THE PREPARATORY SURVEY
ON
EXPANSION OF NAM NGUM 1 HYDROPOWER STATION
IN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
FINAL REPORT

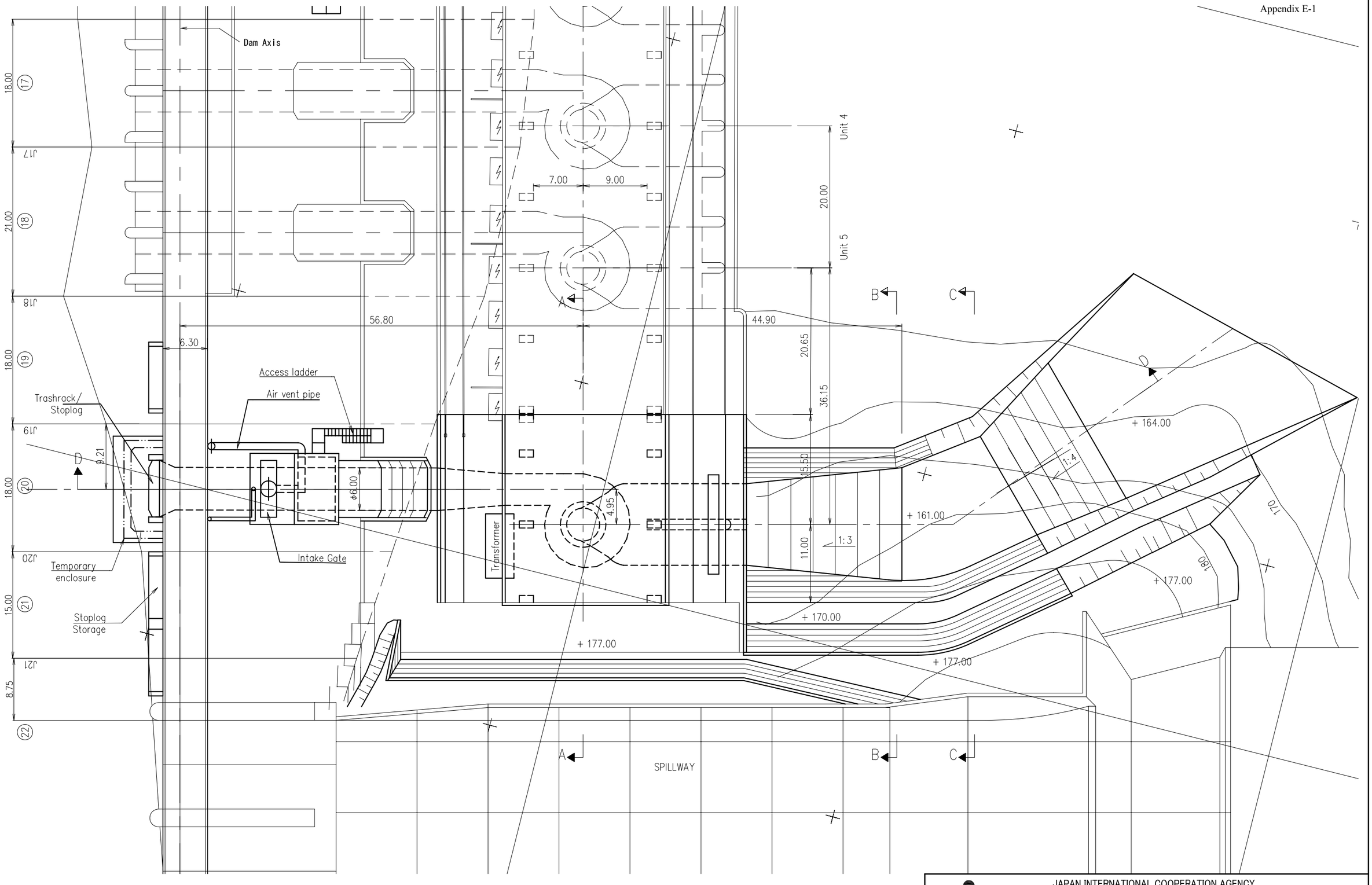
Appendices

Appendix E Alternative Plans

Appendix E-1 Drawings of Alternative Plans

Appendix E-2 Cost of Alternatives Plans

Appendix E-3 Summary of Alternative Plans



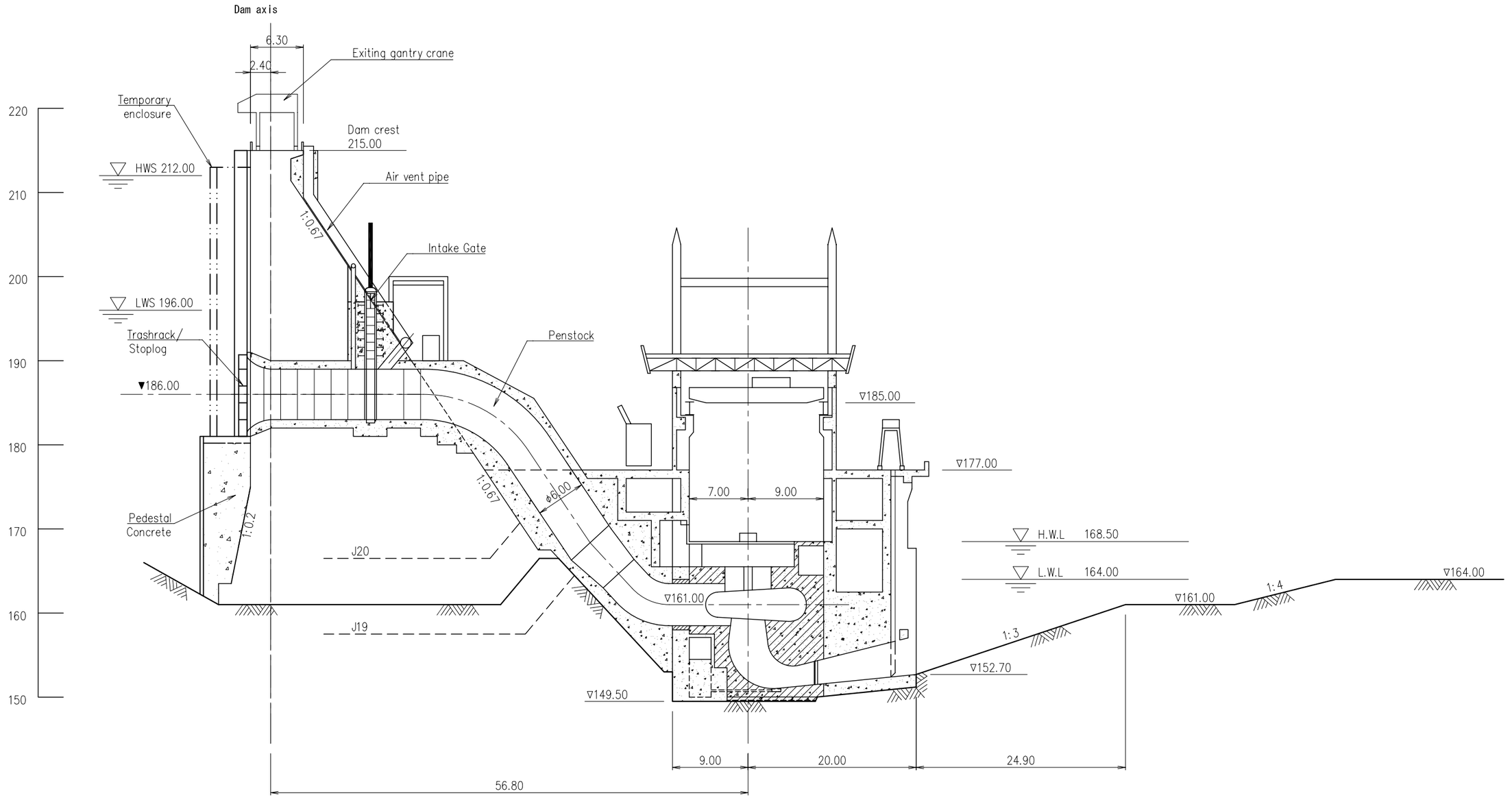
0 10 20 30M

SCALE

PLAN A1
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / POWER	Alternative Plan A1 Plan	A1(1)
		Date: June 2009



PROFILE

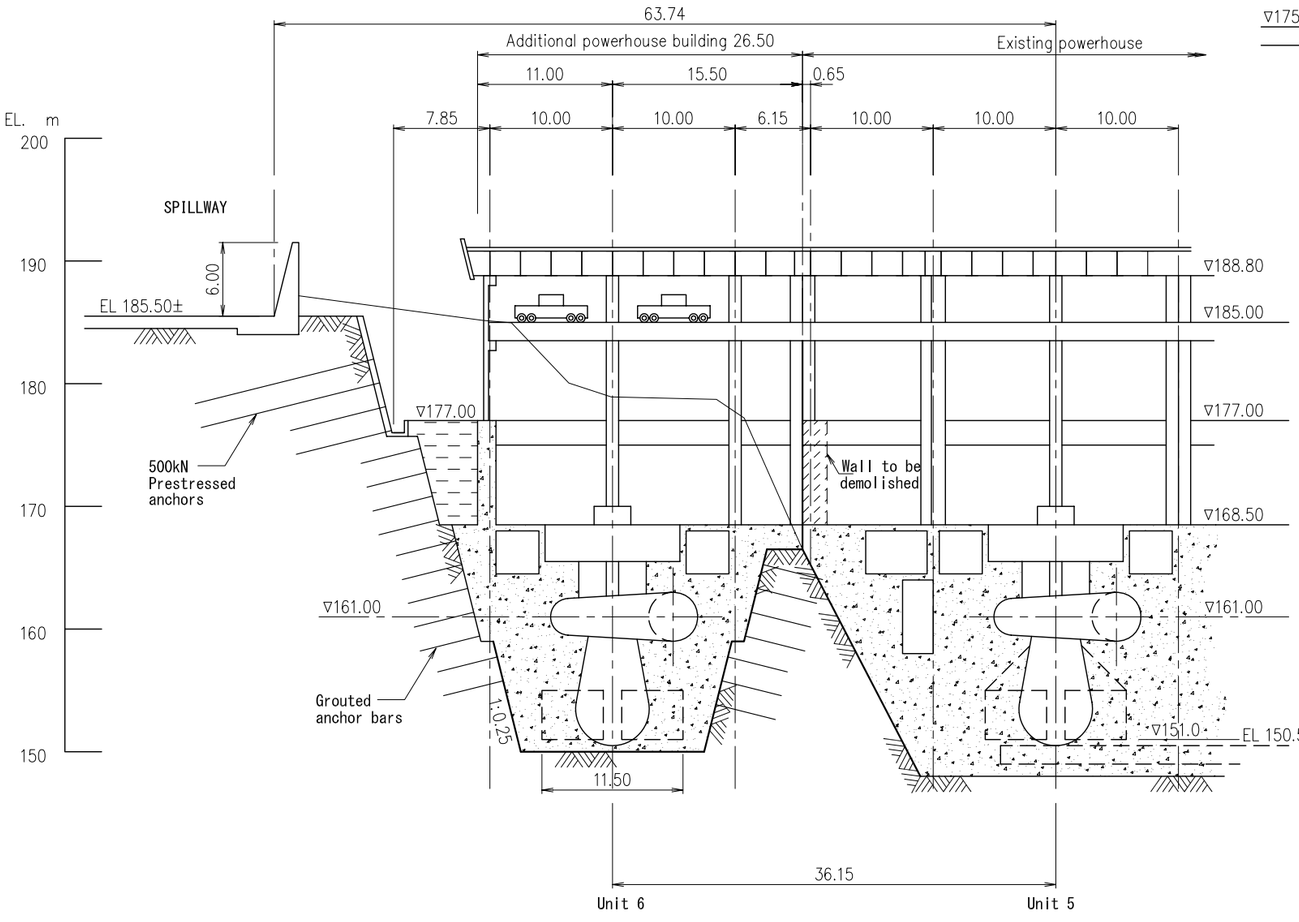
0 10 20 30M

SCALE

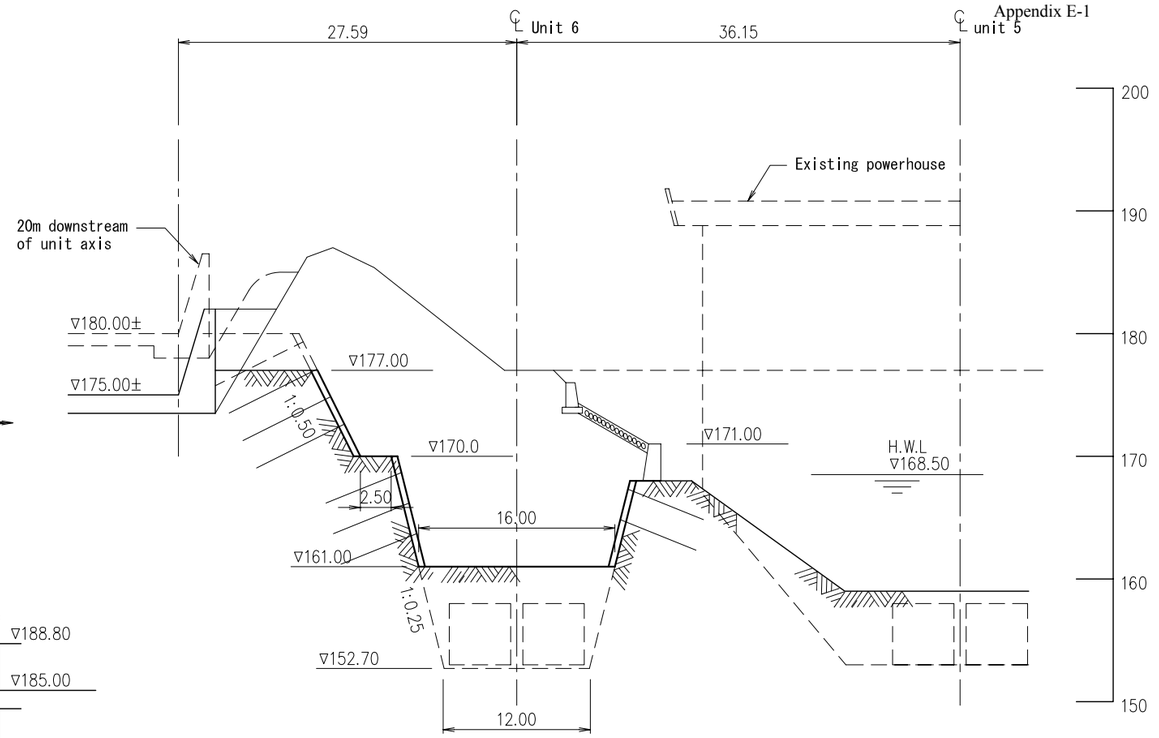
PLAN A1
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / POWER	Alternative Plan A1 Profile	A1(2)
		Date: June 2009



SECTION A-A



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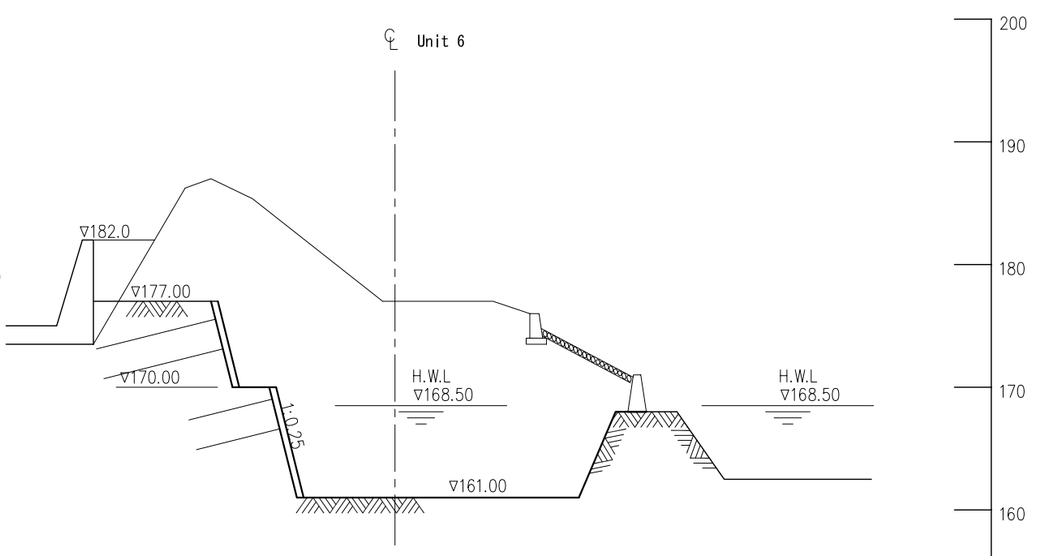


SECTION C-C

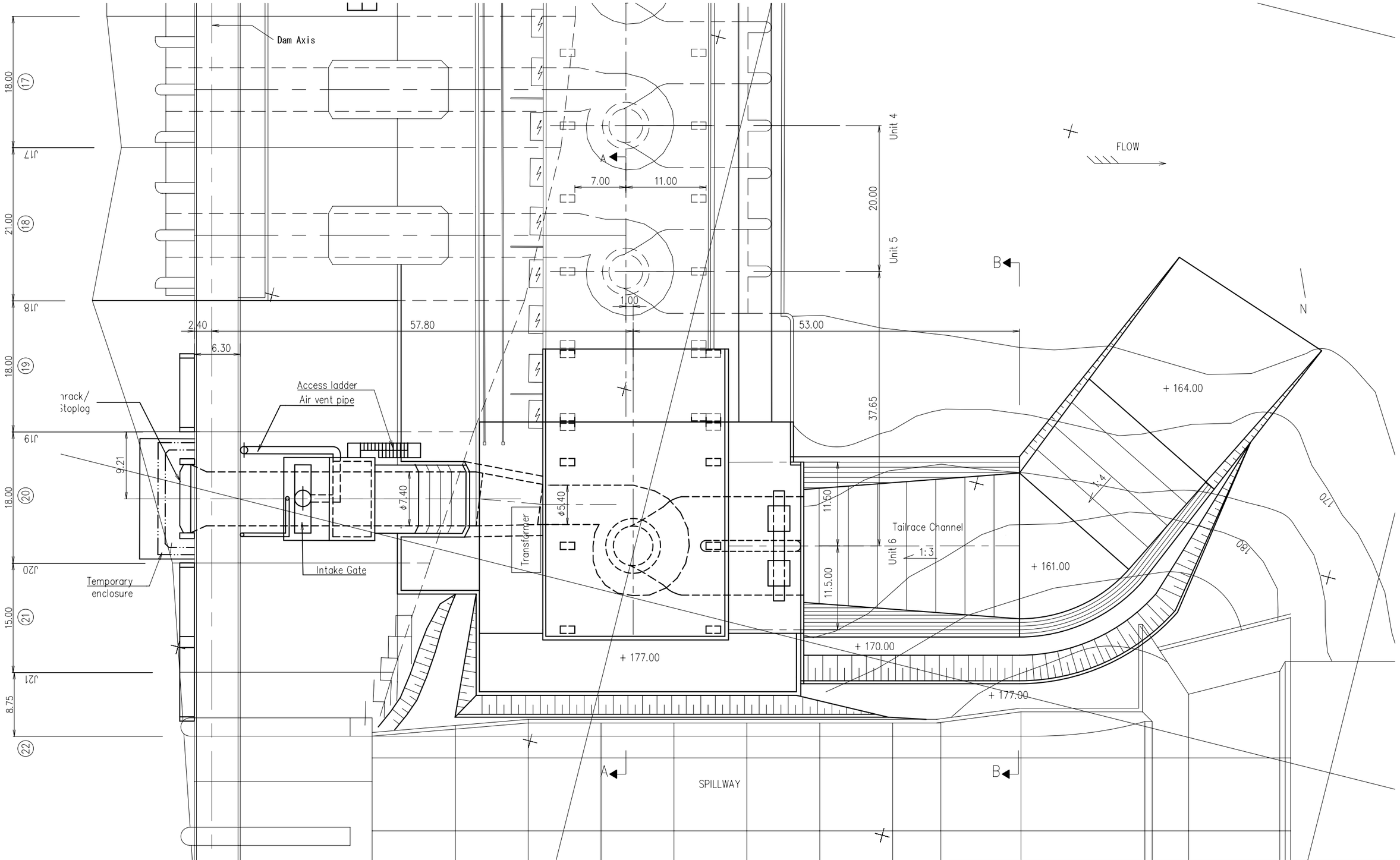
0 10 20 30M

SCALE

PLAN A1
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

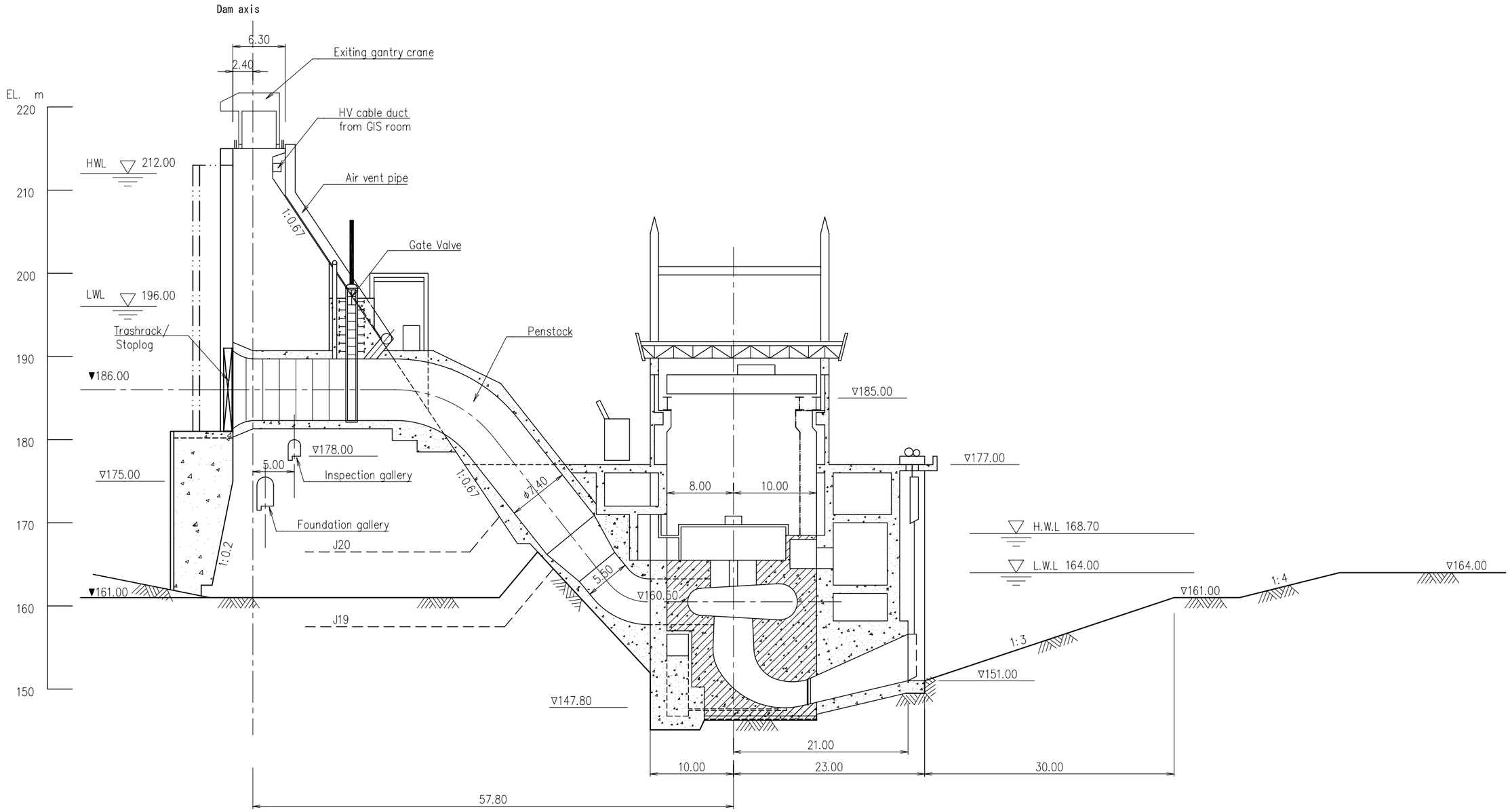
Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / POWER	Alternative Plan A1 Sections	A1(3)
		Date: June 2009



PLAN A2
(60 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI POWER	Alternative Plan A2 Plan	A2(1)
		Date: June 2009



PROFILE

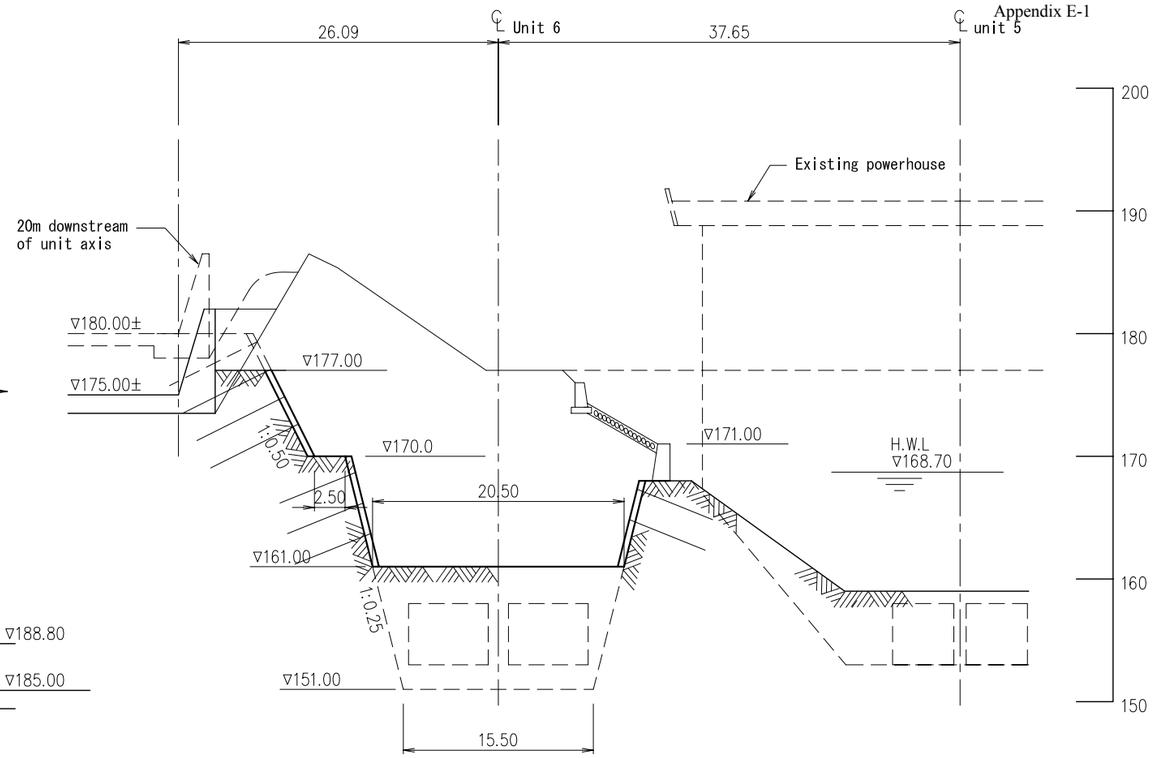
0 10 20 30M

SCALE

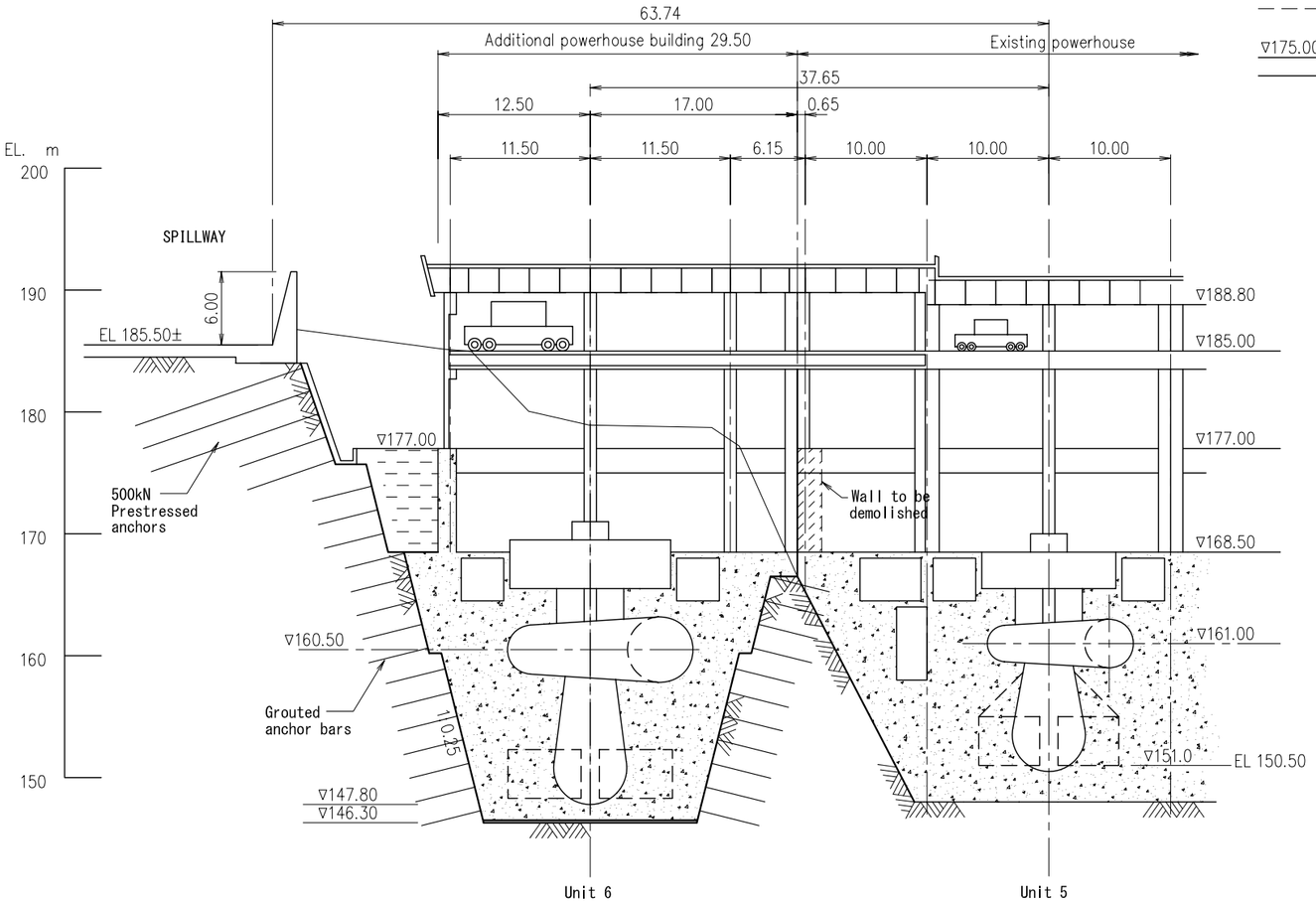
PLAN A2
(60 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title: Alternative Plan A2 Profile	Drawing No: A2(2)
NIPPON KOEI / POWER		Date: June 2009



SECTION B-B



SECTION A-A

0 10 20 30M

SCALE

PLAN A2
(60 MW)

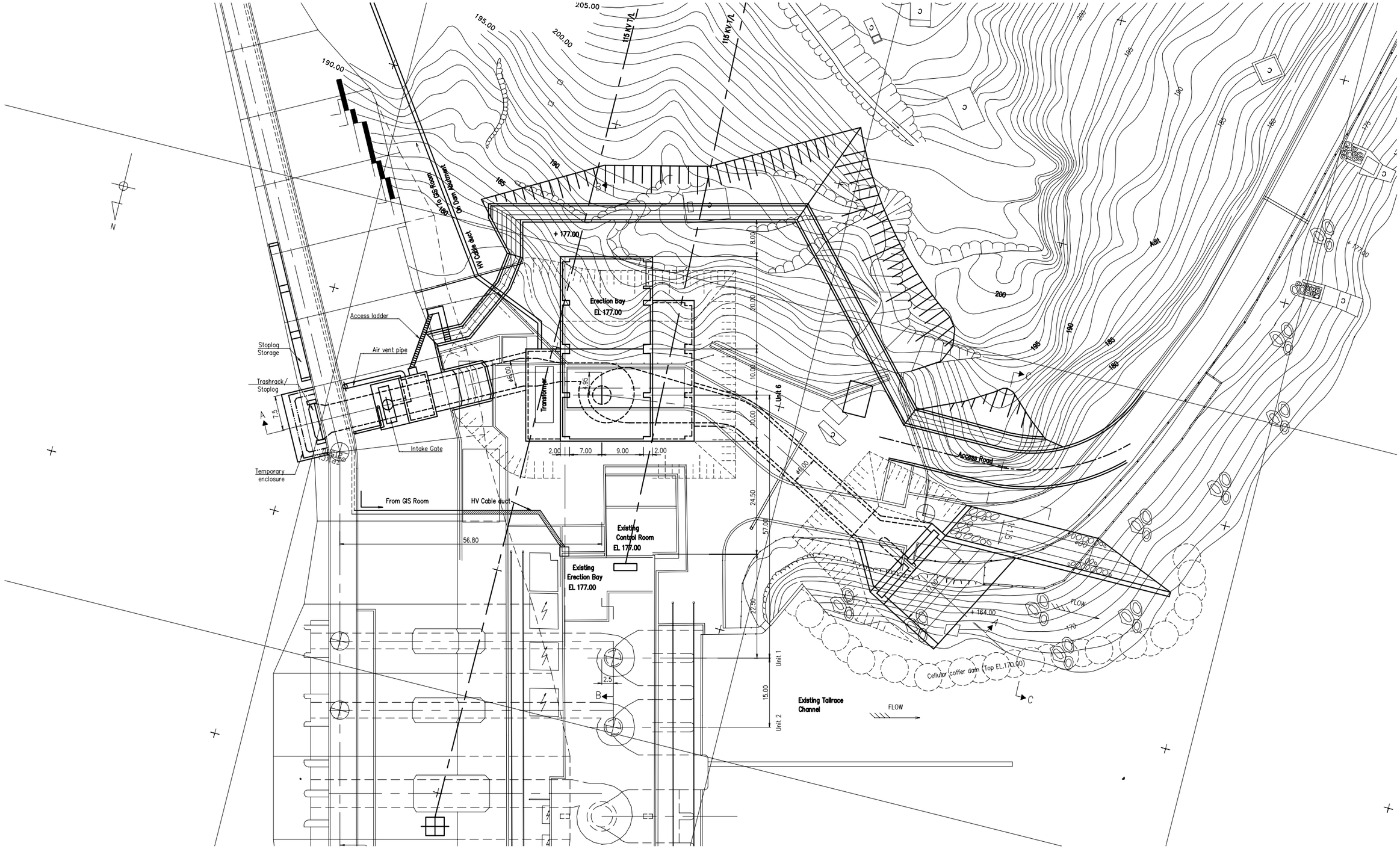
JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by: NIPPON KOEI, POWER

Drawing Title: Alternative Plan A2 Sections

Drawing No: A2(3)

Date: June 2009

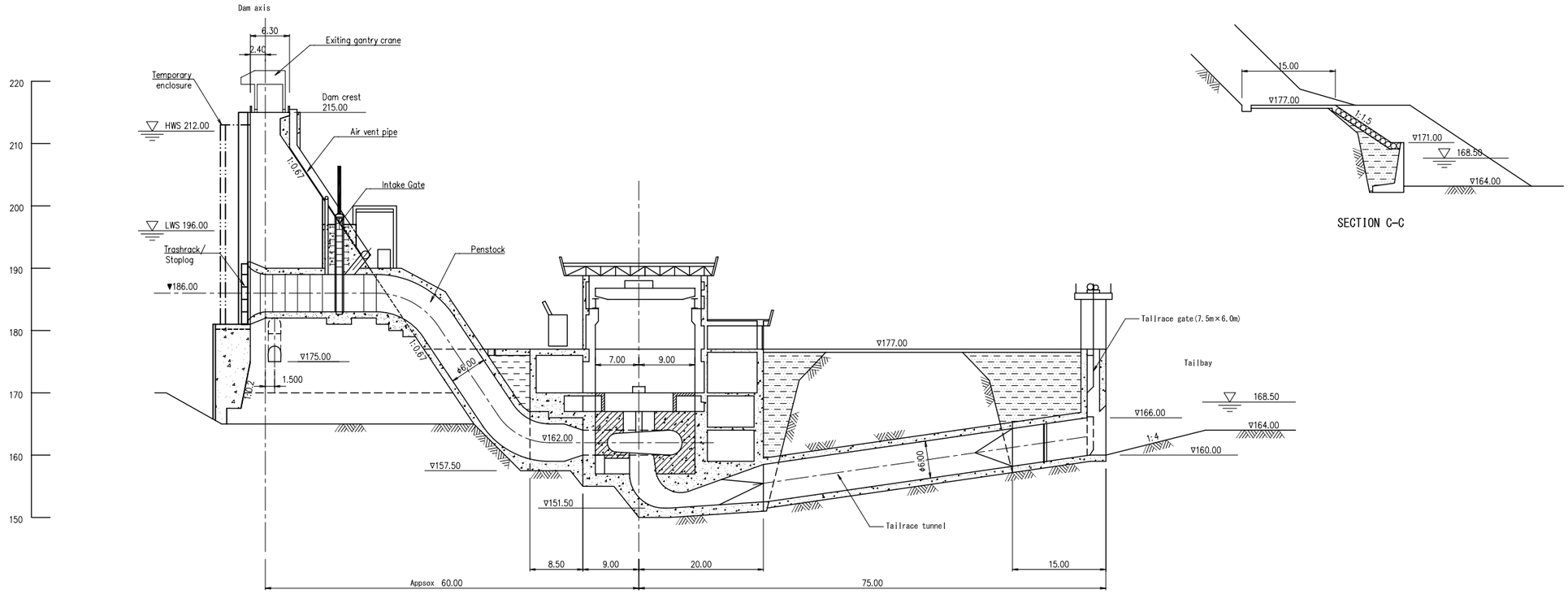


0 10 20 30M

SCALE

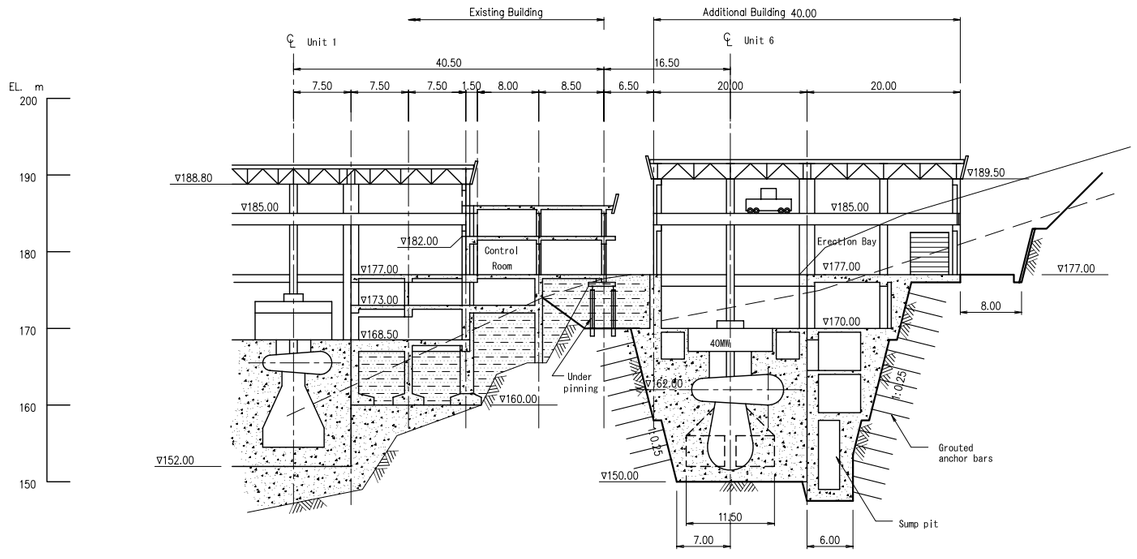
PLAN A4-1
(40 MW)

JICA	JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC	
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan A4-1 Plan	Drawing No: A4-1(1) Date: June 2009



SECTION C-C

PROFILE (SECTION A-A)



SECTION B-B

0 10 20 30M

SCALE

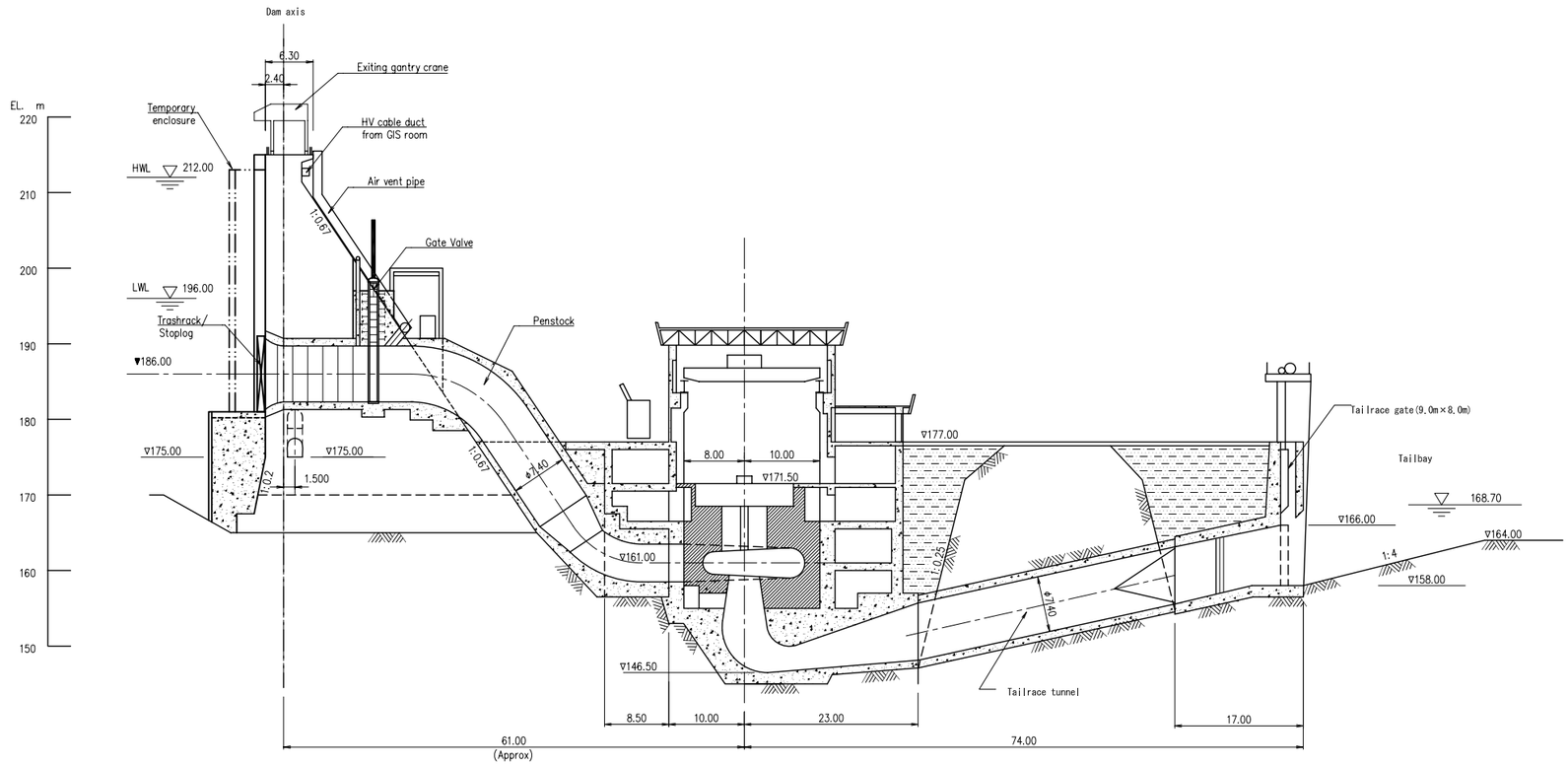
PLAN A4-1
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC		
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan A4-1 Profile And Sections	Drawing No: A4-1(2) Date: June 2009

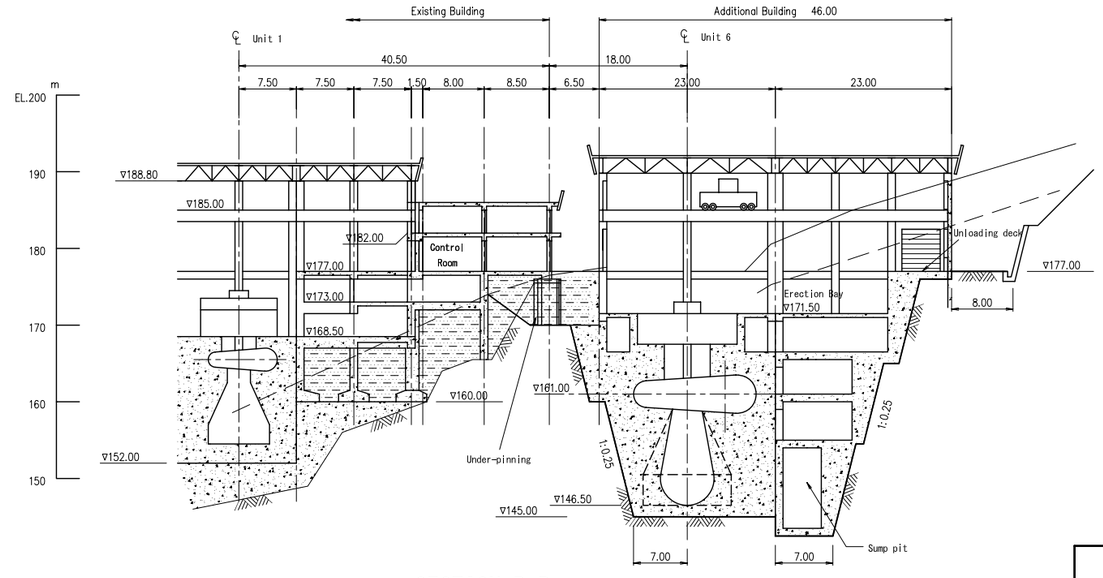
PLAN A4-2
(60 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / POWER	Alternative Plan A4-2 Plan	A4-2(1)
		Date: June 2009



PROFILE (SECTION A-A)



SECTION B-B

PLAN A4-2
(60MW)

0 10 20 30M

SCALE

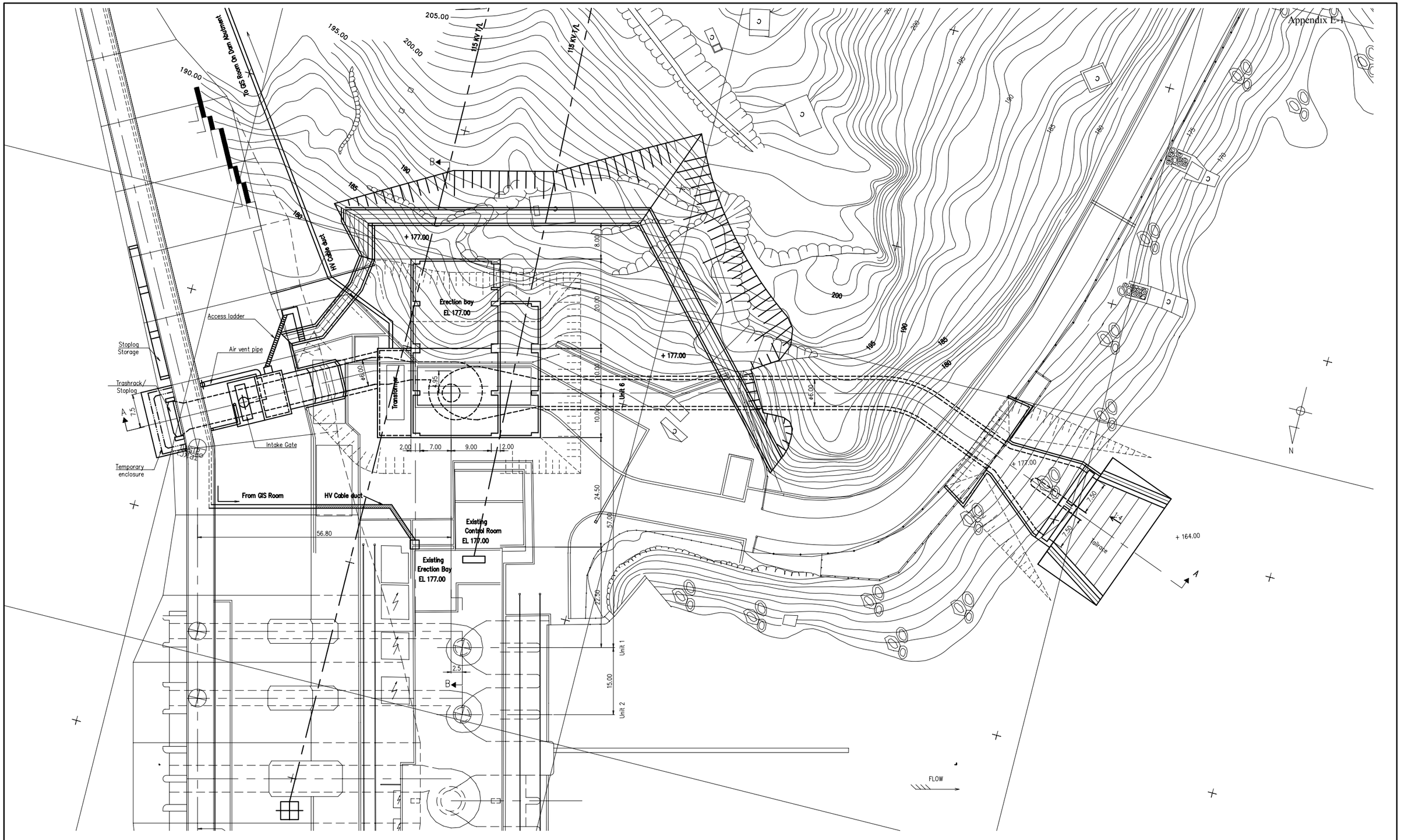
JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by: NIPPON KOEI / POWER

Drawing Title: Alternative Plan A4-2 Profile And Sections

Drawing No: A4-2(2)

Date: June 2009



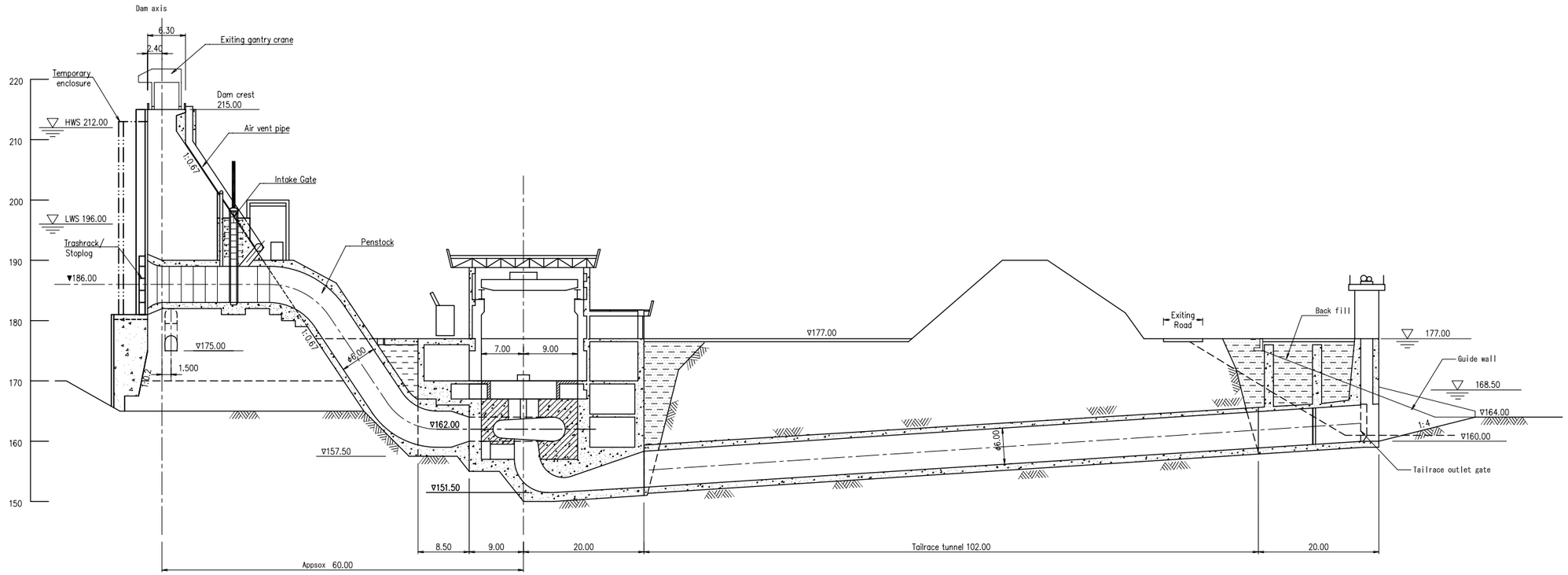
0 10 20 30M

SCALE

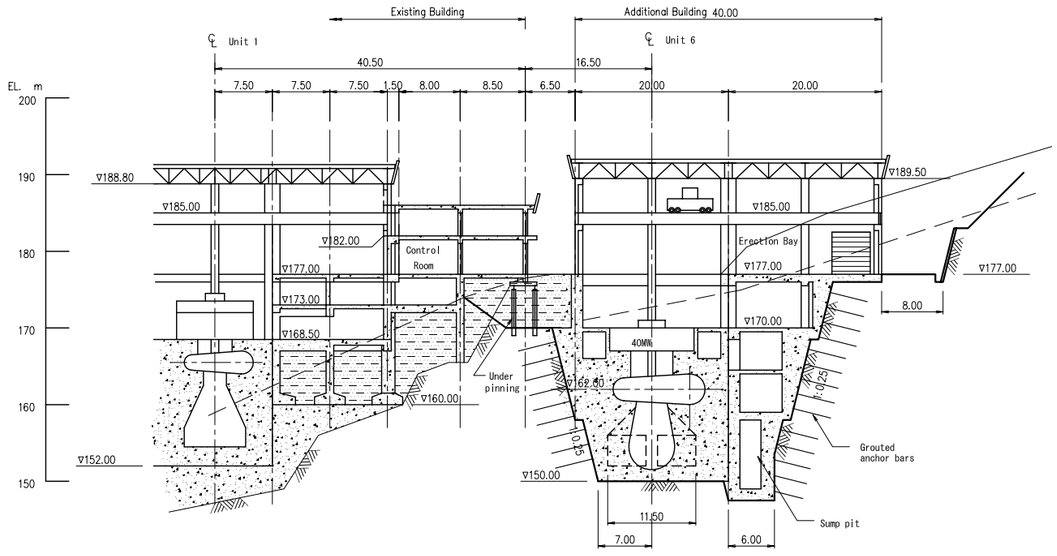
PLAN A4-3
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / J-POWER	Alternative Plan A4-3 Plan	A4-3(1)
		Date: June 2009



PROFILE (SECTION A-A)



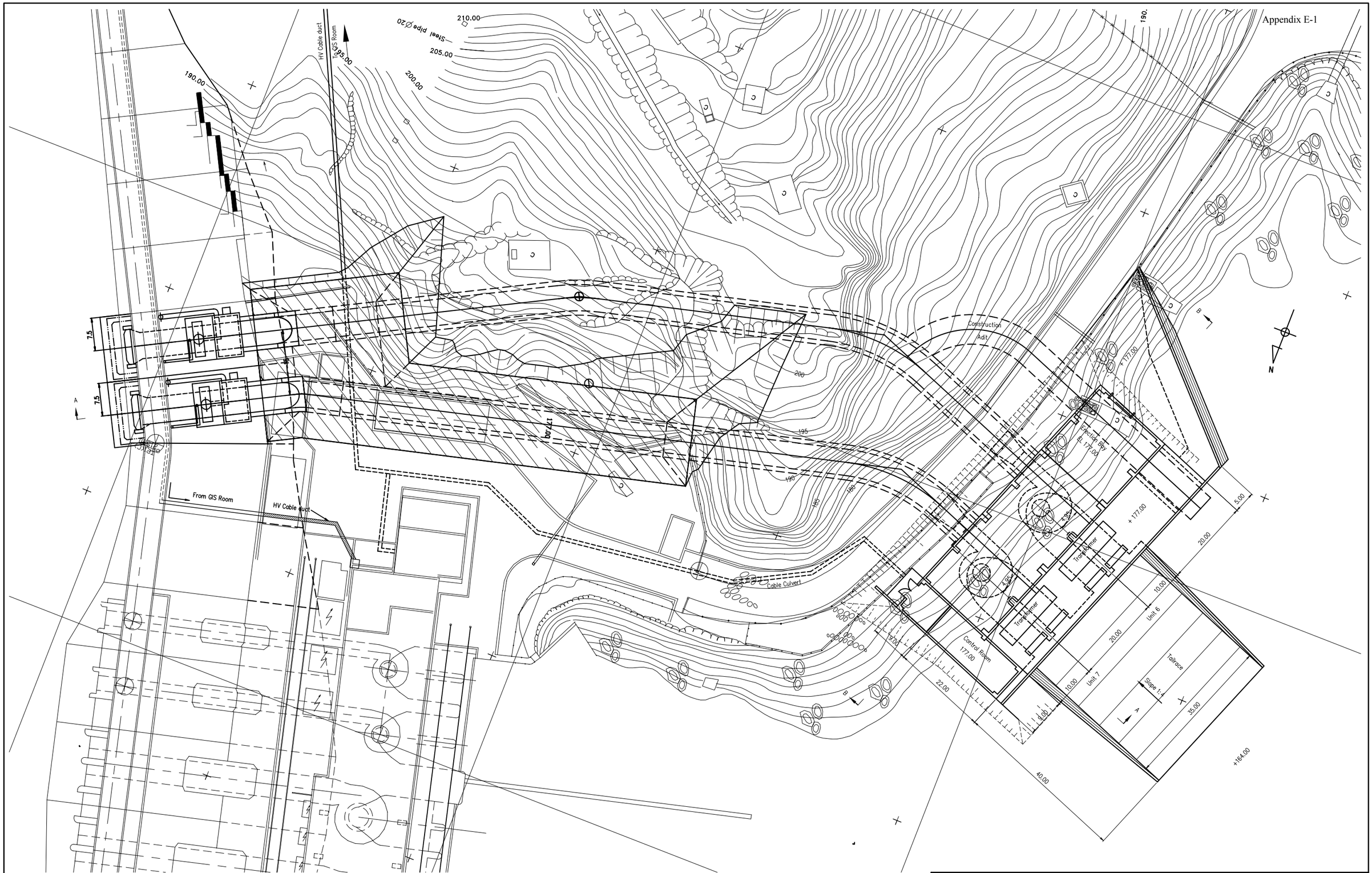
SECTION B-B

0 10 20 30M

SCALE

PLAN A4-3
(40 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC		
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan A4-3 Profile	Drawing No: A4-3(2) Date: June 2009

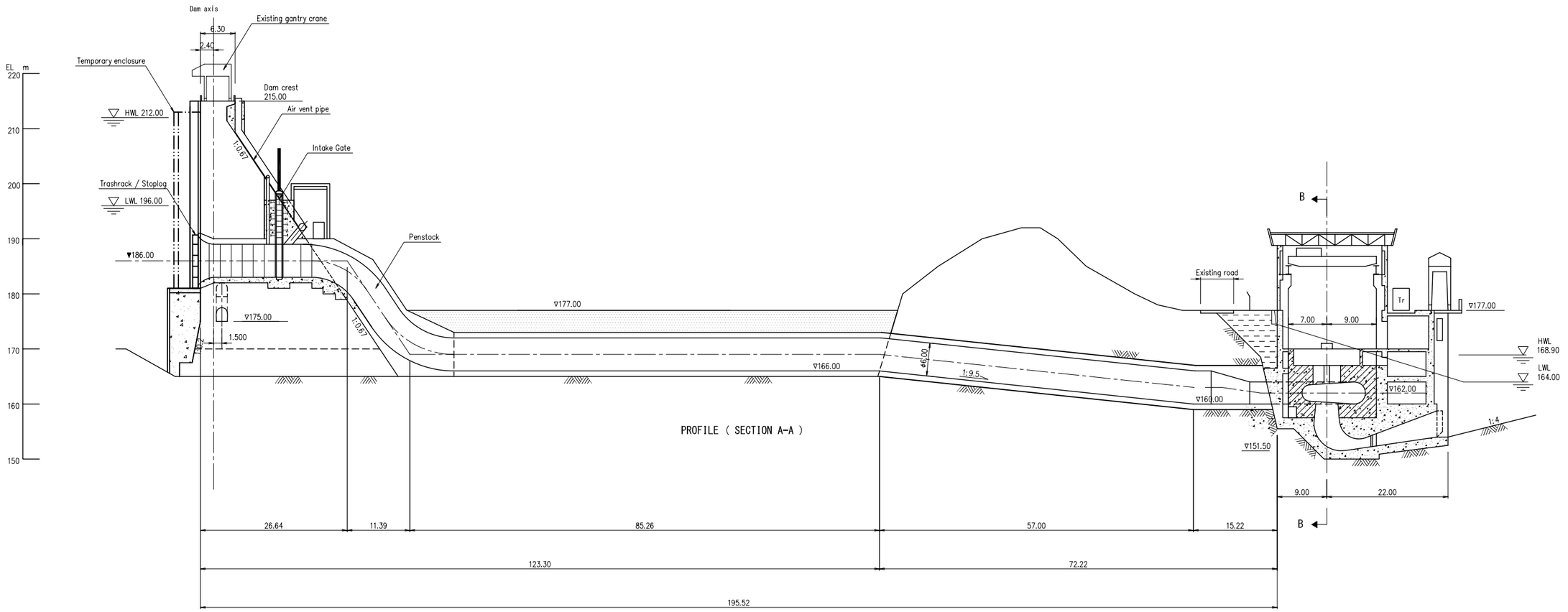


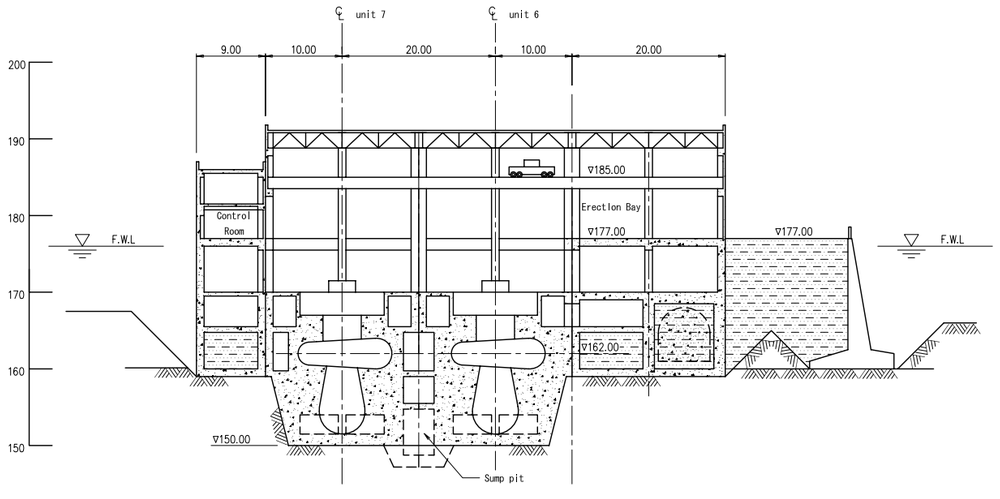
0 10 20 30M

SCALE

PLAN B2
(80 MW)

JICA	JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC	
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan B2-1 Plan	Drawing No: B2-1(1) Date: June 2009





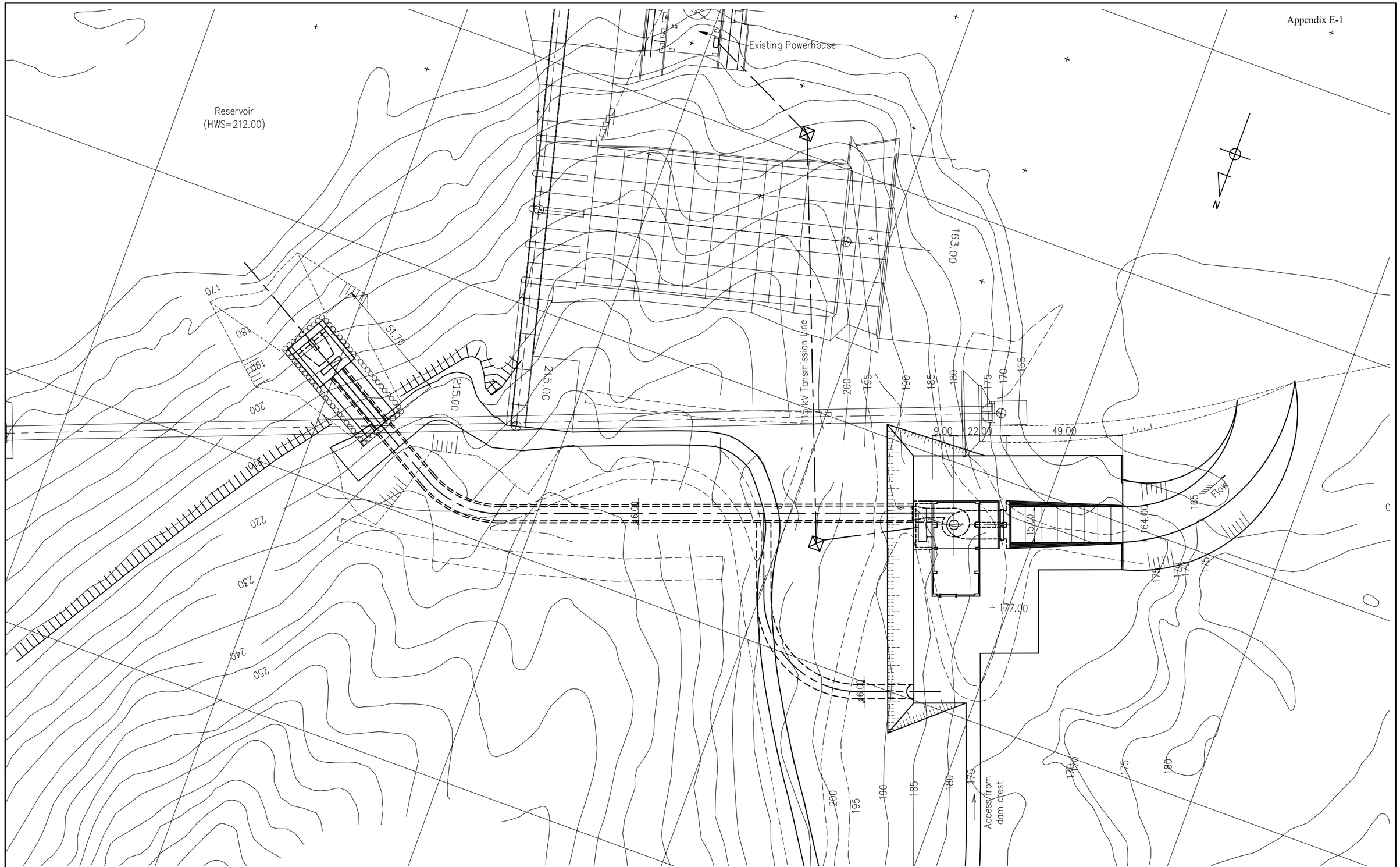
SECTION B-B

0 10 20 30M

SCALE

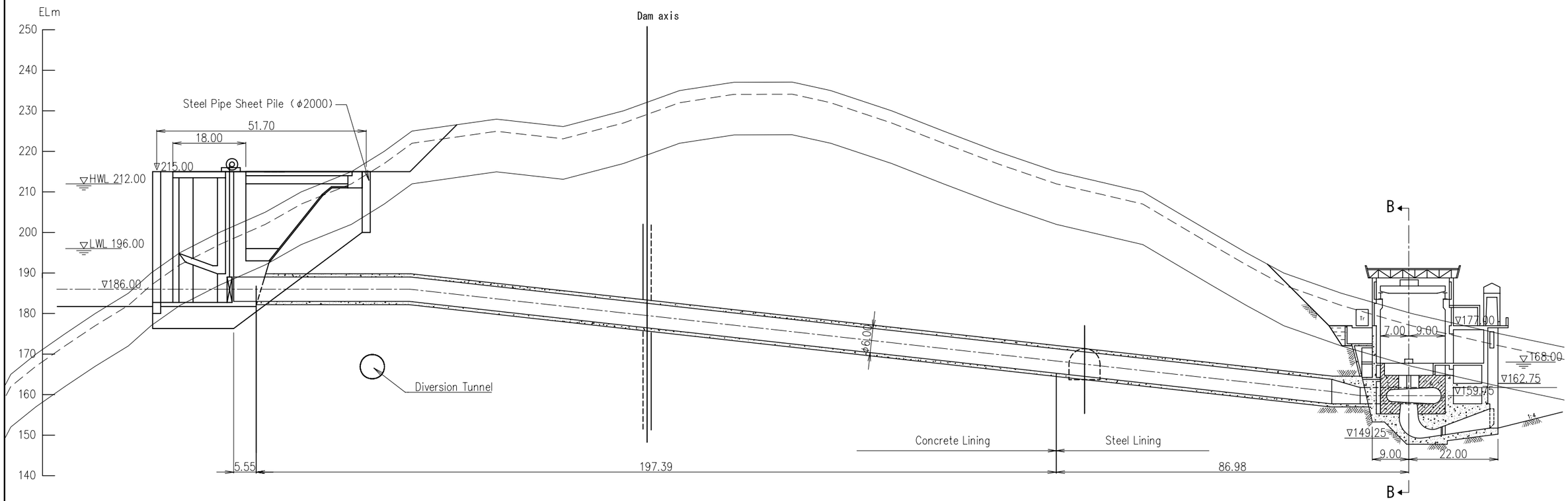
PLAN B2-1
(80 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC		
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan B2-1 Profile	Drawing No: B2-1(2) Date: June 2009

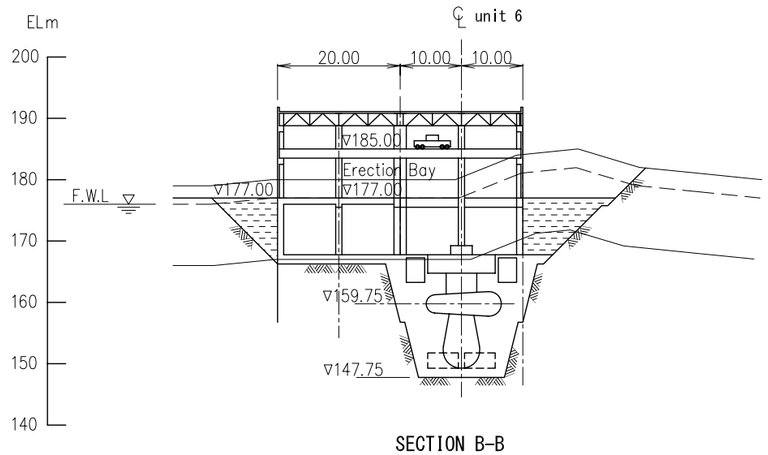


PLAN D2–1
(40 MW)

JICA	JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC	
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan D2-1 Plan	Drawing No: D2-1(1) Date: June 2009



PROFILE (SECTION A-A)



SECTION B-B

0 10 20 30M

SCALE

PLAN D2-1
(40 MW)

JICA JAPAN INTERNATIONAL COOPERATION AGENCY PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC		
Prepared by: NIPPON KOEI POWER	Drawing Title: Alternative Plan D2-1 Profile and Sections	Drawing No: D2-1(2) Date: June 2009

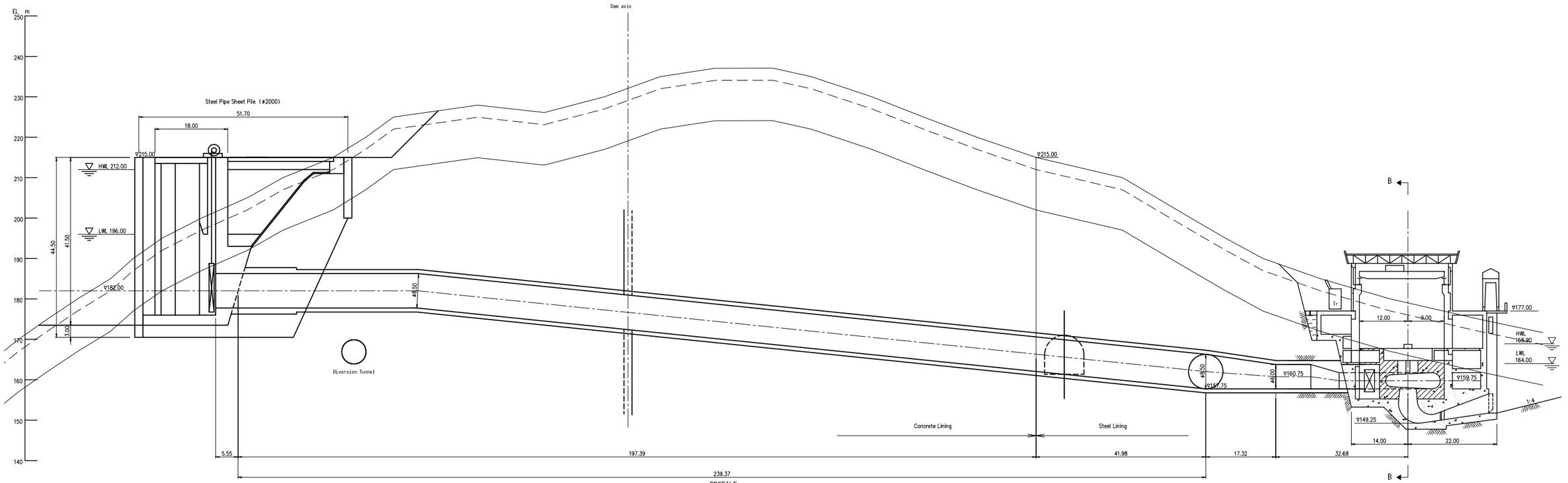
0 10 20 30M

SCALE

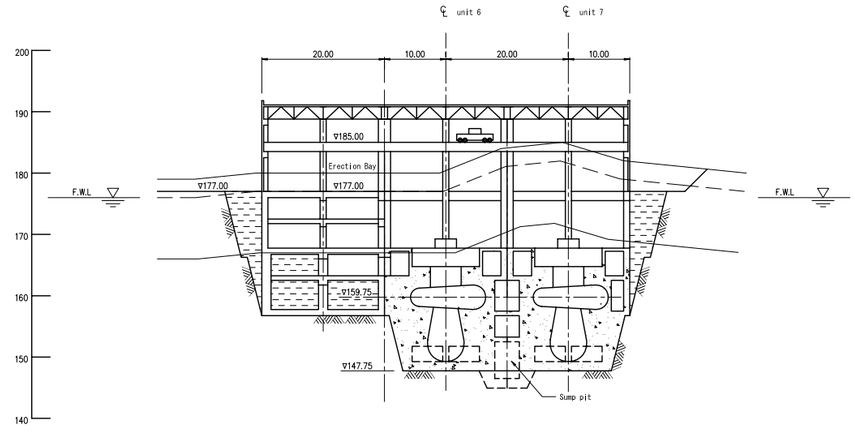
PLAN D2-3
(80 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by:	Drawing Title:	Drawing No:
NIPPON KOEI / POWER	Alternative Plan D2-3 Plan	D2-3(1)
		Date: June 2009



PROFILE



SECTION B-B

0 10 20 30M

SCALE

PLAN D2-3
(80 MW)

JAPAN INTERNATIONAL COOPERATION AGENCY
PREPARATORY SURVEY ON NAM NGUM 1 HYDROPOWER STATION
EXPANSION IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Prepared by: NIPPON KOEI, POWER

Drawing Title: Alternative Plan D2-3 Profile and Sections

Drawing No: D2-3(2)

Date: June 2009

Appendix E-2 Cost of Alternative Plans

Cost Estimate for Comparison of Alternatives — **Alternative A1 (40MW)**

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of access on the existing draft tube deck	LS			10,000
	b) Relocation of gantry cranes (dam crest & draft tube)	LS			20,000
	Sub-total				30,000
A2	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			10,130,000
	b) Platform for dam penetration work	LS			1,260,000
2	Concrete excavation for dam penetration	m3	1,450	320	464,000
3	Concrete (above El. 177m)	m3	1,130	190	214,700
4	Re-bars	t	48	1,500	72,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,214,300
	Sub-total				13,355,000
A3	**Powerhouse and Tailrace**				
1	Temporary works				
	a) Tailrace coffer structure (incl. grouting and rock anchoring)	LS			62,000
	b) Trestle at EL. 177 m for muck loading	LS			1,030,000
2	Excavation				
	a) Open excavation, rock, above El. 168m	m3	33,000	15	495,000
	b) Pit excavation, rock, below El. 168m	m3	23,000	45	1,035,000
	d) Underwater excavation, rock, outside coffer	m3	2,600	60	156,000
	e) Demolition of existing reinforced conc.	m3	450	60	27,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	2,600	25	65,000
	b) Shotcrete on cut slope	m3	380	400	152,000
4	Backfill with free draining materials	m3	2,800	5	14,000
5	Cut slope stabilization (spillway side)	LS			140,000
6	Concrete (incl. formwork cost)				
	a) Penstock below El. 177 m	m3	1,300	210	273,000
	b) Powerhouse	m3	9,200	220	2,024,000
	c) Tailrace	m3	500	210	105,000
7	Re-bars	t	810	1,500	1,215,000
8	Steel structures (roof truss, crane beams)	t	98	4,500	441,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			380,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			228,000
	Sub-total				7,842,000
A4	**Roof Switchyard**				
1	Concrete	m3	40	300	12,000
2	Re-bars	t	2.4	1,500	3,600
3	Miscellaneous works	LS			1,400
	Sub-total				17,000
A5	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			3,186,000
	Total of A				24,430,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	24	4,000	96,000
2	Stoplog	t	63	7,000	441,000
3	Intake gate and hoist	t	156	9,000	1,404,000
4	Gantry crane rails & cable extension	LS			30,000
5	Penstock steel pipe	t	214	7,000	1,499,000
	Sub-total				3,470,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			30,000
2	Draft tube gates and hoists	t			0
	Sub-total				30,000
	Total of B				3,500,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			7,880,000
2	Generator and auxiliaries	LS			8,630,000
3	Transformers	LS			1,380,000
4	Indoor switchgear	LS			620,000
5	Outdoor switchyard equipment	LS			390,000
6	Control and protection equipment	LS			540,000
7	Auxiliary equipment	LS			70,000
8	Miscellaneous materials	LS			440,000
	Sub-total				19,950,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				19,960,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			3,350,000
2	Environmental treatment work	LS			800,000
	Total of D				4,150,000
Grand Total					52,040,000

Cost Estimate for Comparison of Alternatives

Alternative A2 (60MW)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of access on the existing draft tube deck	LS			10,000
	b) Relocation of existing equipment (intake and draft tube gantry cranes)	LS			20,000
	Sub-total				30,000
A2	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			10,870,000
	b) Platform for dam penetration work	LS			1,120,000
2	Concrete excavation for dam penetration	m3	2,100	320	672,000
3	Concrete (above El. 177 m)	m3	1,600	190	304,000
4	Re-bars	t	64	1,500	96,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,306,000
	Sub-total				14,368,000
A3	**Powerhouse and Tailrace**				
1	Temporary works				
	a) Tailrace coffer structure (incl. grouting and anchoring)	LS			90,000
	a) Trestle at EL. 177 m for muck loading	LS			1,550,000
2	Excavation				
	a) Open excavation, rock, above El. 168m	m3	42,000	15	630,000
	b) Pit excavation, rock, below El. 168m	m3	31,000	45	1,395,000
	d) Underwater excavation, rock, outside coffer	m3	3,500	60	210,000
	e) Demolition of existing reinforced conc.	m3	550	60	33,000
3	Removal of existing roof (Columns 17 to 18)	LS			50,000
4	Slope protection and rock support				
	a) Rock bolts on cut slope	m	4,400	25	110,000
	b) Shotcrete on cut slope	m3	500	400	200,000
5	Backfill with free draining materials	m3	3,200	5	16,000
6	Cut slope stabilization (spillway side)	LS			250,000
7	Concrete (incl. formwork cost)				
	a) Penstock below El. 177 m	m3	1,600	210	336,000
	b) Powerhouse	m3	13,000	220	2,860,000
	c) Tailrace	m3	700	210	147,000
8	Re-bars	t	1,130	1,500	1,695,000
9	Steel structures (roof truss, crane beam)	t	200	4,500	900,000
10	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			570,000
11	Miscellaneous works (metal works, earthing, paving, landscaping, etc.)	LS			331,000
	Sub-total				11,373,000
A4	**Roof Switchyard**				
1	Concrete	m3	60	300	18,000
2	Re-bars	t	3.6	1,500	5,400
3	Miscellaneous works	LS			2,600
	Sub-total				26,000
A5	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			3,872,000
	Total of A				29,669,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	31	4,000	124,000
2	Stoplog	t	115	7,000	805,000
3	Intake gate and hoist	t	242	11,000	2,662,000
4	Gantry crane rails & cable extension	LS			30,000
5	Penstock steel pipe	t	320	7,000	2,240,000
	Sub-total				5,861,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				6,661,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			10,950,000
2	Generator and auxiliaries	LS			12,520,000
3	Transformers	LS			2,100,000
4	Indoor switchgear	LS			630,000
5	Outdoor switchyard equipment	LS			510,000
6	Control and protection equipment	LS			540,000
7	Auxiliary equipment	LS			970,000
8	Miscellaneous materials	LS			640,000
	Sub-total				28,860,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				28,870,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			4,560,000
2	Environmental treatment work	LS			1,020,000
	Total of D				5,580,000
Grand Total					70,780,000
	Decrease of energy production due to 3 month stoppage of Unit 5 during renewing of roof on spillway side of existing powerhouse.	LS	(see below)		2,710,000
	Total				**73,490,000**

Decrease of energy production

Electricity selling price	6.21	cents/kWh (2008 tariff)
Stoppage duration of Unit-5 operation	3	months
Plant factor, if operated during stopage	50.5	%
Reduction of energy production during stoppage	43,632,000	kWh
Reduction of peak energy sale	2,709,547	US$
=	2,710,000	US$ Rounded

Cost Estimate for Comparison of Alternatives — **Alternative A4-1 (40MW)**

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary buildings for power station O&M staff including guard room	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	150	6	900
2	Concrete for tower foundations and cable ducts	m3	12	220	2,640
3	Re-bars	t	1	1,500	900
4	New building for GIS (150 m^2)	LS			75,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			1,560
	Sub-total				89,000
A3	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			9,820,000
	b) Platform for dam penetration work	LS			1,260,000
2	Concrete excavation for dam penetration	m3	1,450	320	464,000
3	Concrete (including formwork cost)	m3	1,130	190	214,700
4	Re-bars	t	48	1,500	72,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,183,300
	Sub-total				13,014,000
A4	**Powerhouse**				
1	Under-pinning of existing control building columns	LS			300,000
2	Excavation				
	a) Open excavation above El. 168m(loose)	m3	9,000	4	36,000
	b) Open excavation above El. 168m(rock)	m3	34,000	15	510,000
	c) Pit excavation (rock) below El. 168m	m3	20,000	30	600,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	2,800	25	70,000
	b) Shotcrete on cut slope	m3	420	400	168,000
4	Backfill with free draining materials	m3	11,000	5	55,000
5	Concrete of powerhouse building	m3	19,000	220	4,180,000
6	Concrete of cable duct to GIS room	m3	100	220	22,000
7	Re-bars	t	1,450	1,500	2,175,000
8	Steel structures (roof truss, crane beam)	t	140	4,500	630,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			494,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			277,000
	Sub-total				9,517,000
A5	**Tailrace**				
1	Temporary works				
	a) Tailrace cellular cofferdam	LS			600,000
	b) Access road to outlet bottom	LS			55,000
2	Excavation				
	a) Open excavation (loose material)	m3	4,000	4	16,000
	b) Open excavation (rock)	m3	16,500	10	165,000
	c) Underwater excavation during coffer removal	m3	1,500	60	90,000
	d) Tunnel excavation for tailrace tunnel	m3	2,200	50	110,000
3	Rock support and slope protection				
	a) Rock bolts	m	1,000	25	25,000
	b) Shotcrete	m3	180	400	72,000
4	Backfill with free draining materials	m3	6,600	5	33,000
5	Concrete				
	a) Tunnel lining	m3	520	300	156,000
	b) Outlet structure	m3	2,500	210	525,000
6	Re-bars	t	120	1,500	180,000
7	Consolidation grouting	m	225	80	18,000
8	Miscellaneous works	LS			61,000
	Sub-total				2,106,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			3,725,000
	Total of A				28,551,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	24	4,000	96,000
2	Stoplog	t	63	7,000	441,000
3	Intake gate and hoist	t	156	9,000	1,404,000
4	Gantry crane rails & cable extension	LS			40,000
5	Penstock steel pipe	t	214	7,000	1,498,000
	Sub-total				3,479,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	56	10,000	560,000
	Sub-total				560,000
	Total of B				4,039,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			7,880,000
2	Generator and auxiliaries	LS			8,630,000
3	Transformers	LS			1,380,000
4	Indoor switchgear	LS			680,000
5	Outdoor switchyard equipment	LS			2,860,000
6	Control and protection equipment	LS			690,000
7	Auxiliary equipment	LS			690,000
8	Miscellaneous materials	LS			510,000
	Sub-total				23,320,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				23,330,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			3,910,000
2	Environmental treatment work	LS			800,000
	Total of D				4,710,000
Grand Total					60,630,000

Cost Estimate for Comparison of Alternatives

Alternative A4-2 (60MW)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary buildings for power station O&M staff including guard room	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	150	6	900
2	Concrete for tower foundations and cable ducts	m3	12	220	2,640
3	Re-bars	t	1	1,500	900
4	New building for GIS (150 m^2)	LS			75,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			1,560
	Sub-total				89,000
A3	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			10,540,000
	b) Platform for dam penetration work	LS			1,120,000
2	Concrete excavation for dam penetration	m3	2,100	320	672,000
3	Concrete	m3	1,600	190	304,000
4	Re-bars	t	64	1,500	96,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,273,000
	Sub-total				14,005,000
A4	**Powerhouse**				
1	Under-pinning of existing control building columns	LS			300,000
2	Excavation				
	a) Open excavation above El. 168m(loose)	m3	10,000	4	40,000
	b) Open excavation above El. 168m(rock)	m3	52,000	15	780,000
	c) Pit excavation (rock) below El. 168m	m3	33,000	30	990,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	3,800	25	95,000
	b) Shotcrete on cut slope	m3	640	400	256,000
4	Backfill with free draining materials	m3	15,000	5	75,000
5	Concrete of powerhouse building	m3	27,000	220	5,940,000
6	Concrete of cable duct to GIS room	m3	300	220	66,000
7	Re-bars	t	2,280	1,500	3,420,000
8	Steel structures (roof truss, crane beam)	t	220	4,500	990,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			760,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			411,000
	Sub-total				14,123,000
A5	**Tailrace**				
1	Temporary works				
	a) Tailrace cellular cofferdam	LS			600,000
	b) Access road to outlet bottom	LS			55,000
2	Excavation				
	a) Open excavation (loose material)	m3	4,500	4	18,000
	b) Open excavation (rock)	m3	18,800	10	188,000
	c) Underwater excavation during coffer removal	m3	1,500	60	90,000
	d) Tunnel excavation for tailrace tunnel	m3	2,200	50	110,000
3	Rock support and slope protection				
	a) Rock bolts	m	1,240	25	31,000
	b) Shotcrete	m3	220	400	88,000
3	Backfill with free draining materials	m3	8,200	5	41,000
4	Concrete				
	a) Tunnel lining	m3	470	300	141,000
	b) Outlet structure	m3	3,100	210	651,000
5	Re-bars	t	140	1,500	210,000
6	Consolidation grouting	m	200	80	16,000
7	Miscellaneous works	LS			67,000
	Sub-total				2,306,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			4,596,000
	Total of A				35,219,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	31	4,000	124,000
2	Stoplog	t	115	7,000	805,000
3	Intake gate and hoist	t	242	11,000	2,662,000
4	Gantry crane rails & cable extension	LS			40,000
5	Penstock steel pipe	t	320	7,000	2,240,000
	Sub-total				5,871,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				6,671,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			10,950,000
2	Generator and auxiliaries	LS			12,520,000
3	Transformers	LS			2,100,000
4	Indoor switchgear	LS			700,000
5	Outdoor switchyard equipment	LS			2,860,000
6	Control and protection equipment	LS			690,000
7	Auxiliary equipment	LS			970,000
8	Miscellaneous materials	LS			690,000
	Sub-total				31,480,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				31,490,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			5,140,000
2	Environmental treatment work	LS			1,020,000
	Total of D				6,160,000
Grand Total					79,540,000

Cost Estimate for Comparison of Alternatives

Alternative A4-3 (40MW)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary buildings for power station O&M staff including guard room	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	150	6	900
2	Concrete for tower foundations and cable ducts	m3	12	220	2,640
3	Re-bars	t	1	1,500	900
4	New building for GIS (150 m^2)	LS			75,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			1,560
	Sub-total				89,000
A3	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			9,820,000
	b) Platform for dam penetration work	LS			1,260,000
2	Concrete excavation for dam penetration	m3	1,450	320	464,000
3	Concrete (including formwork cost)	m3	1,130	190	214,700
4	Re-bars	t	48	1,500	72,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,183,300
	Sub-total				13,014,000
A4	**Powerhouse**				
1	Under-pinning of existing control building columns	LS			300,000
2	Excavation				
	a) Open excavation above El. 168m(loose)	m3	9,000	4	36,000
	b) Open excavation above El. 168m(rock)	m3	34,000	15	510,000
	c) Pit excavation (rock) below El. 168m	m3	20,000	30	600,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	2,800	25	70,000
	b) Shotcrete on cut slope	m3	420	400	168,000
4	Backfill with free draining materials	m3	11,000	5	55,000
5	Concrete of powerhouse building	m3	19,000	220	4,180,000
6	Concrete of cable duct to GIS room	m3	100	220	22,000
7	Re-bars	t	1,450	1,500	2,175,000
8	Steel structures (roof truss, crane beam)	t	140	4,500	630,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			494,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			277,000
	Sub-total				9,517,000
A5	**Tailrace**				
1	Temporary cofferdam and access road	LS			120,000
2	Excavation				
	a) Open excavation (loose material)	m3	4,000	4	16,000
	b) Open excavation (rock)	m3	4,000	10	40,000
	c) Tunnel excavation for tailrace tunnel	m3	5,700	50	285,000
3	Rock support and slope protection				
	a) Rock bolts	m	1,400	25	35,000
	b) Shotcrete	m3	330	400	132,000
4	Backfill with free draining materials	m3	5,400	5	27,000
5	Concrete				
	a) Tunnel lining	m3	2,370	190	450,300
	b) Outlet structure	m3	1,330	210	279,300
6	Re-bars	t	161	1,500	241,500
7	Consolidation grouting	m	520	80	41,600
8	Miscellaneous works	LS			46,300
	Sub-total				1,714,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			3,667,000
	Total of A				28,101,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	24	4,000	96,000
2	Stoplog	t	63	7,000	441,000
3	Intake gate and hoist	t	156	9,000	1,404,000
4	Gantry crane rails & cable extension	LS			40,000
5	Penstock steel pipe	t	214	7,000	1,498,000
	Sub-total				3,479,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	56	10,000	560,000
	Sub-total				560,000
	Total of B				4,039,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			7,880,000
2	Generator and auxiliaries	LS			8,630,000
3	Transformers	LS			1,380,000
4	Indoor switchgear	LS			680,000
5	Outdoor switchyard equipment	LS			2,860,000
6	Control and protection equipment	LS			690,000
7	Auxiliary equipment	LS			690,000
8	Miscellaneous materials and services	LS			510,000
	Sub-total				23,320,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				23,330,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			3,880,000
2	Environmental treatment work	LS			800,000
	Total of D				4,680,000
Grand Total					60,150,000

Cost Estimate for Comparison of Alternatives — **Alternative A4-4 (60MW)**

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary buildings for power station O&M staff including guard room	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	150	6	900
2	Concrete for tower foundations and cable ducts	m3	12	220	2,640
3	Re-bars	t	1	1,500	900
4	New building for GIS (150 m^2)	LS			75,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			1,560
	Sub-total				89,000
A3	**Intake and Penstock**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			10,540,000
	b) Platform for dam penetration work	LS			1,120,000
2	Concrete excavation for dam penetration	m3	2,100	320	672,000
3	Concrete (including formwork cost)	m3	1,600	190	304,000
4	Re-bars	t	64	1,500	96,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			1,273,000
	Sub-total				14,005,000
A4	**Powerhouse**				
1	Under-pinning of existing control building columns	LS			300,000
2	Excavation				
	a) Open excavation above El. 168m(loose)	m3	10,000	4	40,000
	b) Open excavation above El. 168m(rock)	m3	52,000	15	780,000
	c) Pit excavation (rock) below El. 168m	m3	33,000	30	990,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	3,800	25	95,000
	b) Shotcrete on cut slope	m3	640	400	256,000
4	Backfill with free draining materials	m3	15,000	5	75,000
5	Concrete of powerhouse building	m3	27,000	220	5,940,000
6	Concrete of cable duct to GIS room	m3	300	220	66,000
7	Re-bars	t	2,280	1,500	3,420,000
8	Steel structures (roof truss, crane beam)	t	220	4,500	990,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			760,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			411,000
	Sub-total				14,123,000
A5	**Tailrace**				
1	Temporary cofferdam and access road	LS			120,000
2	Excavation				
	a) Open excavation (loose material)	m3	5,000	4	20,000
	b) Open excavation (rock)	m3	5,000	10	50,000
	c) Tunnel excavation for tailrace tunnel	m3	7,300	50	365,000
3	Rock support and slope protection				
	a) Rock bolts	m	2,000	25	50,000
	b) Shotcrete	m3	380	400	152,000
4	Backfill with free draining materials	m3	16,000	5	80,000
5	Concrete				
	a) Tunnel lining	m3	3,200	190	608,000
	b) Outlet structure	m3	1,800	210	378,000
6	Re-bars	t	86	1,500	129,000
7	Consolidation grouting	m	600	80	48,000
8	Miscellaneous works	LS			56,000
	Sub-total				2,056,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			4,556,000
	Total of A				34,929,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	31	4,000	124,000
2	Stoplog	t	115	7,000	805,000
3	Intake gate and hoist	t	242	11,000	2,662,000
4	Gantry crane rails & cable extension	LS			40,000
5	Penstock steel pipe	t	320	7,000	2,240,000
	Sub-total				5,871,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				6,671,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			10,950,000
2	Generator and auxiliaries	LS			12,520,000
3	Transformers	LS			2,100,000
4	Indoor switchgear	LS			700,000
5	Outdoor switchyard equipment	LS			2,860,000
6	Control and protection equipment	LS			690,000
7	Auxiliary equipment	LS			970,000
8	Miscellaneous materials and services	LS			690,000
	Sub-total				31,480,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				31,490,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			5,120,000
2	Environmental treatment work	LS			1,020,000
	Total of D				6,140,000
Grand Total					79,230,000

Cost Estimate for Comparison of Alternatives — **Alternative B2-1 (80 MW)**

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary office building for power station O&M (civil) staff	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	300	6	1,800
2	Concrete for tower foundations and cable ducts	m3	200	220	44,000
3	Re-bars	t	12	1,500	18,000
4	New building for GIS (220 m^2)	LS			165,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			7,200
	Sub-total				244,000
A3	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			19,650,000
	b) Platform for dam penetration work	LS			1,780,000
2	Concrete excavation for dam penetration	m3	2,900	320	928,000
3	Concrete (including formwork cost)	m3	2,260	190	429,400
4	Re-bars	t	96	1,500	144,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			2,292,600
	Sub-total				25,224,000
A4	**Penstock Tunnels**				
1	Excavation				
	a) Open excavation (loose materials)	m3	2,000	4	8,000
	b) Open excavation (Rock)	m3	33,000	15	495,000
	c) Tunnel excavation	m3	19,000	50	950,000
2	Rock support and slope protection				
	a) Rock bolts	m	2,600	25	65,000
	b) Shotcrete	m3	1,100	400	440,000
3	Backfill with free draining materials	m3	15,400	5	77,000
4	Concrete				
	a) Concrete for cut-and-cover conduit	m3	3,200	210	672,000
	b) Filling behind penstock pipe	m3	5,800	190	1,102,000
5	Re-bars	t	490	1,500	735,000
6	Consolidation grouting	m	2,300	80	184,000
7	Contact grouting	LS			70,000
8	Miscellaneous works	LS			144,000
	Sub-total				4,942,000
A5	**Powerhouse and Tailrace**				
1	Temporary cofferdam & access road	LS			960,000
2	Excavation				
	a) Open excavation, loose materials	m3	16,000	4	64,000
	b) Open excavation, rock	m3	38,000	10	380,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	880	25	22,000
	b) Shotcrete on cut slope	m3	240	400	96,000
4	Backfill with free draining materials	m3	15,000	5	75,000
5	Concrete				
	a) Powerhouse building	m3	26,000	220	5,720,000
	b) Tailrace wall and retaining wall	m3	4,500	210	945,000
	c) HV cable culvert and duct	m3	800	210	168,000
6	Re-bars	t	2,400	1,500	3,600,000
7	Steel structures (roof truss, crane beam)	t	270	4,500	1,215,000
8	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			1,330,000
9	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			437,000
	Sub-total				15,012,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			6,826,000
	Total of A				52,348,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	48	4,000	192,000
2	Stoplog	t	64	7,000	448,000
3	Intake gate and hoist	t	312	9,000	2,808,000
4	Gantry crane rails & cable extension	LS			60,000
5	Penstock steel pipe	t	1,434	6,000	8,604,000
	Sub-total				12,112,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	56	10,000	560,000
	Sub-total				560,000
	Total of B				12,672,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			15,360,000
2	Generator and auxiliaries	LS			17,220,000
3	Transformers	LS			3,160,000
4	Indoor switchgear	LS			1,610,000
5	Outdoor switchyard equipment	LS			4,040,000
6	Control and protection equipment	LS			1,570,000
7	Auxiliary equipment	LS			1,050,000
8	Miscellaneous materials	LS			990,000
	Sub-total				45,000,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				45,010,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			7,700,000
2	Environmental treatment work	LS			1,240,000
	Total of D				8,940,000
Grand Total					118,970,000

Cost Estimate for Comparison of Alternatives — **Alternative B2-2 (120 MW)**

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Temporary office building for power station O&M (civil) staff	LS			100,000
	Sub-total				100,000
A2	**Nam Leuk SS Building Relocation**				
1	Excavation for land preparation at new site	m3	150	6	900
2	Concrete for tower foundations and cable ducts	m3	12	220	2,640
3	Re-bars	t	1	1,500	900
4	New building for GIS (150 m^2)	LS			75,000
5	Cable rack along dam crest	LS			8,000
6	Miscellaneous work	LS			1,560
	Sub-total				89,000
A3	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			21,080,000
	b) Platform for dam penetration work	LS			2,240,000
2	Concrete excavation for dam penetration	m3	4,200	320	1,344,000
3	Concrete (including formwork cost)	m3	3,200	190	608,000
4	Re-bars	t	128	1,500	192,000
5	Miscellaneous works (metal works, road, landscaping, etc.)	LS			2,546,000
	Sub-total				28,010,000
A4	**Penstock Tunnels**				
1	Excavation				
	a) Open excavation (loose materials)	m3	2,500	4	10,000
	b) Open excavation (Rock)	m3	40,000	15	600,000
	c) Tunnel excavation	m3	18,800	50	940,000
2	Rock support and slope protection				
	a) Rock bolts	m	3,200	25	80,000
	b) Shotcrete	m3	1,300	400	520,000
3	Backfill with free draining materials	m3	19,000	5	95,000
4	Concrete				
	a) Concrete for cut-and-cover conduit	m3	4,800	210	1,008,000
	b) Filling behind penstock pipe	m3	7,100	190	1,349,000
5	Re-bars	t	730	1,500	1,095,000
6	Consolidation grouting	m	3,800	80	304,000
7	Contact grouting	LS			90,000
8	Miscellaneous works	LS			183,000
	Sub-total				6,274,000
A5	**Powerhouse and Tailrace**				
1	Temporary cofferdam & access road	LS			320,000
2	Excavation				
	a) Open excavation, loose materials	m3	20,000	4	80,000
	b) Open excavation, rock	m3	47,000	10	470,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	1,000	25	25,000
	b) Shotcrete on cut slope	m3	310	400	124,000
4	Backfill with free draining materials	m3	22,000	5	110,000
5	Concrete				
	a) Powerhouse building	m3	33,000	220	7,260,000
	b) Tailrace wall and retaining wall	m3	4,000	210	840,000
	c) HV cable culvert and duct	m3	600	210	126,000
6	Re-bars	t	2,800	1,500	4,200,000
7	Steel structures (roof truss, crane beam)	t	270	4,500	1,215,000
8	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			1,140,000
9	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			477,000
	Sub-total				16,387,000
A6	**General Item Cost**				
	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			7,629,000
	Total of A				58,489,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	62	4,000	248,000
2	Stoplog	t	117	7,000	819,000
3	Intake gate and hoist	t	484	11,000	5,324,000
4	Gantry crane rails & cable extension	LS			60,000
5	Penstock steel pipe	t	2,140	6,000	12,840,000
	Sub-total				19,291,000
B2	**Draft Tube Stoplog Facility**				
1	Gantry crane rails & cable extension	LS			0
2	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				20,091,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			21,510,000
2	Generator and auxiliaries	LS			24,990,000
3	Transformers	LS			4,350,000
4	Indoor switchgear	LS			1,660,000
5	Outdoor switchyard equipment	LS			3,330,000
6	Control and protection equipment	LS			1,570,000
7	Auxiliary equipment	LS			1,330,000
8	Miscellaneous materials	LS			1,330,000
	Sub-total				60,070,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
C3	**115kV Transmission Line**				
1	Overhead power conductors	LS			5,350,000
	Sub-total				5,350,000
	Total of C				65,430,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			10,080,000
2	Environmental treatment work	LS			1,670,000
	Total of D				11,750,000
Grand Total					155,760,000

Cost Estimate for Comparison of Alternatives

Alternative D1 (40MW)

(surface powerhouse)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of permanent access road to intake and powerhouse	LS			200,000
	b) Relocation of intake gantry crane	LS			50,000
	Sub-total				250,000
A2	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			9,280,000
	b) Work platform	LS			10,000,000
2	Open excavation above El. 215 m	m3	12,600	10	126,000
3	Intake channel excavation				
	a) Open excavation	m3	9,300	10	93,000
	b) Underwater excavation	m3	14,800	35	518,000
4	Concrete	m3	8,100	250	2,025,000
5	Re-bars	t	650	1,500	975,000
6	Miscellaneous works (metal works, road, landscaping, etc.)	LS			2,302,000
	Sub-total				25,319,000
A3	**Headrace Tunnel and Penstocks**				
1	Open excavation at adit portals	m3	2,500	6	15,000
2	Underground excavation, tunnel	m3	18,000	50	900,000
3	Rock support and slope protection				
	a) Rock bolts	m	2,600	25	65,000
	b) Shotcrete	m3	900	400	360,000
4	Concrete				
	a) Invert lining	m3	200	190	38,000
	b) Concrete lining	m3	3,400	290	986,000
	c) Filling behind steel liner	m3	1,400	190	266,000
4	Re-bars	t	140	1,500	210,000
5	**Curtain grouting**	m	380	120	45,600
6	Consolidation grouting	m	2,000	80	160,000
7	Miscellaneous works	LS			305,400
	Sub-total				3,351,000
A4	**Powerhouse & Tailrace**				
1	Temporary cofferdam	LS			100,000
2	Excavation				
	a) Open excavation, loose materials	m3	66,000	4	264,000
	b) Open excavation, rock	m3	20,000	10	200,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	600	25	15,000
	b) Shotcrete on cut slope	m3	200	400	80,000
4	Backfill with free draining materials	m3	20,000	5	100,000
5	Rock riprap on tailrace channel bank slopes	m3	7,000	15	105,000
6	Concrete				
	a) Powerhouse building	m3	18,000	220	3,960,000
	b) Tailrace wall and retaining wall	m3	2,500	210	525,000
7	Re-bars	t	1,500	1,500	2,250,000
8	Steel structures (roof truss, crane beam)	t	140	4,500	630,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			456,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			261,000
	Sub-total				8,946,000
A5	**Outdoor Switchyard**				
	Sub-total				0
A6	**General Item Cost**				
1	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			5,678,000
	Total of A				43,544,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	17	4,000	68,000
2	Stoplog	t	181	7,000	1,267,000
3	Intake gate and hoist	t	60	8,000	480,000
4	Gantry crane	t	36	10,000	360,000
5	Penstock steel pipe	t	263	7,000	1,841,000
	Sub-total				4,016,000
B2	**Draft Tube Stoplog Facility**				
1	Draft tube gates and hoists	t	56	10,000	560,000
	Sub-total				560,000
	Total of B				4,576,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			7,880,000
2	Generator and auxiliaries	LS			8,630,000
3	Transformers	LS			1,660,000
4	Indoor switchgear	LS			1,090,000
5	Outdoor switchyard equipment	LS			620,000
6	Control and protection equipment	LS			1,010,000
7	Auxiliary equipment	LS			1,020,000
8	Miscellaneous materials	LS			490,000
	Sub-total				22,400,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				22,410,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			4,940,000
2	Environmental treatment work	LS			800,000
	Total of D				5,740,000
Grand Total					76,270,000

Cost Estimate for Comparison of Alternatives

Alternative D2 (60MW)

(surface powerhouse)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of permanent access road to intake and powerhouse	LS			200,000
	b) Relocation of intake gantry crane	LS			50,000
	Sub-total				250,000
A2	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			10,440,000
	b) Work platform	LS			11,250,000
2	Open excavation above El. 215 m	m3	14,100	10	141,000
3	Intake channel excavation				
	a) Open excavation	m3	10,400	10	104,000
	b) Underwater excavation	m3	16,800	35	588,000
4	Concrete	m3	9,100	250	2,275,000
5	Re-bars	t	730	1,500	1,095,000
6	Miscellaneous works (metal works, road, landscaping, etc.)	LS			2,589,000
	Sub-total				28,482,000
A3	**Headrace Tunnel and Penstocks**				
1	Open excavation at adit portals	m3	2,500	6	15,000
2	Underground excavation, tunnel	m3	26,000	50	1,300,000
3	Rock support and slope protection				
	a) Rock bolts	m	3,600	25	90,000
	b) Shotcrete	m3	1,050	400	420,000
4	Concrete				
	a) Invert lining	m3	200	190	38,000
	b) Concrete lining	m3	5,100	290	1,479,000
	c) Filling behind steel liner	m3	2,100	190	399,000
4	Re-bars	t	210	1,500	315,000
5	**Curtain grouting**	m	430	120	51,600
6	Consolidation grouting	m	2,600	80	208,000
7	Miscellaneous works	LS			432,400
	Sub-total				4,748,000
A4	**Powerhouse & Tailrace**				
1	Temporary cofferdam	LS			100,000
2	Excavation				
	a) Open excavation, loose materials	m3	69,000	4	276,000
	b) Open excavation, rock	m3	25,000	10	250,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	700	25	17,500
	b) Shotcrete on cut slope	m3	250	400	100,000
4	Backfill with free draining materials	m3	30,000	5	150,000
5	Rock riprap on tailrace channel bank slopes	m3	7,500	15	112,500
6	Concrete				
	a) Powerhouse building	m3	24,000	220	5,280,000
	b) Tailrace wall and retaining wall	m3	2,700	210	567,000
7	Re-bars	t	2,020	1,500	3,030,000
8	Steel structures (roof truss, crane beam)	t	170	4,500	765,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			570,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			337,000
	Sub-total				11,555,000
A5	**Outdoor Switchyard**				
	Sub-total				0
A6	**General Item Cost**				
1	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			6,754,000
	Total of A				51,789,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	25	4,000	100,000
2	Stoplog	t	307	7,000	2,149,000
3	Intake gate and hoist	t	91	8,000	728,000
4	Gantry crane	t	47	10,000	470,000
5	Penstock steel pipe	t	392	7,000	2,744,000
	Sub-total				6,191,000
B2	**Draft Tube Stoplog Facility**				
1	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				6,991,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			10,950,000
2	Generator and auxiliaries	LS			12,520,000
3	Transformers	LS			2,260,000
4	Indoor switchgear	LS			1,110,000
5	Outdoor switchyard equipment	LS			630,000
6	Control and protection equipment	LS			1,010,000
7	Auxiliary equipment	LS			1,290,000
8	Miscellaneous materials	LS			670,000
	Sub-total				30,440,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				30,450,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			6,250,000
2	Environmental treatment work	LS			1,020,000
	Total of D				7,270,000
Grand Total					96,500,000

Cost Estimate for Comparison of Alternatives

Alternative D3 (80MW)

(surface powerhouse)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of permanent access road to intake and powerhouse	LS			200,000
	b) Relocation of intake gantry crane	LS			50,000
	Sub-total				250,000
A2	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			11,600,000
	b) Work platform	LS			12,500,000
2	Open excavation above El. 215 m	m3	15,700	10	157,000
3	Intake channel excavation				
	a) Open excavation	m3	11,600	10	116,000
	b) Underwater excavation	m3	18,600	35	651,000
4	Concrete	m3	10,100	250	2,525,000
5	Re-bars	t	810	1,500	1,215,000
6	Miscellaneous works (metal works, road, landscaping, etc.)	LS			2,876,000
	Sub-total				31,640,000
A3	**Headrace Tunnel and Penstocks**				
1	Open excavation at adit portals	m3	3,000	6	18,000
2	Underground excavation, tunnel	m3	40,300	50	2,015,000
3	Rock support and slope protection				
	a) Rock bolts	m	2,000	25	50,000
	b) Shotcrete	m3	1,800	400	720,000
4	Concrete				
	a) Invert lining	m3	700	190	133,000
	b) Concrete lining	m3	7,600	290	2,204,000
	c) Filling behind steel liner	m3	3,000	190	570,000
4	Re-bars	t	430	1,500	645,000
5	**Curtain grouting**	m	480	120	57,600
6	Consolidation grouting	m	3,200	80	256,000
7	Miscellaneous works	LS			667,400
	Sub-total				7,336,000
A4	**Powerhouse & Tailrace**				
1	Temporary cofferdam	LS			100,000
2	Excavation				
	a) Open excavation, loose materials	m3	76,000	4	304,000
	b) Open excavation, rock	m3	36,000	10	360,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	800	25	20,000
	b) Shotcrete on cut slope	m3	300	400	120,000
4	Backfill with free draining materials	m3	40,000	5	200,000
5	Rock riprap on tailrace channel bank slopes	m3	8,000	15	120,000
6	Concrete				
	a) Powerhouse building	m3	28,000	220	6,160,000
	b) Tailrace wall and retaining wall	m3	4,800	210	1,008,000
7	Re-bars	t	2,500	1,500	3,750,000
8	Steel structures (roof truss, crane beam)	t	270	4,500	1,215,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			1,140,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			431,000
	Sub-total				14,928,000
A5	**Outdoor Switchyard**				
	Sub-total				0
A6	**General Item Cost**				
1	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			8,128,000
	Total of A				62,282,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	34	4,000	136,000
2	Intake gate and hoist	t	120	8,000	960,000
3	Penstock steel pipe	t	516	7,000	3,612,000
	Sub-total				4,708,000
B2	**Draft Tube Stoplog Facility**				
1	Draft tube gates and hoists	t	56	10,000	560,000
	Sub-total				560,000
	Total of B				5,268,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			18,650,000
2	Generator and auxiliaries	LS			17,230,000
3	Transformers	LS			3,160,000
4	Indoor switchgear	LS			1,520,000
5	Outdoor switchyard equipment	LS			910,000
6	Control and protection equipment	LS			1,450,000
7	Auxiliary equipment	LS			1,050,000
8	Miscellaneous materials	LS			1,000,000
	Sub-total				44,970,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
	Total of C				44,980,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			7,880,000
2	Environmental treatment work	LS			1,240,000
	Total of D				9,120,000
Grand Total					121,650,000

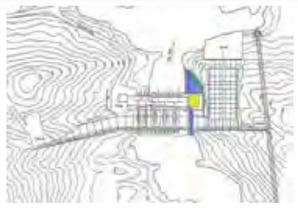
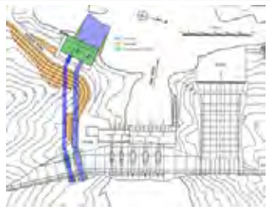
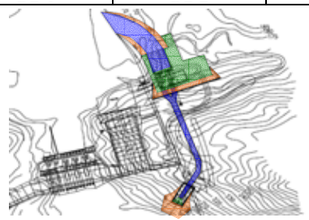
Cost Estimate for Comparison of Alternatives

Alternative D4 (120MW)

(surface powerhouse)

Item	Description	Unit	Quantity	Rate (US$)	Cost (US$)
A	**CIVIL WORKS**				
A1	**Preparatory Works**				
	a) Preparation of permanent access road to intake and powerhouse	LS			200,000
	b) Relocation of intake gantry crane	LS			50,000
	Sub-total				250,000
A2	**Intake**				
1	Temporary works				
	a) Intake enclosure structure in reservoir	LS			13,920,000
	b) Work platform	LS			15,000,000
2	Open excavation above El. 215 m	m3	18,800	10	188,000
3	Intake channel excavation				
	a) Open excavation	m3	15,000	10	150,000
	b) Underwater excavation	m3	24,000	35	840,000
4	Concrete	m3	13,000	250	3,250,000
5	Re-bars	t	1,100	1,500	1,650,000
6	Miscellaneous works (metal works, road, landscaping, etc.)	LS			3,500,000
	Sub-total				38,498,000
A3	**Headrace Tunnel and Penstocks**				
1	Open excavation at adit portals	m3	4,000	6	24,000
2	Underground excavation, tunnel	m3	52,000	50	2,600,000
3	Rock support and slope protection				
	a) Rock bolts	m	3,000	25	75,000
	b) Shotcrete	m3	2,700	400	1,080,000
4	Concrete				
	a) Invert lining	m3	900	190	171,000
	b) Concrete lining	m3	9,900	290	2,871,000
	c) Filling behind steel liner	m3	4,100	190	779,000
4	Re-bars	t	560	1,500	840,000
5	**Curtain grouting**	m	550	120	66,000
6	Consolidation grouting	m	4,100	80	328,000
7	Miscellaneous works	LS			883,000
	Sub-total				9,717,000
A4	**Powerhouse & Tailrace**				
1	Temporary cofferdam	LS			100,000
2	Excavation				
	a) Open excavation, loose materials	m3	98,000	4	392,000
	b) Open excavation, rock	m3	54,000	10	540,000
3	Slope protection and rock support				
	a) Rock bolts on cut slope	m	1,000	25	25,000
	b) Shotcrete on cut slope	m3	500	400	200,000
4	Backfill with free draining materials	m3	50,000	5	250,000
5	Rock riprap on tailrace channel bank slopes	m3	9,000	15	135,000
6	Concrete				
	a) Powerhouse building	m3	33,000	220	7,260,000
	b) Tailrace wall and retaining wall	m3	4,000	210	840,000
7	Re-bars	t	2,800	1,500	4,200,000
8	Steel structures (roof truss, crane beam)	t	270	4,500	1,215,000
9	Architectural works (finishing, windows, doors, roofing, plumbing, lighting, ventilating, etc.)	LS			1,140,000
10	Miscellaneous works (metalwork, earthing, paving, landscaping, etc.)	LS			489,000
	Sub-total				16,786,000
A5	**Outdoor Switchyard**				
1	Open excavation	m3	3,000	10	30,000
2	Concrete	m3	800	210	168,000
3	Re-bars	t	40	1,500	60,000
4	Miscellaneous works	LS			13,000
	Sub-total				271,000
A6	**General Item Cost**				
1	Contractors' offices, camps, workshop, power/water supply, insurance, bonds, etc.)	LS			9,826,000
	Total of A				75,348,000
B	**HYDRAULIC STEEL STRUCTURES**				
B1	**Intake and Penstock**				
1	Trash rack	t	54	4,000	216,000
2	Intake gate and hoist	t	180	8,000	1,440,000
3	Penstock steel pipe	t	764	6,500	4,966,000
	Sub-total				6,622,000
B2	**Draft Tube Stoplog Facility**				
1	Draft tube gates and hoists	t	80	10,000	800,000
	Sub-total				800,000
	Total of B				7,422,000
C	**ELECTRICAL /MECHANICAL EQUIPMENT**				
C1	**Generating Equipment**				
1	Turbine and auxiliaries	LS			26,310,000
2	Generator and auxiliaries	LS			24,990,000
3	Transformers	LS			4,350,000
4	Indoor switchgear	LS			1,660,000
5	Outdoor switchyard equipment	LS			1,990,000
6	Control and protection equipment	LS			1,580,000
7	Auxiliary equipment	LS			1,330,000
8	Miscellaneous materials	LS			1,410,000
	Sub-total				63,620,000
C2	**Thalat Substation Improvement**				
1	Overhead power conductors	LS			10,000
	Sub-total				10,000
C3	**115kV Transmission Line**				
1	Overhead power conductors	LS			5,350,000
					5,350,000
	Total of C				68,980,000
D	**ENGINEERING & ENVIRONMENTAL WORKS**				
1	Design and construction supervision	LS			10,620,000
2	Environmental treatment work	LS			1,670,000
	Total of D				12,290,000
Grand Total					164,040,000

Appendix E-3 Summary of Alternative Plans

	Alternatives		A1	A2	A4-1	A4-2	A4-3	A4-4	B2-1	B2-2	D2-1	D2-2	D2-3	D2-4
1	Layout												Pre-screened Alternative D1 that is underground power-house plan is eliminated from this comparison due to high construction cost.	
2	Installed Capacity (Additional Units Total)		40 MW	60 MW	40 MW	60 MW	40 MW	60 MW	80 MW	120 MW	40 MW	60 MW	80 MW	120 MW
	Nos. of additional units		1	1	1	1	1	1	2	2	1	1	2	2
3	Max. turbine discharge (m3/s)		118	177	118	177	118	177	118 x 2 = 236	177 x 2 = 354	118	177	118 x 2 = 236	177 x 2 = 354
	Tail water level rise (max.)	(m)	0.5	0.8	0.5	0.8	0.5	0.8	1.0	1.4	0.5	0.8	1.0	1.4
4	Design													
	1) Intake	Dam block width (m)	18.0		15.0				15.0		==	==	==	==
		Water passage dia. (m)	Φ6.0	Φ7.4	Φ6.0	Φ7.4	Φ6.0	Φ7.4	Φ6.0	Φ7.4	Φ6.0	Φ7.4	Φ8.5	Φ10.5
		Dam piercing dia. x length (m)	Φ7.2 x 21.8	Φ8.6 x 22.7	Φ7.2 x 21.8	Φ8.6 x 23.6	Φ7.2 x 21.8	Φ8.6 x 23.6	Φ7.2 x 21.8 x 2	Φ8.6 x 21.8 x 2	==	==	==	==
		Intake trash rack	Removable type		Removable type				Removable type		Fixed type		Fixed type	
		Intake stoplog	New stoplog		New stoplog				New stoplog		New stoplog		None	
		Gantry crane	Existing crane is utilized		Existing crane is utilized				Existing crane is utilized		New gantry crane		None	
		Intake gate	Hydraulic hoist gate		Hydraulic hoist gate				Hydraulic hoist gate		Rope hoist gate		Rope hoist gate	
	2) Headrace Tunnel	Dia x length (m)	None		None				same as penstock		Φ6.0 x 198 x 1	Φ7.4 x 198 x 1	Φ8.5 x 198 x 1	Φ10.5 x 198 x 1
		Tunnel lining	===		===				Φ6.0 x 205 x 2	Φ7.4 x 205 x 2	Concrete lining			
	3) Penstock steel pipe	Dia. x length (m)	Φ6.0 x 62	Φ7.4 x 62	Φ6.0 x 64	Φ7.4 x 64	Φ6.0 x 64	Φ7.4 x 64	Φ6.0 x 205 x 2	Φ7.4 x 205 x 2	Φ6.0 x 80	Φ7.4 x 80	Φ8.5 x 42 x 1 + Φ6.0 x 39 x 2	Φ10.5 x 42 x 1 + Φ7.4 x 39 x 2
	4) Powerhouse	Building add. length (m)	26.5	29.5	41	47	41	47	69	78	41	47	69	78
		Stator outer diameter (m)	9.5	11.2	9.5	11.2	9.5	11.2	9.5	11.2	9.5	11.2	9.5	11.2
		Weight of rotor (t)	164	246	164	246	164	246	164	246	164	246	164	246
		Turbine inlet valve	None	None	None	None	None	None	None	None	None	None	2 sets	2 sets
		Additional OHT crane (t)	None	250	170	250	170	250	170	250	170	250	170	250
		Crane span (m)	16.2	18.2	16.2	18.2	16.2	18.2	16.2	18.2	16.2	18.2	16.2	18.2
	5) Tailrace	Type	Open channel		Short tunnel		Long tunnel		Open channel		Open channel			
		Tunnel dia. x length (m)	===		Φ6.0 x 40	Φ7.0 x 40	Φ6.0 x 102	Φ7.0 x 102	===		===			
		Additional tailrace gate (t)	None	80	56	80	56	80	56	80	56	80	56	80
		Tailrace gate & gantry crane	Existing	New	New		New		New		New			
	6) Switchyard	Type	Conventional		GIS				GIS	Conventional	Conventional			Conventional
		Location	Additional bay in PH roof switchyard		New GIS room on left abutment (with relocated Nam Leuk GIS)				New GIS room on left abutment (with relocated Nam Leuk GIS)	Roof of new powerhouse	Additional bays in existing PH roof switchyard			Beside new powerhouse
		Replacement of main bus conductor (Existing: HDCC 325 sq. mm)	725 sq.mm	850 sq.mm	725 sq.mm	850 sq.mm	725 sq.mm	850 sq.mm	1000 sq.mm	500 sq.mm	725 sq.mm	850 sq.mm	1000 sq.mm	500 sq.mm
		Extension of existing S/Y	1 bay	1 bay	None	None	None	None	None	None	1 bay	1 bay	2 bays	None
		Extension of existing GIS	None	None	1 bay	1 bay	1 bay	1 bay	2 bays	None	None	None	None	None
		Relocation of GIS room	None	None	Yes	Yes	Yes	Yes	Yes	None	None	None	None	None
		Additional switchyard	None	None	None	None	None	None	None	5 bays	None	None	None	5 bays
		Additional transmission line	None	None	None	None	None	None	None	double-circuit	None	None	None	double-circuit
		Connection point to existing T/L line	Existing PH switchyard		Existing PH switchyard				Existing PH switchyard	No connection to existing T/L	Existing PH switchyard			No connection to existing T/L
	7) New 115 kV transmission line		None		None				None	New 54 km line	None			New 54 km line
5	Increased energy production (with NN2 operated)	Peak time (GWh)	100	143	99	142	99	141	169	245	100	143	166	240
		Off-peak time (GWh)	-48	-88	-48	-89	-49	-89	-102	-173	-48	-88	-104	-175
		Annual (GWh)	52	55	51	53	50	52	67	72	52	55	62	65
6	Construction cost	(million US$)	52.1	73.6	60.6	79.6	60.1	79.2	118.9	155.9	76.2	96.6	121.7	164.0
7	B/C (provisional calculation)	Economic B/C (i=10%)	2.06	1.99	1.75	1.82	1.76	1.82	1.80	1.94	1.40	1.52	1.72	1.79
		Financial B/C (i=1.4%)	1.65	1.22	1.38	1.09	1.38	1.08	0.92	0.76	1.12	0.94	0.85	0.66
		Ranking (economical)	1	2		4		4		3				
8	Particular conditions		Existing transformer access way is blocked by temporary ramp way for 10 months during dam piercing and penstock construction. Plan A2 requires shutdown of Unit 5 for 3 months to renew powerhouse roof for operation of new 250t OHT crane in unit-5 erection bay.		Nam Leuk GIS is shut down for 3 months to relocate it to left abutment. Powerhouse construction is carried out below existing 115 kV overhead lines. Conventional type of switchyard on the roof is not applicable.				Nam Leuk GIS is shut down for 3 months to relocate it to left abutment.	Additional 115kV transmission line (54 km) is required.	New 115 kV lines cross over existing spillway to connect the lines with existing PH switchyard.			Additional 115kV transmission line (54 km) is required.