FSL	425	EL. m
Reservoir MOL	400	EL. m
Effective volume	176.5	MCM
Peak operation time	6	hours
Maximum discharge	127.2	m^3/s
Intake Water level	425	m
Tailrace Water Level	289.1	m
Effective head	132.9	m

Installed Capacity	151	MW
Annual generated Energy	670.0	GWh

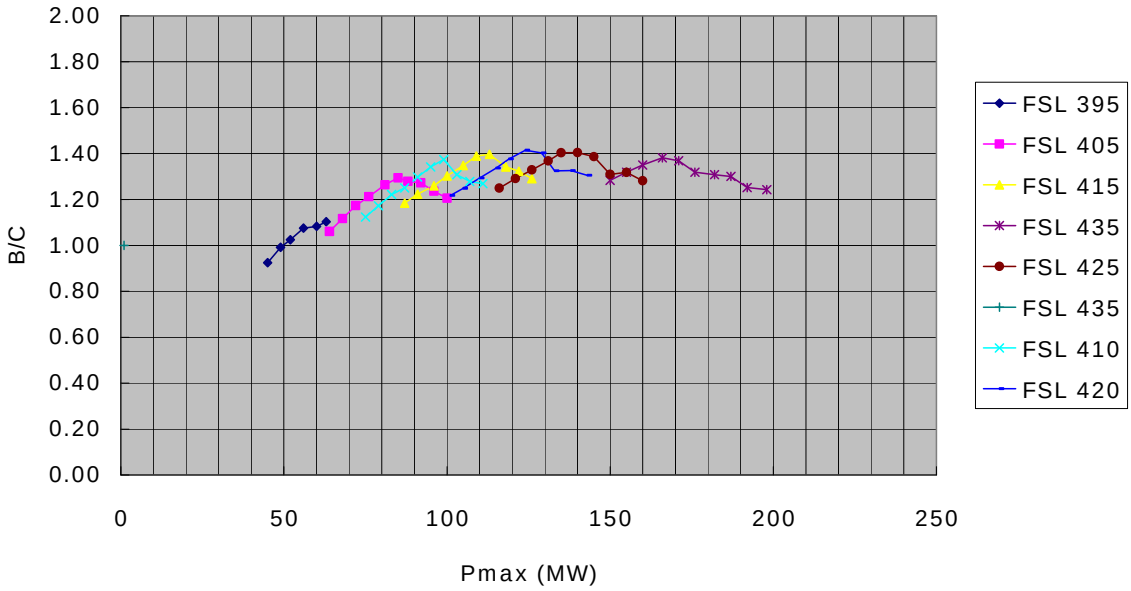


Fig. 10.3-1 Relation between B/C and Pmax for Option I

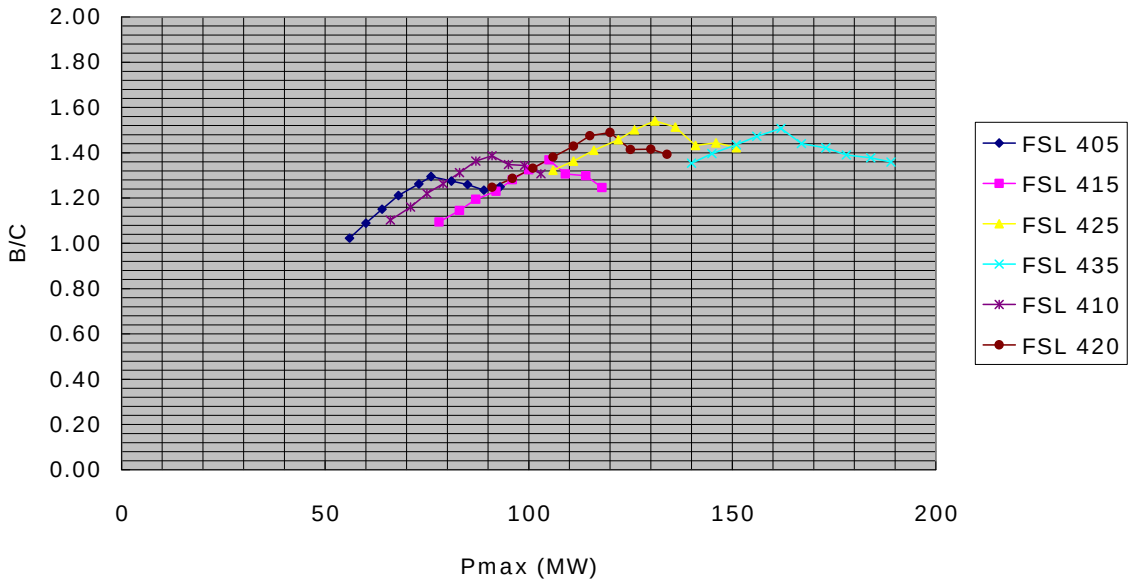


Fig. 10.3-2 Relation between B/C and Pmax for Option II

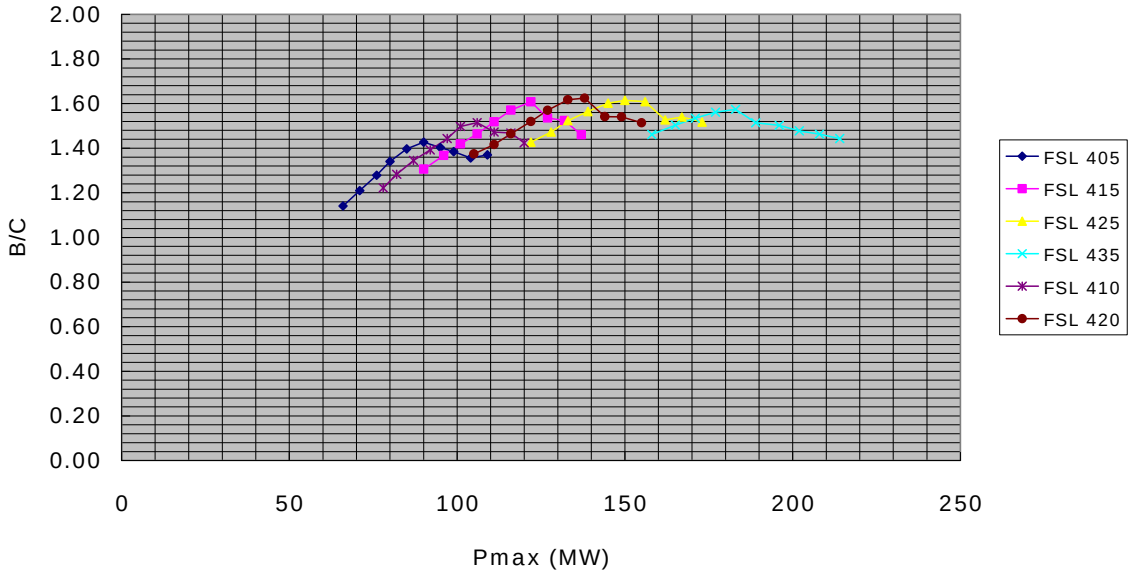


Fig. 10.3-3 Relation between B/C and Pmax for Option IIIa

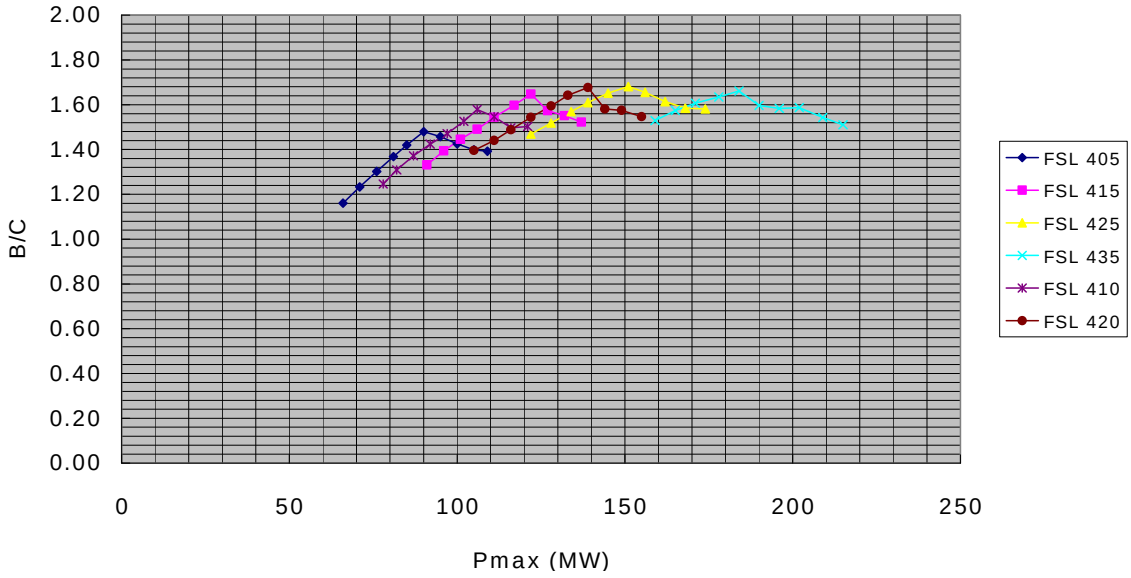


Fig. 10.3-4 Relation between B/C and Pmax for Option IIIb

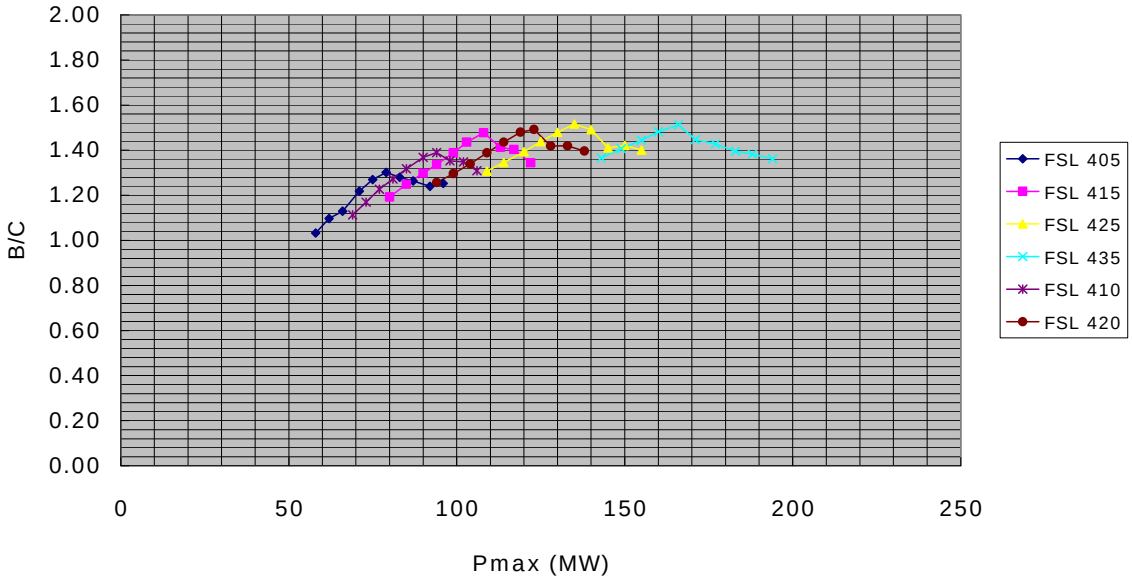


Fig. 10.3-5 Relation between B/C and Pmax for Option IV

Table 10.3-1 Result of Economic Evaluation (Option I: FSL=395m)

Item	Unit	FSL=395									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	58.3	63.2	68	72.9	77.7	82.6	87.4	92.3	97.1	102
FSL	EL.m	395	395	395	395	395	395	395	395	395	395
MOL	EL.m	393.6	393.8	394	394.2	394.6	394.8	NG	NG	NG	NG
TWL	EL.m	307.3	307.5	307.6	307.7	307.8	307.9				
Loss	m	1	1	1	1	1	1				
Effective Head	m	86.7	86.5	86.4	86.3	86.2	86.1				
Pmax	MW	45	49	52	56	60	63				
Primary Energy	GWh	95.22	102.82	109.72	117.20	124.11	130.52				
Pfirm	MW	40.35	43.77	46.60	48.77	46.71	46.13				
Benefit	1000USD	27,830	30,112	32,100	33,986	34,509	35,393				
Cost	1000USD	30,090	30,377	31,338	31,605	31,868	32,080				
B/C		0.92	0.99	1.02	1.08	1.08	1.10				

Note: The numbers 1 to 6 show case No. of maximum discharge (Qmax).

Table 10.3-2 Result of Economic Evaluation (Option I: FSL=405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	75	79.8	84.6	89.4	94.2	99	103.7	108.5	113.3	118.12
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	394.4	394.6	394.8	395	395.2	395.4	395.6	395.8	396	396.2
TWL	EL.m	307.7	307.9	308	308.1	308.2	308.3	308.4	308.5	308.6	308.7
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	96.3	96.1	96	95.9	95.8	95.7	95.6	95.5	95.4	95.3
Pmax	MW	64	68	72	76	81	85	88	92	96	100
Primary Energy	GWh	130.48	138.18	145.83	153.23	160.56	167.34	173.32	179.38	184.87	190.24
Pfirm	MW	50.52	53.78	57.12	58.58	61.87	62.73	58.47	55.31	48.85	43.03
Benefit	1000USD	36,704	38,954	41,219	42,879	45,077	46,454	46,163	46,216	45,184	44,324
Cost	1000USD	34,608	34,873	35,132	35,378	35,661	35,899	36,095	36,319	36,551	36,771
B/C		1.06	1.12	1.17	1.21	1.26	1.29	1.28	1.27	1.24	1.21

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-3 Result of Economic Evaluation (Option I: FSL=410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	83.3	87.8	92.4	96.9	101.5	106	110.6	115.1	119.7	124.2
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	394.8	395	395.2	395.4	395.6	395.8	396	396.2	396.2	396.4
TWL	EL.m	307.9	308.1	308.2	308.3	308.4	308.5	308.6	308.7	308.8	308.8
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	101.1	100.9	100.8	100.7	100.6	100.5	100.4	100.3	100.2	100.2
Pmax	MW	75	79	83	87	91	95	99	103	107	111
Primary Energy	GWh	149.17	156.46	163.80	170.90	177.77	184.21	190.38	195.95	201.23	206.32
Pfirm	MW	55.52	58.55	61.50	62.18	65.28	68.33	70.02	59.48	53.80	50.67
Benefit	1000USD	41,291	43,403	45,501	46,877	48,942	50,920	52,446	50,203	49,370	49,271
Cost	1000USD	36,759	37,009	37,253	37,484	37,722	37,948	38,171	38,392	38,611	38,825
B/C		1.12	1.17	1.22	1.25	1.30	1.34	1.37	1.31	1.28	1.27

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-4 Result of Economic Evaluation (Option I: FSL=415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.2	96.9	101.7	106.4	111.2	115.9	120.7	125.4	130.2	134.92
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	395.2	395.4	395.6	395.8	396	396.2	396.4	396.4	396.6	396.8
TWL	EL.m	308.2	308.3	308.4	308.5	308.6	308.7	308.8	308.9	309	309.1
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	105.8	105.7	105.6	105.5	105.4	105.3	105.2	105.1	105	104.9
Pmax	MW	87	91	96	100	105	109	113	118	122	126
Primary Energy	GWh	169.14	176.73	184.68	191.97	199.08	205.28	211.18	216.94	222.40	227.10
Pfirm	MW	60.81	62.65	64.24	66.91	70.09	73.21	72.09	62.61	58.08	52.05
Benefit	1000USD	46,175	47,981	49,770	51,775	53,904	55,864	56,502	54,608	54,150	53,117
Cost	1000USD	38,977	39,222	39,501	39,738	39,999	40,220	40,451	40,703	40,919	41,132
B/C		1.18	1.22	1.26	1.30	1.35	1.39	1.40	1.34	1.32	1.29

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-5 Result of Economic Evaluation (Option I: FSL=420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	101.88	106.7	111.6	116.5	121.3	126.2	131	135.9	140.7	145.6
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	395.6	395.8	396	396.2	396.4	396.6	396.6	396.8	397	397.2
TWL	EL.m	308.4	308.5	308.6	308.7	308.8	308.9	309	309.1	309.2	309.3
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	110.6	110.5	110.4	110.3	110.2	110.1	110	109.9	109.8	109.7
Pmax	MW	101	105	110	115	119	124	129	133	138	143
Primary Energy	GWh	191.20	198.96	206.78	214.14	220.52	226.96	232.71	238.28	243.63	248.25
Pfirm	MW	64.55	65.66	68.81	71.98	75.11	78.31	74.55	61.16	59.49	54.96
Benefit	1000USD	50,940	52,554	54,791	56,957	58,950	60,974	60,795	57,696	58,079	57,482
Cost	1000USD	41,834	42,076	42,350	42,609	42,830	43,094	43,345	43,560	43,806	44,039
B/C		1.22	1.25	1.29	1.34	1.38	1.41	1.40	1.32	1.33	1.31

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-6 Result of Economic Evaluation (Option I: FSL=425m)

Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	112.5	117.4	122.2	127.1	131.9	136.8	141.6	146.5	151.3	156.2
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	396	396.2	396.4	396.6	396.8	397	397	397.2	397.4	397.6
TWL	EL.m	308.6	308.7	308.8	308.9	309	309.1	309.2	309.3	309.4	309.5
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	115.4	115.3	115.2	115.1	115	114.9	114.8	114.7	114.6	114.5
Pmax	MW	116	121	126	131	135	140	145	150	155	160
Primary Energy	GWh	215.25	223.05	230.19	237.29	243.19	249.21	254.71	260.22	265.33	269.14
Pfirm	MW	68.05	71.00	74.06	77.20	80.29	78.34	73.67	59.80	59.33	52.70
Benefit	1000USD	55,961	58,134	60,232	62,346	64,248	64,656	64,163	60,911	61,614	60,253
Cost	1000USD	44,779	45,041	45,311	45,565	45,784	46,034	46,281	46,514	46,756	46,997
B/C		1.25	1.29	1.33	1.37	1.40	1.40	1.39	1.31	1.32	1.28

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-7 Result of Economic Evaluation (Option I: FSL=435m)

Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	134.2	139.1	144	149	153.9	158.8	163.7	168.7	173.6	178.5
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	396.8	397	397.2	397.4	397.4	397.6	397.8	398	398.2	398.2
TWL	EL.m	309.1	309.1	309.2	309.3	309.4	309.5	309.6	309.7	309.8	309.9
Loss	m	1	1	1	1	1	1	1	1	1	1
Effective Head	m	124.9	124.9	124.8	124.7	124.6	124.5	124.4	124.3	124.2	124.1
Pmax	MW	150	155	160	166	171	176	182	187	192	198
Primary Energy	GWh	265.74	273.31	279.93	286.34	291.74	296.79	301.71	305.86	309.10	312.30
Pfirm	MW	78.12	81.26	84.31	87.43	83.37	72.85	69.28	66.56	57.04	54.75
Benefit	1000USD	67,320	69,512	71,520	73,515	73,188	70,865	70,606	70,475	68,153	67,995
Cost	1000USD	52,451	52,706	52,958	53,224	53,471	53,715	53,973	54,214	54,440	54,692
B/C		1.28	1.32	1.35	1.38	1.37	1.32	1.31	1.30	1.25	1.24

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-8 Result of Economic Evaluation (Option II: FSL=405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
TWL	EL.m	307.6	307.6	307.7	307.7	307.7	307.8	307.8	307.8	307.8	307.9
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	96.2	96.2	96.1	96.1	96.1	96	96	96	96	95.9
Pmax	MW	56	60	64	68	73	76	81	85	89	93
Primary Energy	GWh	115.44	123.60	131.56	139.56	147.49	154.17	161.42	168.04	174.27	180.10
Pfirm	MW	45.75	49.40	52.87	56.16	58.73	59.65	54.38	49.71	44.19	43.62
Benefit	1000USD	34,541	37,108	39,584	42,014	44,214	45,693	45,413	45,200	44,661	45,539
Cost	1000USD	33,758	34,079	34,378	34,688	35,018	35,276	35,615	35,890	36,160	36,449
B/C		1.02	1.09	1.15	1.21	1.26	1.30	1.28	1.26	1.24	1.25

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-9 Result of Economic Evaluation (Option II: FSL=410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
TWL	EL.m	307.7	307.7	307.7	307.8	307.8	307.8	307.8	307.9	307.9	307.9
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	101.1	101.1	101.1	101	101	101	101	100.9	100.9	100.9
Pmax	MW	66	71	75	79	83	87	91	95	99	103
Primary Energy	GWh	133.90	142.01	150.02	157.39	164.94	171.94	178.92	185.12	191.13	196.56
Pfirm	MW	51.18	54.46	58.00	60.04	62.75	66.04	66.12	58.78	55.81	49.10
Benefit	1000USD	39,497	41,943	44,450	46,390	48,564	50,814	52,094	51,003	51,191	50,150
Cost	1000USD	35,815	36,142	36,443	36,719	37,012	37,280	37,567	37,830	38,090	38,367
B/C		1.10	1.16	1.22	1.26	1.31	1.36	1.39	1.35	1.34	1.31

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-10 Result of Economic Evaluation (Option II: FSL=415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
TWL	EL.m	307.7	307.8	307.8	307.8	307.8	307.9	307.9	307.9	307.9	308
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	106.1	106	106	106	106	105.9	105.9	105.9	105.9	105.8
Pmax	MW	78	83	87	92	96	100	105	109	114	118
Primary Energy	GWh	154.52	162.73	171.05	179.12	187.02	193.85	201.13	207.22	213.60	218.79
Pfirm	MW	57.09	60.44	63.36	64.72	68.38	71.70	74.82	63.50	59.85	50.29
Benefit	1000USD	44,986	47,472	49,848	51,709	54,232	56,460	58,709	56,400	56,451	54,509
Cost	1000USD	41,121	41,440	41,735	42,043	42,332	42,596	42,915	43,173	43,465	43,740
B/C		1.09	1.15	1.19	1.23	1.28	1.33	1.37	1.31	1.30	1.25

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-11 Result of Economic Evaluation (Option II: FSL=420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
TWL	EL.m	307.8	307.8	307.8	307.9	307.9	307.9	307.9	308	308	308
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	111	111	111	110.9	110.9	110.9	110.9	110.8	110.8	110.8
Pmax	MW	91	96	101	106	111	115	120	125	130	134
Primary Energy	GWh	176.91	185.64	194.20	202.29	209.90	216.81	223.62	230.05	235.99	241.23
Pfirm	MW	63.27	64.62	67.06	70.43	74.08	77.59	76.99	63.99	61.94	56.71
Benefit	1000USD	50,875	52,853	55,128	57,598	60,065	62,365	63,410	60,657	61,110	60,480
Cost	1000USD	40,769	41,079	41,402	41,704	42,020	42,279	42,568	42,878	43,161	43,410
B/C		1.25	1.29	1.33	1.38	1.43	1.48	1.49	1.41	1.42	1.39

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-12 Result of Economic Evaluation (Option II: FSL=425m)

Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
TWL	EL.m	307.8	307.9	307.9	307.9	307.9	308	308	308	308	308.1
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	116	115.9	115.9	115.9	115.9	115.8	115.8	115.8	115.8	115.7
Pmax	MW	106	111	116	122	126	131	136	141	146	151
Primary Energy	GWh	201.75	210.31	218.44	226.57	233.70	240.29	246.69	252.94	258.88	263.76
Pfirm	MW	67.72	69.79	73.14	76.57	80.21	83.36	76.93	62.61	62.09	57.31
Benefit	1000USD	56,685	58,849	61,320	63,815	66,193	68,327	67,545	64,362	65,275	64,716
Cost	1000USD	42,858	43,177	43,470	43,795	44,069	44,355	44,635	44,937	45,212	45,488
B/C		1.32	1.36	1.41	1.46	1.50	1.54	1.51	1.43	1.44	1.42

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-13 Result of Economic Evaluation (Option II: FSL=435m)

Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
TWL	EL.m	308	308	308	308	308	308.1	308.1	308.1	308.1	308.1
Loss	m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Effective Head	m	125.8	125.8	125.8	125.8	125.8	125.7	125.7	125.7	125.7	125.7
Pmax	MW	140	145	151	156	162	167	173	178	184	189
Primary Energy	GWh	254.59	262.84	270.84	277.99	284.96	290.87	296.81	302.14	306.49	310.72
Pfirm	MW	78.36	81.99	85.37	88.84	92.19	78.42	73.05	65.48	61.97	57.30
Benefit	1000USD	69,397	71,974	74,430	76,761	79,024	75,945	75,399	74,082	73,809	73,165
Cost	1000USD	51,238	51,539	51,847	52,123	52,425	52,719	53,015	53,282	53,574	53,835
B/C		1.35	1.40	1.44	1.47	1.51	1.44	1.42	1.39	1.38	1.36

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-14 Result of Economic Evaluation (Option IIIa: FSL=405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
TWL	EL.m	288.6	288.7	288.7	288.8	288.8	288.9	288.9	288.9	289	289
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	113	112.9	112.9	112.8	112.8	112.7	112.7	112.7	112.6	112.6
Pmax	MW	66	71	76	80	85	90	95	99	104	109
Primary Energy	GWh	136.43	146.02	155.63	164.75	173.87	182.24	190.45	197.98	205.33	212.51
Pfirm	MW	54.76	59.02	63.21	67.04	70.18	70.87	64.87	59.47	52.92	52.28
Benefit	1000USD	41,029	44,037	47,027	49,821	52,407	54,121	53,794	53,525	52,878	53,978
Cost	1000USD	35,964	36,399	36,766	37,154	37,511	37,929	38,345	38,655	38,998	39,408
B/C		1.14	1.21	1.28	1.34	1.40	1.43	1.40	1.38	1.36	1.37

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-15 Result of Economic Evaluation (Option IIIa: FSL=410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
TWL	EL.m	288.7	288.8	288.8	288.8	288.9	288.9	289	289	289	289.1
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	117.9	117.8	117.8	117.8	117.7	117.7	117.6	117.6	117.6	117.5
Pmax	MW	78	82	87	92	97	101	106	111	116	120
Primary Energy	GWh	157.72	166.57	176.06	185.03	193.70	201.83	210.03	217.58	224.75	230.87
Pfirm	MW	61.35	65.19	69.35	71.82	75.20	79.10	78.48	70.00	66.72	58.68
Benefit	1000USD	46,844	49,592	52,551	54,909	57,486	60,123	61,412	60,220	60,524	59,208
Cost	1000USD	38,345	38,662	39,080	39,426	39,838	40,141	40,549	40,883	41,215	41,582
B/C		1.22	1.28	1.34	1.39	1.44	1.50	1.51	1.47	1.47	1.42

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-16 Result of Economic Evaluation (Option IIIa: FSL=415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
TWL	EL.m	288.8	288.8	288.9	288.9	289	289	289	289.1	289.1	289.1
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	122.8	122.8	122.7	122.7	122.6	122.6	122.6	122.5	122.5	122.5
Pmax	MW	90	96	101	106	111	116	122	127	132	137
Primary Energy	GWh	180.47	190.44	200.13	209.50	218.57	226.99	235.45	242.70	249.94	256.44
Pfirm	MW	68.44	72.50	75.68	77.85	82.08	86.11	88.67	75.71	71.44	60.16
Benefit	1000USD	53,071	56,087	58,788	61,127	64,032	66,760	69,053	66,460	66,478	64,255
Cost	1000USD	40,621	41,005	41,420	41,761	42,170	42,505	42,944	43,274	43,603	44,002
B/C		1.31	1.37	1.42	1.46	1.52	1.57	1.61	1.54	1.52	1.46

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-17 Result of Economic Evaluation (Option IIIa: FSL=420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
TWL	EL.m	288.9	288.9	289	289	289	289.1	289.1	289.1	289.2	289.2
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	127.7	127.7	127.6	127.6	127.6	127.5	127.5	127.5	127.4	127.4
Pmax	MW	105	111	116	122	127	133	138	144	149	155
Primary Energy	GWh	206.15	216.41	226.00	235.78	244.60	252.87	260.71	268.52	275.20	281.71
Pfirm	MW	75.67	77.50	80.81	84.92	89.22	93.30	91.47	76.41	73.83	67.59
Benefit	1000USD	59,869	62,266	64,988	67,984	70,865	73,581	74,442	71,318	71,744	71,039
Cost	1000USD	43,571	43,948	44,356	44,725	45,128	45,492	45,819	46,251	46,574	46,927
B/C		1.37	1.42	1.47	1.52	1.57	1.62	1.62	1.54	1.54	1.51

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-18 Result of Economic Evaluation (Option IIIa: FSL=425m)

Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
TWL	EL.m	289	289	289	289.1	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	132.6	132.6	132.6	132.5	132.5	132.5	132.4	132.4	132.3	132.3
Pmax	MW	122	128	133	139	145	150	156	162	167	173
Primary Energy	GWh	234.21	244.44	253.83	261.01	267.61	272.46	283.93	293.26	300.79	306.91
Pfirm	MW	81.13	84.26	88.25	92.26	96.56	97.50	91.53	74.72	74.04	68.42
Benefit	1000USD	66,562	69,345	72,235	74,734	77,215	78,371	78,640	75,263	76,413	75,825
Cost	1000USD	46,640	47,077	47,407	47,768	48,197	48,522	48,873	49,299	49,617	49,964
B/C		1.43	1.47	1.52	1.56	1.60	1.62	1.61	1.53	1.54	1.52

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-19 Result of Economic Evaluation (Option IIIa: FSL=435m)

Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
TWL	EL.m	289.1	289.2	289.2	289.2	289.3	289.3	289.3	289.4	289.4	289.4
Loss	m	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Effective Head	m	142.5	142.4	142.4	142.4	142.3	142.3	142.3	142.2	142.2	142.2
Pmax	MW	158	165	171	177	183	189	196	202	208	214
Primary Energy	GWh	293.48	303.28	309.44	313.95	318.67	328.98	339.00	349.20	354.14	359.26
Pfirm	MW	95.14	99.32	103.36	107.50	108.88	93.35	87.07	77.79	73.70	68.38
Benefit	1000USD	81,445	84,466	86,790	88,847	90,112	87,296	87,211	86,255	85,914	85,236
Cost	1000USD	55,728	56,186	56,536	56,887	57,234	57,657	58,027	58,371	58,710	59,047
B/C		1.46	1.50	1.54	1.56	1.57	1.51	1.50	1.48	1.46	1.44

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-20 Result of Economic Evaluation (Option IIIb: FSL=405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	396.4	396.6	397	397.2	397.6	397.8	398.2	398.4	398.6	399
TWL	EL.m	288.6	288.7	288.7	288.8	288.8	288.9	288.9	288.9	289	289
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	113.4	113.3	113.3	113.2	113.2	113.1	113.1	113.1	113	113
Pmax	MW	66	71	76	81	85	90	95	100	105	109
Primary Energy	GWh	136.55	146.23	155.91	165.22	174.08	182.57	190.96	198.94	206.13	213.00
Pfirm	MW	54.56	58.65	62.97	67.10	69.85	73.87	68.27	61.09	55.14	51.98
Benefit	1000USD	40,991	43,963	47,005	49,923	52,345	55,083	54,908	54,185	53,690	53,976
Cost	1000USD	35,310	35,664	36,092	36,479	36,861	37,237	37,659	38,023	38,384	38,763
B/C		1.16	1.23	1.30	1.37	1.42	1.48	1.46	1.43	1.40	1.39

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-21 Result of Economic Evaluation (Option IIIb: FSL=410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	396.8	397.2	397.4	397.8	398	398.2	398.6	398.8	399	399.2
TWL	EL.m	288.7	288.8	288.8	288.8	288.9	288.9	289	289	289	289.1
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	118.3	118.2	118.2	118.2	118.1	118.1	118	118	118	117.9
Pmax	MW	78	82	87	92	97	102	106	111	116	121
Primary Energy	GWh	157.85	166.65	176.07	185.27	194.02	202.38	210.26	218.00	225.33	231.64
Pfirm	MW	60.98	64.95	68.94	72.05	74.64	78.51	82.63	75.67	66.37	65.09
Benefit	1000USD	46,756	49,534	52,430	55,021	57,375	60,044	62,702	62,002	60,523	61,274
Cost	1000USD	37,515	37,843	38,219	38,627	38,997	39,352	39,728	40,078	40,428	40,781
B/C		1.25	1.31	1.37	1.42	1.47	1.53	1.58	1.55	1.50	1.50

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-22 Result of Economic Evaluation (Option IIIb: FSL=415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	397.4	397.8	398	398.4	398.6	398.8	399	399.4	399.6	399.8
TWL	EL.m	288.8	288.8	288.9	288.9	289	289	289	289.1	289.1	289.1
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	123.2	123.2	123.1	123.1	123	123	123	122.9	122.9	122.9
Pmax	MW	91	96	101	106	111	117	122	127	132	137
Primary Energy	GWh	180.95	190.74	200.20	209.64	218.69	227.53	235.73	243.08	250.35	256.85
Pfirm	MW	68.03	72.24	75.21	77.68	81.46	85.46	89.57	76.85	71.05	64.99
Benefit	1000USD	53,034	56,063	58,659	61,101	63,867	66,662	69,374	66,871	66,435	65,782
Cost	1000USD	39,845	40,203	40,576	40,982	41,349	41,735	42,096	42,494	42,842	43,194
B/C		1.33	1.39	1.45	1.49	1.54	1.60	1.65	1.57	1.55	1.52

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-23 Result of Economic Evaluation (Option IIIb: FSL=420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398	398.4	398.6	398.8	399.2	399.4	399.6	399.8	400.2	400.4
TWL	EL.m	288.9	288.9	289	289	289	289.1	289.1	289.1	289.2	289.2
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	128.1	128.1	128	128	128	127.9	127.9	127.9	127.8	127.8
Pmax	MW	105	111	116	122	128	133	139	144	149	155
Primary Energy	GWh	206.15	216.64	225.98	235.90	245.03	253.17	261.22	268.66	275.52	282.22
Pfirm	MW	75.19	77.18	80.19	84.28	88.55	92.60	95.04	78.17	75.13	68.82
Benefit	1000USD	59,724	62,211	64,798	67,813	70,741	73,425	75,608	71,872	72,193	71,501
Cost	1000USD	42,785	43,168	43,533	43,922	44,362	44,714	45,091	45,445	45,841	46,214
B/C		1.40	1.44	1.49	1.54	1.59	1.64	1.68	1.58	1.57	1.55

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-24 Result of Economic Evaluation (Option IIIb: FSL=425m)

Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	398.6	399	399.2	399.4	399.6	400	400.2	400.4	400.6	400.8
TWL	EL.m	289	289	289	289.1	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	133	133	133	132.9	132.9	132.9	132.8	132.8	132.7	132.7
Pmax	MW	122	128	134	139	145	151	156	162	168	174
Primary Energy	GWh	234.30	244.63	254.17	261.03	268.83	273.01	284.11	293.44	301.38	307.48
Pfirm	MW	80.61	83.65	87.60	91.57	95.56	99.93	91.10	81.01	73.48	71.27
Benefit	1000USD	66,421	69,195	72,101	74,530	77,134	79,201	78,543	77,187	76,351	76,784
Cost	1000USD	45,208	45,582	45,959	46,306	46,686	47,110	47,448	47,824	48,188	48,551
B/C		1.47	1.52	1.57	1.61	1.65	1.68	1.66	1.61	1.58	1.58

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-25 Result of Economic Evaluation (Option IIIb: FSL=435m)

Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	399.8	400	400.2	400.6	400.8	401	401.2	401.4	401.6	401.8
TWL	EL.m	289.1	289.2	289.2	289.2	289.3	289.3	289.3	289.4	289.4	289.4
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	142.9	142.8	142.8	142.8	142.7	142.7	142.7	142.6	142.6	142.6
Pmax	MW	159	165	171	178	184	190	196	202	209	215
Primary Energy	GWh	293.91	303.28	309.46	314.39	319.15	329.48	339.23	349.42	354.71	359.75
Pfirm	MW	94.41	98.29	102.29	106.67	110.61	94.74	88.34	84.75	75.42	68.09
Benefit	1000USD	81,302	84,156	86,472	88,677	90,718	87,804	87,634	88,388	86,534	85,236
Cost	1000USD	53,148	53,444	53,809	54,256	54,617	54,984	55,341	55,700	56,080	56,432
B/C		1.53	1.57	1.61	1.63	1.66	1.60	1.58	1.59	1.54	1.51

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-26 Result of Economic Evaluation (Option IV: FSL=405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	65.4	70.2	75	79.8	84.6	89.3	94.1	98.9	103.7	108.5
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	397	397.4	397.6	398	398.2	398.6	399	399.2	399.4	399.8
TWL	EL.m	302.5	302.5	302.6	302.6	302.6	302.7	302.7	302.7	302.7	302.8
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	99.3	99.3	99.2	99.2	99.2	99.1	99.1	99.1	99.1	99
Pmax	MW	58	62	66	71	75	79	83	87	92	96
Primary Energy	GWh	119.48	127.80	130.03	144.59	152.50	159.69	166.78	173.49	180.27	186.31
Pfirm	MW	47.47	51.25	54.84	58.26	60.93	61.97	56.70	51.96	46.30	45.73
Benefit	1000USD	35,785	38,420	39,901	43,551	45,778	47,385	47,076	46,858	46,376	47,291
Cost	1000USD	34,661	35,034	35,350	35,759	36,066	36,426	36,786	37,084	37,417	37,772
B/C		1.03	1.10	1.13	1.22	1.27	1.30	1.28	1.26	1.24	1.25

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-27 Result of Economic Evaluation (Option IV: FSL=410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	73.7	78.2	82.8	87.3	91.9	96.4	101	105.5	110.1	114.6
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	397.6	397.8	398.2	398.4	398.8	399	399.4	399.6	399.8	400.2
TWL	EL.m	302.5	302.6	302.6	302.6	302.7	302.7	302.7	302.8	302.8	302.8
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	104.3	104.2	104.2	104.2	104.1	104.1	104.1	104	104	104
Pmax	MW	69	73	77	81	85	90	94	98	102	106
Primary Energy	GWh	138.78	146.67	154.93	162.66	170.16	177.66	184.89	191.32	197.51	203.09
Pfirm	MW	53.22	56.56	60.21	62.43	65.18	68.59	68.69	61.32	58.33	51.43
Benefit	1000USD	40,989	43,414	45,999	48,058	50,235	52,611	53,942	52,883	53,097	52,026
Cost	1000USD	36,822	37,127	37,486	37,783	38,139	38,469	38,820	39,108	39,394	39,740
B/C		1.11	1.17	1.23	1.27	1.32	1.37	1.39	1.35	1.35	1.31

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-28 Result of Economic Evaluation (Option IV: FSL=415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	82.6	87.3	92.1	96.8	101.6	106.3	111.1	115.8	120.6	125.3
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	398.2	398.4	398.8	399	399.4	399.6	400	400.2	400.4	400.8
TWL	EL.m	302.6	302.6	302.7	302.7	302.7	302.8	302.8	302.8	302.8	302.9
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	109.2	109.2	109.1	109.1	109.1	109	109	109	109	108.9
Pmax	MW	80	85	90	94	99	103	108	113	117	122
Primary Energy	GWh	159.33	168.09	176.67	184.74	193.15	200.21	207.66	214.26	220.50	226.19
Pfirm	MW	59.34	62.88	65.85	67.33	71.12	74.55	77.67	66.27	62.56	52.70
Benefit	1000USD	46,529	49,171	51,608	53,506	56,160	58,462	60,742	58,501	58,508	56,566
Cost	1000USD	39,025	39,363	39,758	40,050	40,440	40,728	41,115	41,433	41,716	42,098
B/C		1.19	1.25	1.30	1.34	1.39	1.44	1.48	1.41	1.40	1.34

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-29 Result of Economic Evaluation (Option IV: FSL=420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.3	97.2	102	106.9	111.7	116.6	121.4	126.3	131.1	136
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	398.8	399	399.4	399.6	400	400.2	400.4	400.8	401	401.2
TWL	EL.m	302.7	302.7	302.7	302.8	302.8	302.8	302.8	302.9	302.9	302.9
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	114.1	114.1	114.1	114	114	114	114	113.9	113.9	113.9
Pmax	MW	94	99	104	109	114	119	123	128	133	138
Primary Energy	GWh	182.69	191.65	200.38	208.71	216.60	223.94	230.48	237.31	243.54	249.22
Pfirm	MW	65.81	67.30	69.85	73.35	77.12	80.76	79.97	66.87	64.77	59.38
Benefit	1000USD	52,680	54,741	57,079	59,631	62,186	64,602	65,541	62,830	63,320	62,721
Cost	1000USD	41,907	42,238	42,624	42,949	43,332	43,650	43,931	44,313	44,623	44,933
B/C		1.26	1.30	1.34	1.39	1.44	1.48	1.49	1.42	1.42	1.40

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-30 Result of Economic Evaluation (Option IV: FSL=425m)

Item	Unit	FSL=425									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	102.9	107.8	112.6	117.5	122.3	127.2	132	136.9	141.7	146.6
FSL	EL.m	425	425	425	425	425	425	425	425	425	425
MOL	EL.m	399.4	399.8	400	400.2	400.6	400.8	401	401.4	401.6	401.8
TWL	EL.m	302.7	302.8	302.8	302.8	302.9	302.9	302.9	302.9	302.9	303
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	119.1	119	119	119	118.9	118.9	118.9	118.9	118.9	118.8
Pmax	MW	109	114	120	125	130	135	140	145	150	155
Primary Energy	GWh	208.02	216.82	225.47	233.65	241.03	248.06	254.63	261.07	267.18	272.22
Pfirm	MW	70.57	72.75	76.22	79.78	83.45	86.40	80.17	65.51	64.99	60.06
Benefit	1000USD	58,671	60,911	63,512	66,055	68,487	70,640	69,949	66,698	67,641	67,066
Cost	1000USD	44,872	45,257	45,608	45,923	46,301	46,613	46,920	47,296	47,600	47,905
B/C		1.31	1.35	1.39	1.44	1.48	1.52	1.49	1.41	1.42	1.40

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.3-31 Result of Economic Evaluation (Option IV: FSL=435m)

Item	Unit	FSL=435									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	124.6	129.5	134.4	139.4	144.3	149.2	154.1	159.1	164	168.9
FSL	EL.m	435	435	435	435	435	435	435	435	435	435
MOL	EL.m	400.6	401	401.2	401.4	401.6	402	402.2	402.4	402.6	402.8
TWL	EL.m	302.9	302.9	302.9	302.9	303	303	303	303	303	303.1
Loss	m	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Effective Head	m	128.9	128.9	128.9	128.9	128.8	128.8	128.8	128.8	128.8	128.7
Pmax	MW	143	149	155	160	166	171	177	183	188	194
Primary Energy	GWh	262.04	270.88	279.00	286.47	293.41	299.76	305.88	311.68	315.90	320.33
Pfirm	MW	81.85	85.61	89.13	92.73	95.73	81.87	76.38	68.53	64.96	60.05
Benefit	1000USD	71,788	74,510	77,030	79,458	81,609	78,583	78,034	76,716	76,402	75,722
Cost	1000USD	52,593	52,996	53,331	53,635	53,965	54,335	54,662	54,988	55,283	55,606
B/C		1.36	1.41	1.44	1.48	1.51	1.45	1.43	1.40	1.38	1.36

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

10.4 Reconsideration of MOL

During the 3rd Field Work in Nepal, conducted from November to December, 2006, NEA gave the following comments to the JICA Team:

- It was agreed that the Layout alternative of Option IIIb, which would use an additional head of 20 m and which was the optimal choice in the comparative study during discussions on the Interim Report, should be adopted for the project.
- MOL should be lowered in order to utilize the reservoir effectively for reduction of environmental affects.

Based on these comments, reconsideration of MOL for the layout alternative of Option IIIb is executed as shown in this section.

10.4.1 Reconsideration of MOL

In order for MOL to be set to the minimal level, the probable lowest elevation of EL. 387.2 m is adopted as the MOL in this study, which takes the following equation into consideration:

Planned Sedimentation Level + supplement height = EL. 386.2 m + 1.0 m = EL. 387.2 m

To prevent cavitation in the headrace tunnel, a supplement depth of around twice of the diameter of the headrace tunnel from MOL is taken into consideration to set the waterway bottom elevation as described in **10.2.1**. With this in mind, the bottom elevations of the headrace tunnel in the waterway profiles become lower than those of the alternatives shown in **10.1** to **10.3**. Conception of how to determine MOL is shown in **Fig 10.4.1-1**.

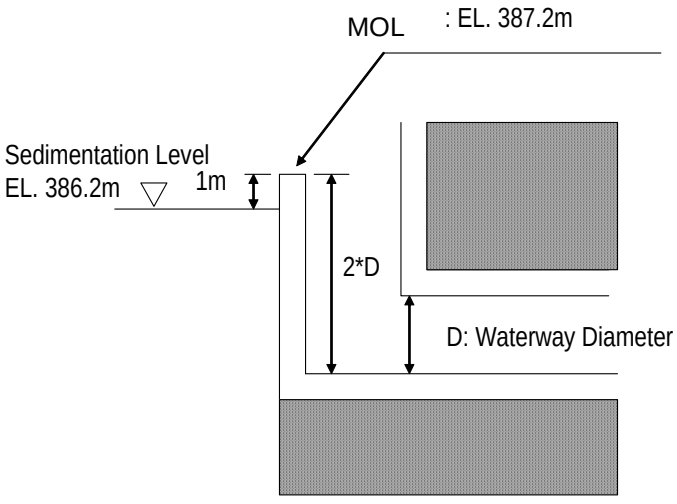


Fig 10.4.1-1 How to determine the Minimum Operation Level 2

10.4.2 Comparison of Project Alternatives

The procedures for project alternative setting and project cost estimation are the same as those shown in **10.2**, while FSLs for comparative study are assumed for EL. 405 m, 410 m, 415 m, and 420 m. The maximum discharge for each project alternative is assumed to be in terms of a 6 hour peak discharge between firm discharge of 80% and 100%, which are estimated using the mass curve method and considering the reservoir effective volume for each FSL. Profiles of the project alternatives are as shown in **Table 10.4.2-1**.

Table 10.4.2-1 Main Features of Alternatives for Option IIIb with Lower MOL

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	65.4	72.3	79.2	86.1	93	99.8	106.7	113.6	120.5	127.4
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
Effective Vol.	MCM	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8
TWL	EL.m	288.6	288.7	288.8	288.8	288.9	288.9	289	289	289.1	289.2
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	113.6	113.5	113.4	113.4	113.3	113.3	113.2	113.2	113.1	113
Pmax	MW	66	73	80	87	94	101	108	115	122	128
Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	73.7	80.1	86.5	92.9	99.3	105.7	112.1	118.5	124.9	131.3
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
Effective Vol.	MCM	132.1	132.1	132.1	132.1	132.1	132.1	132.1	132.1	132.1	132.1
TWL	EL.m	288.8	288.9	288.9	289	289	289.1	289.1	289.2	289.2	289.2
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	123.4	123.3	123.3	123.2	123.2	123.1	123.1	123	123	123
Pmax	MW	91	98	105	112	119	126	133	140	147	154
Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	82.6	89	95.4	101.8	108.2	114.6	121	127.4	133.8	140.2
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
Effective Vol.	MCM	167	167	167	167	167	167	167	167	167	167
TWL	EL.m	288.8	288.8	288.9	288.9	289	289	289	289.1	289.1	289.1
Loss	m	3	3	3	3	3	3	3	3	3	3
Effective Head	m	123.2	123.2	123.1	123.1	123	123	123	122.9	122.9	122.9
Pmax	MW	91	96	101	106	111	117	122	127	132	137
Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m^3/s	92.3	98.7	105.1	111.5	117.9	124.2	130.6	137	143.4	149.8
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
Effective Vol.	MCM	205	205	205	205	205	205	205	205	205	205
TWL	EL.m	288.9	288.9	289	289	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	128.3	128.3	128.2	128.2	128.1	128.1	128	128	127.9	127.9
Pmax	MW	106	113	120	128	135	142	149	156	164	171

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax)..

The project cost of each alternative was estimated as mentioned in **10.2.2**. In this case, if the maximum discharge increases, the diameter of the headrace tunnel expands, meaning the bottom elevation level of the headrace tunnel is reduced and the headrace tunnel length is extended. However, the length of penstock becomes shorter, which decreases the penstock weight. The project cost estimation results are shown in **Tables 10.4.2-2** to **5**.

Table 10.4.2-2 Project Cost (FSL 405)

Project Cost Summary 1,000USD

Item	FSL=405									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	2,957	2,984	3,018	3,051	3,084	3,117	3,150	3,184	3,217	3,250
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360	103,360
(3) Intake	1,108	1,183	1,256	1,327	1,397	1,465	1,533	1,600	1,666	1,731
(4) Power Tunnel	6,674	7,074	7,486	7,909	8,341	8,786	9,240	9,705	10,183	10,669
(5) Penstock	721	769	816	861	906	949	993	1,036	1,077	1,119
(6) Power House	8,064	8,476	8,869	9,247	9,607	9,952	10,288	10,615	10,930	11,235
(7) Tailrace Tunnel	1,507	1,585	1,704	1,786	1,870	1,955	2,041	2,130	2,220	2,311
(8) Tailrace	300	327	359	387	415	443	471	500	529	558
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	5,736	6,265	6,799	7,337	7,881	8,425	8,979	9,539	10,103	10,673
(11) Others	7,041	6,808	6,863	6,916	6,968	7,020	7,073	7,126	7,178	7,231
4. Hydro-Mechanical Works	17,196	17,497	17,794	18,091	18,389	18,680	18,977	19,275	19,567	19,862
5. Electro-Mechanical Works	27,209	29,112	30,957	32,741	34,488	36,183	37,850	39,472	41,073	42,424
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	231,275	234,842	238,682	242,415	246,110	249,738	253,359	256,943	260,504	263,827
7. Administration Fee	34,691	35,226	35,802	36,362	36,917	37,461	38,004	38,542	39,076	39,574
8. Contingency	23,127	23,484	23,868	24,242	24,611	24,974	25,336	25,694	26,050	26,383
9. Interest During Construction	57,819	58,711	59,671	60,604	61,528	62,434	63,340	64,236	65,126	65,957
Total	346,912	352,264	358,024	363,623	369,165	374,607	380,038	385,415	390,757	395,740

Note: The numbers 1 to 10 correspond to case No. of maximum discharge at each FSL in Table 10.4.2-1.

Table 10.4.2-3 Project Cost (FSL 410)

Project Cost Summary 1,000USD

Item	FSL=410									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,142	3,168	3,200	3,231	3,263	3,296	3,328	3,353	3,385	3,417
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230	28,230
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062	110,062
(3) Intake	1,349	1,424	1,498	1,570	1,641	1,711	1,780	1,844	1,911	1,977
(4) Power Tunnel	7,076	7,488	7,910	8,344	8,788	9,244	9,709	9,948	10,431	10,924
(5) Penstock	776	819	862	902	942	981	1,022	1,058	1,095	1,133
(6) Power House	8,682	9,048	9,403	9,741	10,071	10,388	10,698	10,996	11,289	11,571
(7) Tailrace Tunnel	1,624	1,704	1,786	1,870	1,955	2,041	2,130	2,220	2,265	2,358
(8) Tailrace	335	362	388	415	441	469	496	523	546	574
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	6,346	6,853	7,365	7,882	8,404	8,931	9,464	9,907	10,447	10,993
(11) Others	7,481	7,216	7,267	7,319	7,370	7,421	7,473	7,512	7,561	7,613
4. Hydro-Mechanical Works	17,649	17,932	18,217	18,498	18,779	19,057	19,343	19,617	19,894	20,174
5. Electro-Mechanical Works	29,994	31,775	33,256	34,954	36,602	37,997	39,581	41,146	42,671	43,969
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	245,870	249,202	252,565	256,139	259,672	262,951	266,438	269,538	272,910	276,118
7. Administration Fee	36,880	37,380	37,885	38,421	38,951	39,443	39,966	40,431	40,936	41,418
8. Contingency	24,587	24,920	25,257	25,614	25,967	26,295	26,644	26,954	27,291	27,612
9. Interest During Construction	61,467	62,301	63,141	64,035	64,918	65,738	66,609	67,384	68,227	69,029
Total	368,805	373,803	378,848	384,209	389,507	394,426	399,657	404,307	409,365	414,177

Note: The numbers 1 to 10 correspond to case No. of maximum discharge at each FSL in Table 10.4.2-1.

Table 10.4.2-4 Project Cost (FSL 415)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,343	3,368	3,401	3,433	3,466	3,491	3,523	3,555	3,581	3,613
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180	30,180
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131	117,131
(3) Intake	1,605	1,684	1,763	1,839	1,915	1,985	2,059	2,131	2,198	2,269
(4) Power Tunnel	7,698	8,125	8,563	9,014	9,473	9,709	10,186	10,672	10,921	11,426
(5) Penstock	835	879	922	965	1,008	1,050	1,091	1,133	1,174	1,214
(6) Power House	9,316	9,667	10,009	10,336	10,656	10,964	11,266	11,557	11,844	12,124
(7) Tailrace Tunnel	1,745	1,828	1,912	1,998	2,085	2,174	2,220	2,311	2,404	2,452
(8) Tailrace	373	399	426	453	480	508	530	558	586	609
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	7,075	7,590	8,110	8,635	9,166	9,608	10,146	10,689	11,138	11,689
(11) Others	7,960	7,658	7,710	7,763	7,815	7,854	7,904	7,956	7,996	8,046
4. Hydro-Mechanical Works	18,141	18,436	18,732	19,025	19,321	19,613	19,908	20,202	20,496	20,790
5. Electro-Mechanical Works	32,800	34,474	36,100	37,700	39,258	40,797	42,297	43,783	45,233	46,660
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	261,324	264,543	268,081	271,595	275,076	278,187	281,562	284,981	288,003	291,325
7. Administration Fee	39,199	39,681	40,212	40,739	41,261	41,728	42,234	42,747	43,201	43,699
8. Contingency	26,132	26,454	26,808	27,159	27,508	27,819	28,156	28,498	28,800	29,132
9. Interest During Construction	65,331	66,136	67,020	67,899	68,769	69,547	70,391	71,245	72,001	72,831
Total	391,987	396,814	402,121	407,392	412,614	417,280	422,344	427,472	432,005	436,987

Note: The numbers 1 to 10 correspond to case No. of maximum discharge at each FSL in Table 10.4.2-1.

Table 10.4.2-5 Project Cost (FSL 420)

Project Cost Summary 1,000USD

Item	FSL=420									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,555	3,580	3,612	3,645	3,670	3,702	3,728	3,761	3,794	3,819
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570	35,570
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053	6,053
(2) Dam	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578	124,578
(3) Intake	1,876	1,960	2,041	2,122	2,198	2,274	2,348	2,424	2,499	2,569
(4) Power Tunnel	8,345	8,788	9,243	9,709	9,947	10,428	10,676	11,173	11,682	11,943
(5) Penstock	896	939	982	1,024	1,065	1,106	1,147	1,188	1,228	1,268
(6) Power House	9,976	10,316	10,643	10,962	11,269	11,566	11,858	12,145	12,422	12,696
(7) Tailrace Tunnel	1,870	1,955	2,041	2,130	2,174	2,265	2,358	2,452	2,499	2,596
(8) Tailrace	413	440	467	494	517	544	572	600	623	652
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900	6,900
(10) Surge Tank	7,860	8,383	8,912	9,445	9,889	10,425	10,872	11,421	11,975	12,429
(11) Others	8,464	8,124	8,176	8,229	8,267	8,319	8,359	8,412	8,462	8,501
4. Hydro-Mechanical Works	18,684	18,986	19,286	19,588	19,887	20,184	20,482	20,783	21,083	21,382
5. Electro-Mechanical Works	35,850	37,414	38,957	40,673	42,156	43,604	45,040	46,442	48,032	49,392
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170
Direct Cost	281,060	284,156	287,631	291,291	294,309	297,689	300,708	304,071	307,569	310,518
7. Administration Fee	42,159	42,623	43,145	43,694	44,146	44,653	45,106	45,611	46,135	46,578
8. Contingency	28,106	28,416	28,763	29,129	29,431	29,769	30,071	30,407	30,757	31,052
9. Interest During Construction	70,265	71,039	71,908	72,823	73,577	74,422	75,177	76,018	76,892	77,629
Total	421,590	426,233	431,447	436,937	441,464	446,533	451,062	456,107	461,354	465,777

Note: The numbers 1 to 10 correspond to case No. of maximum discharge at each FSL in Table 10.4.2-1.

The reservoir simulation procedure is the same as described in **10.2.1** and the results are shown in **Table 10.4.2.6**.

Table 10.4.2-6 Reservoir simulation Result

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	061128 405-1 output_.xls	405	405	387.20	288.60	65.40	66	0.951	48.670	132.880	264.010	396.890
2	061219 405-2 output_.xls	405	405	387.20	288.70	72.30	73	0.951	53.750	146.100	273.230	419.320
3	061219 405-3 output_.xls	405	405	387.20	288.80	79.20	80	0.951	58.810	159.190	281.500	440.700
4	061219 405-4 output_.xls	405	405	387.20	288.80	86.10	87	0.951	63.930	172.030	289.140	461.170
5	061219 405-5 output_.xls	405	405	387.20	288.90	93.00	94	0.951	67.600	184.370	296.000	480.370
6	061219 405-6 output_.xls	405	405	387.20	288.90	99.80	101	0.951	70.730	196.270	302.830	499.110
7	061219 405-7 output_.xls	405	405	387.20	289.00	106.70	108	0.951	75.530	207.140	309.140	516.280
8	061219 405-8 output_.xls	405	405	387.20	289.00	113.60	115	0.951	69.610	217.210	315.170	532.380
9	061219 405-9 output_.xls	405	405	387.20	289.10	120.50	122	0.951	63.210	226.370	320.870	547.240
10	061219 405-10 output_.xls	405	405	387.20	289.20	127.40	128	0.951	51.000	234.200	326.400	560.600
11	061128 410-1 output_.xls	410	410	387.20	288.70	73.70	78	0.951	54.220	153.450	292.930	446.380
12	061219 410-2 output_.xls	410	410	387.20	288.80	80.10	85	0.951	58.870	165.830	300.660	466.490
13	061219 410-3 output_.xls	410	410	387.20	288.80	86.50	91	0.951	63.570	177.980	307.100	485.080
14	061219 410-4 output_.xls	410	410	387.20	288.90	92.90	98	0.951	67.290	190.030	314.110	504.140
15	061128 410-5 output_.xls	410	410	387.20	288.90	99.30	105	0.951	69.710	201.780	320.780	522.560
16	061219 410-6 output_.xls	410	410	387.20	289.00	105.70	111	0.951	73.250	212.660	325.440	538.100
17	061219 410-7 output_.xls	410	410	387.20	289.00	112.10	118	0.951	77.690	223.040	331.190	554.230
18	061219 410-8 output_.xls	410	410	387.20	289.10	118.50	125	0.951	82.030	232.300	336.560	568.870
19	061219 410-9 output_.xls	410	410	387.20	289.10	124.90	132	0.951	67.480	241.170	341.930	583.100
20	061219 410-10 output_.xls	410	410	387.20	289.20	131.30	138	0.951	64.730	249.040	346.880	595.930
21	061128 415-1 output_.xls	415	415	387.20	288.80	82.60	91	0.951	60.190	175.750	322.600	498.350
22	061219 415-2 output_.xls	415	415	387.20	288.90	89.00	98	0.951	64.790	188.170	329.480	517.650
23	061219 415-3 output_.xls	415	415	387.20	288.90	95.40	105	0.951	69.140	200.550	336.150	536.690
24	061219 415-4 output_.xls	415	415	387.20	289.00	101.80	112	0.951	70.870	212.390	342.220	554.610
25	061219 415-5 output_.xls	415	415	387.20	289.00	108.20	119	0.951	73.600	223.910	347.670	571.570
26	061219 415-6 output_.xls	415	415	387.20	289.10	114.60	126	0.951	77.860	234.650	352.470	587.110
27	061219 415-7 output_.xls	415	415	387.20	289.10	121.00	133	0.951	82.210	244.540	357.720	602.260
28	061219 415-8 output_.xls	415	415	387.20	289.20	127.40	140	0.951	84.660	253.450	362.670	616.120
29	061219 415-9 output_.xls	415	415	387.20	289.20	133.80	147	0.951	70.520	261.900	367.980	629.880
30	061219 415-10 output_.xls	415	415	387.20	289.20	140.20	154	0.951	64.980	270.080	373.430	643.510
31	061128 420-1 output_.xls	420	420	387.20	288.90	92.30	106	0.951	66.770	200.130	353.350	553.480
32	061219 420-2 output_.xls	420	420	387.20	288.90	98.70	113	0.951	69.840	212.750	359.970	572.710
33	061219 420-3 output_.xls	420	420	387.20	289.00	105.10	120	0.951	72.100	224.770	365.580	590.350
34	061219 420-4 output_.xls	420	420	387.20	289.00	111.50	128	0.951	74.410	236.770	371.250	608.020
35	061219 420-5 output_.xls	420	420	387.20	289.10	117.90	135	0.951	78.590	247.710	375.830	623.550
36	061219 420-6 output_.xls	420	420	387.20	289.10	124.20	142	0.951	82.790	258.100	380.480	638.570
37	061219 420-7 output_.xls	420	420	387.20	289.20	130.60	149	0.951	86.960	267.150	384.960	652.110
38	061219 420-8 output_.xls	420	420	387.20	289.20	137.00	156	0.951	79.860	275.810	389.770	665.580
39	061219 420-9 output_.xls	420	420	387.20	289.30	143.30	164	0.951	71.920	283.870	395.370	679.240
40	061219 420-10 output_.xls	420	420	387.20	289.30	149.80	171	0.951	63.790	291.780	400.270	692.050

10.4.3 Optimization Study Result

The optimal alternative is determined by comparing the B/C values as shown in **10.2.3**, with results shown in **Fig 10.4.3-1** and **Table 10.4.3-1** to **4**.

The B/C value of a project alternative with FSL 415 m and Qmax 127.4 m^3/s is the maximum, whose project feature is as shown below:

Reservoir FSL	415.0	EL. m
Reservoir MOL	387.2	EL. m
Effective volume	167	MCM
Peak operation hours	6	Hours
Maximum discharge	127.4	m^3/s
Intake Water Level	415.0	EL. m
Tailrace Water Level	289.2	EL. m
Effective head	123	m
Installed Capacity	140	MW
Annual Energy	616.1	GWh

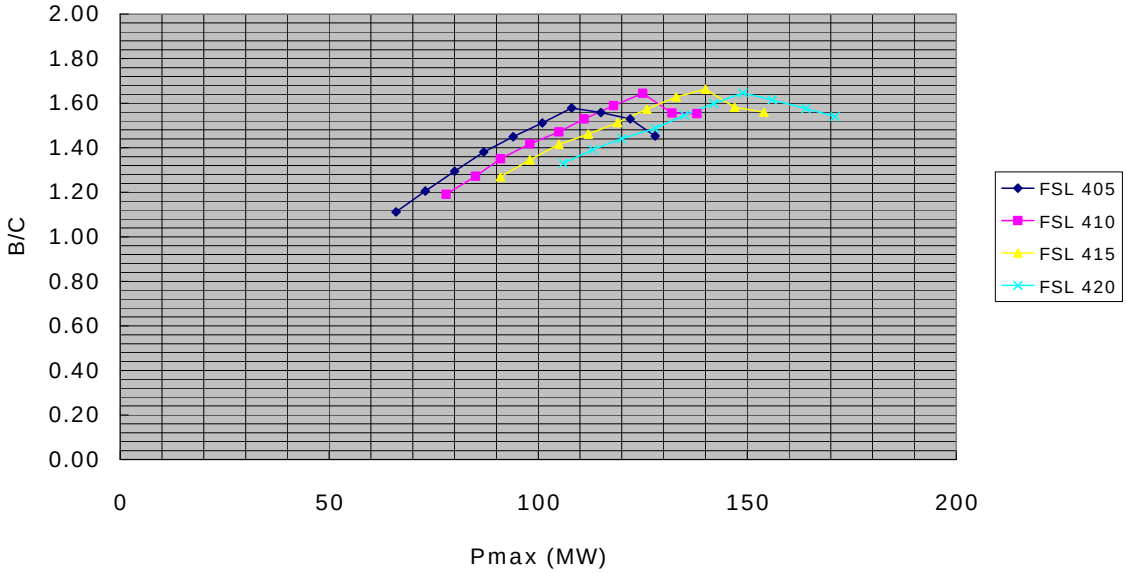


Fig. 10.4.3-1 Relation between Pmax and B/C

Table 10.4.3-1 Result of Economic Evaluation (FSL 405m)

Item	Unit	FSL=405									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	65.4	72.3	79.2	86.1	93	99.8	106.7	113.6	120.5	127.4
FSL	EL.m	405	405	405	405	405	405	405	405	405	405
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
TWL	EL.m	288.6	288.7	288.8	288.8	288.9	288.9	289	289	289.1	289.2
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	113.6	113.5	113.4	113.4	113.3	113.3	113.2	113.2	113.1	113
Pmax	MW	66	73	80	87	94	101	108	115	122	128
Primary Energy	GWh	132.88	146.10	159.19	172.03	184.37	196.27	207.14	217.21	226.37	234.20
Pfirm	MW	48.67	53.75	58.81	63.93	67.60	70.73	75.53	69.61	63.21	51.00
Benefit	1000USD	38,558	42,466	46,344	50,196	53,521	56,604	60,005	60,036	59,760	57,497
Cost	1000USD	34,691	35,226	35,802	36,362	36,917	37,461	38,004	38,542	39,076	39,574
B/C		1.11	1.21	1.29	1.38	1.45	1.51	1.58	1.56	1.53	1.45

Note: The numbers 1 to 6 show case No. of maximum discharge (Qmax).

Table 10.4.3-2 Result of Economic Evaluation (FSL 410m)

Item	Unit	FSL=410									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	73.7	80.1	86.5	92.9	99.3	105.7	112.1	118.5	124.9	131.3
FSL	EL.m	410	410	410	410	410	410	410	410	410	410
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
TWL	EL.m	288.7	288.8	288.8	288.9	288.9	289	289	289.1	289.1	289.2
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	118.5	118.4	118.4	118.3	118.3	118.2	118.2	118.1	118.1	118
Pmax	MW	78	85	91	98	105	111	118	125	132	138
Primary Energy	GWh	153.45	165.83	177.98	190.03	201.78	212.66	223.04	232.30	241.17	249.04
Pfirm	MW	54.22	58.87	63.57	67.29	69.71	73.25	77.69	82.03	67.48	64.73
Benefit	1000USD	43,930	47,557	51,158	54,446	57,289	60,312	63,516	66,489	63,709	64,298
Cost	1000USD	36,880	37,380	37,885	38,421	38,951	39,443	39,966	40,431	40,936	41,418
B/C		1.19	1.27	1.35	1.42	1.47	1.53	1.59	1.6445	1.56	1.55

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.4.3-3 Result of Economic Evaluation (FSL 415m)

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	82.6	89	95.4	101.8	108.2	114.6	121	127.4	133.8	140.2
FSL	EL.m	415	415	415	415	415	415	415	415	415	415
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
TWL	EL.m	288.8	288.9	288.9	289	289	289.1	289.1	289.2	289.2	289.2
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	123.4	123.3	123.3	123.2	123.2	123.1	123.1	123	123	123
Pmax	MW	91	98	105	112	119	126	133	140	147	154
Primary Energy	GWh	175.75	188.17	200.55	212.39	223.91	234.65	244.54	253.45	261.90	270.08
Pfirm	MW	60.19	64.79	69.14	70.87	73.60	77.86	82.21	84.66	70.52	64.98
Benefit	1000USD	49,740	53,359	56,896	59,548	62,443	65,657	68,746	71,087	68,354	68,160
Cost	1000USD	39,199	39,681	40,212	40,739	41,261	41,728	42,234	42,747	43,201	43,699
B/C		1.27	1.34	1.41	1.46	1.51	1.57	1.63	1.6630	1.58	1.56

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

Table 10.4.3-4 Result of Economic Evaluation (FSL 420m)

Item	Unit	FSL=420									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	92.3	98.7	105.1	111.5	117.9	124.2	130.6	137	143.4	149.8
FSL	EL.m	420	420	420	420	420	420	420	420	420	420
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2	387.2
TWL	EL.m	288.9	288.9	289	289	289.1	289.1	289.2	289.2	289.3	289.3
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Effective Head	m	128.3	128.3	128.2	128.2	128.1	128.1	128	128	127.9	127.9
Pmax	MW	106	113	120	128	135	142	149	156	164	171
Primary Energy	GWh	200.13	212.75	224.77	236.77	247.71	258.10	267.15	275.81	283.87	291.78
Pfirm	MW	66.77	69.84	72.10	74.41	78.59	82.79	86.96	79.86	71.92	63.79
Benefit	1000USD	56,108	59,303	62,146	65,001	68,228	71,361	74,245	73,668	72,730	71,708
Cost	1000USD	42,159	42,623	43,145	43,694	44,146	44,653	45,106	45,611	46,135	46,578
B/C		1.33	1.39	1.44	1.49	1.55	1.60	1.65	1.62	1.58	1.54

Note: The numbers 1 to 10 show case No. of maximum discharge (Qmax).

10.5 Selection of Development Plan

10.5.1 Selection of MOL

The optimum development plans considered in **10.3** and **10.4** are as shown in **Table 10.5.1-1**.

Table 10.5.1-1 Comparison of the optimized plan shown in 10.3 and 10.4

Item	Unit	Optimum in 10.3	Optimum in 10.4
FSL	m	425	415
MOL	m	400.0	387.2
Reservoir Effective Volume	MCM	176.5	167
Peak Operation Hours	hours	6	6
Maximum Discharge	m^3/s	127.2	127.4
Tailrace Water Level	m	289.1	289.2
Effective Head	m	132.9	123
Installed Capacity	MW	151	140
Annual Energy	GWh	670.0	616.1
Project Cost	1,000 US$	471,100	427,472
B/C	-	1.68	1.66
Project Cost per Annual Energy	US$/kWh	0.703	0.694
Project Cost per kW	US$/kW	3,130	3,050

The B/C for both alternatives is almost the same, but the optimum plan in **10.4** has a lower project cost per annual energy and per kW than those of the plan selected in **10.3**. In addition to the above, because the optimum in **10.4** involves lower MOL and will result in less environment impact than the other, the optimum in **10.4** is adopted as the development plan in the Study.

10.5.2 Optimum Intake Water Level

The selected project alternative in the optimization study in **10.5.2** is that reservoir FSL is equal to the Intake Water level (IWL). When choosing the development plan, IWL should be optimized to utilize water resources effectively. The study method is the same as for **10.3**. The result of comparative study by IWL between FSL and MOL is shown in **Table 10.5.2-1 and Fig. 10.5.2-1**, while the reservoir simulation result and project cost estimation result of the alternatives are shown in **Tables 10.5.2-2** and **3**.

Finally, the selected development plan for the Upper Seti project becomes the following:

FSL	415	EL. m
MOL	387.2	EL. m
Effective Volume	167	MCM
Peak Operation Time	6	hours
Maximum discharge	127.4	m^3/s
Intake Water Level	405	EL. m
Tailrace Water Level	289.2	EL. m
Effective Head	113	m
Installed Capacity	128	MW
Annual Energy	607.5	GWh

Table 10.5.2-1 Result of the Intake Water Level Optimization

Item	Unit	FSL=415									
		1	2	3	4	5	6	7	8	9	10
Qmax	m3/s	127.4	127.4	127.4	127.4	127.4	127.4	127.4	127.4	127.4	127.4
FSL	EL.m	415	415	415	415	415	415				
IWL	EL.m	390	395	400	405	410	415				
MOL	EL.m	387.2	387.2	387.2	387.2	387.2	387.2				
TWL	EL.m	289.2	289.2	289.2	289.2	289.2	289.2				
Loss	m	2.8	2.8	2.8	2.8	2.8	2.8				
Effective Head	m	98	103	108	113	118	123				
Pmax	MW	111	117	123	128	134	140				
Primary Energy	GWh	233.28	241.61	248.88	252.94	255.38	253.45				
Pfirm	MW	86.20	86.00	85.92	85.85	84.72	84.66				
Benefit	1000USD	67,919	69,359	70,643	71,353	71,452	71,087				
Cost	1000USD	42,185	42,246	42,383	42,483	42,613	42,739				
B/C		1.6100	1.6418	1.6668	1.6796	1.6768	1.6633				

Note: The numbers 1 to 6 show case No. of Intake Water Level (IWL).

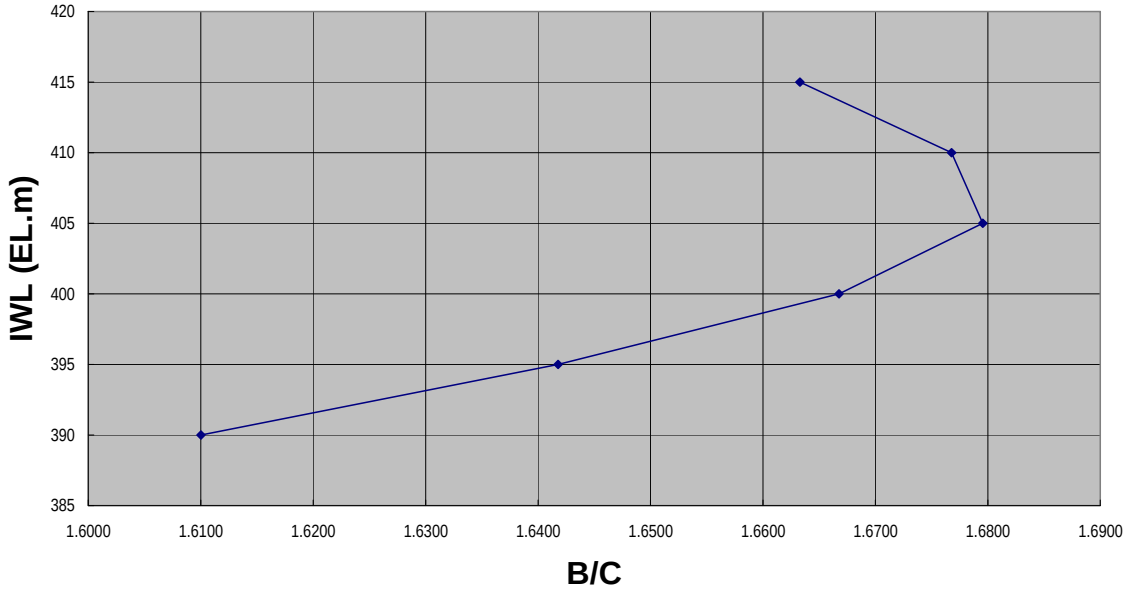


Fig. 10.5.2-1 Optimization of the Intake Water Level

Table 10.5.2-2 Reservoir Simulation Result

No	OutputFileName	InputData						Result				
		HWL	IWL	LWL	TWL	MAX. Discharge	Installed Capacity	Power (MW)		Primary Energy (GWh)	Secondary Energy (GWh)	Total Energy (GWh)
1	070104 415-8-1 output_.xls	415	390	387.20	289.20	127.40	111	0.951	86.200	233.280	339.980	573.270
2	070104 415-8-2 output_.xls	415	395	387.20	289.20	127.40	117	0.951	86.000	241.610	345.870	587.480
3	070104 415-8-3 output_.xls	415	400	387.20	289.20	127.40	123	0.951	85.920	248.880	351.570	600.450
4	070104 415-8-4 output_.xls	415	405	387.20	289.20	127.40	128	0.951	85.850	252.940	354.590	607.530
5	070104 415-8-5 output_.xls	415	410	387.20	289.20	127.40	134	0.951	84.720	255.380	356.650	612.030
6	061219 415-8 output_.xls	415	415	387.20	289.20	127.40	140	0.951	84.660	253.450	362.670	616.120

Table 10.5.2-3 Project Cost (IWL Alternatives for FSL 415m)

Project Cost Summary 1,000USD

Item	FSL=415									
	1	2	3	4	5	6	7	8	9	10
1. Preparation & Compensation	3,548	3,541	3,545	3,548	3,552	3,555				
(1) Access Road										
(2) Conpensation										
(3) Others										
2. Environmental Mitigation	30,180	30,180	30,180	30,180	30,180	30,180				
3. Civil Works										
(1) River Treatment	6,053	6,053	6,053	6,053	6,053	6,053				
(2) Dam	117,131	117,131	117,131	117,131	117,131	117,131				
(3) Intake	2,131	2,131	2,131	2,131	2,131	2,131				
(4) Power Tunnel	10,672	10,672	10,672	10,672	10,672	10,672				
(5) Penstock	1,115	1,115	1,115	1,115	1,115	1,115				
(6) Power House	10,714	10,893	11,067	11,235	11,398	11,557				
(7) Tailrace Tunnel	2,311	2,311	2,311	2,311	2,311	2,311				
(8) Tailrace	558	558	558	558	558	558				
(9)P/S Access Tunnel	6,900	6,900	6,900	6,900	6,900	6,900				
(10) Surge Tank	10,689	10,689	10,689	10,689	10,689	10,689				
(11) Others	8,448	7,922	7,931	7,939	7,948	7,956				
4. Hydro-Mechanical Works	20,164	20,164	20,164	20,164	20,164	20,164				
5. Electro-Mechanical Works	40,451	41,208	41,939	42,424	43,114	43,783				
6. Transmission Line	10,170	10,170	10,170	10,170	10,170	10,170				
Direct Cost	281,235	281,639	282,556	283,221	284,086	284,925				
7. Administration Fee	42,185	42,246	42,383	42,483	42,613	42,739				
8. Contingency	28,124	28,164	28,256	28,322	28,409	28,492				
9. Interest During Construction	70,309	70,410	70,639	70,805	71,021	71,231				
Total	421,853	422,459	423,833	424,831	426,129	427,387				

Note: The numbers 1 to 6 correspond to case No. of IWL (Intake Water Level) in Table 10.5.2-2.