Appendix I-24 Construction Cost for Huari Huari Power Station

I. Summary of Construction Cost for Huari Huari Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**33,662**	
(1) Access Road	24,687	
(2) Facilities for Construction Office	2,737	Cost of Civil Works x 0.05
(3) Transportation cost	6,238	375.36ton x $16.62/ton
2. Cost for Environmental Mesures	**547**	Cost of Civil Works x 0.01
3. Civil Works	**54,746**	
(1) Weir	2,221	
(2) Intake	3,498	
(3) Settling Basin	3,774	
(4) Headrace	5,972	
(5) Head Tank	8,625	
(6) Penstock & Spillway Channel	17,943	
(7) Power House	11,291	
(8) Outlet	1,422	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**55,800**	
(1) Gate & Screen	2,198	
(2) Penstock	830	
(3) PVC (φ500)	37,503	
(4) PVC (φ200)	6,010	
(5) Others	9,259	
5. Electrical Equipment	**53,900**	
6. Direct Cost	**198,655**	1.+2.+3.+4.+5.
7. Engineering Cost	**19,866**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**19,480**	6. x 0.098
9. IGV	**45,220**	19.00%
10. Total Cost	**283,220**	

II. Detailed Statement of Transportation Cost for Huari Huari Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.23	
(2) Intake	ton	**32.71**	
a. Gate		0.17	
b. Screen		0.08	
c. Cements		6.77	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		25.09	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.59	
(3) Settling Basin	ton	**24.64**	
a. Cements		4.94	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		18.30	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.41	
(4) Headrace	ton	**7.73**	
a. PVC (φ500)		7.73	Weight: 900m x 51.522kg/6m
(5) Head Tank	ton	**47.51**	
a. Cements		9.71	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		35.97	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.83	
(6) Penstock & Spillway Channel	ton	**173.99**	
a. Penstock Steel (φ200)		0.27	
b. Penstock PVC (φ200)		1.44	Weight: 173m x 50.000kg/6m
c. Cements		36.62	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		135.62	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.04	
(7) Power House	ton	**67.27**	
a. Cements		13.70	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		50.73	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.84	
(8) Outlet	ton	**4.47**	
a. Cements		0.83	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		3.08	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.55	
(9) Subtotal		**375.36**	
(10) Transportation Cost		**6,239**	(9) x $16.62/ton

III. Detailed Statement of Civil Works Cost for Huari Huari Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**3,498**	
a. Excavation	m^3	5.53	14.0	77	
b. Concrete	m^3	93.05	25.1	2,334	
c. Reinforcement Bars	ton	1,070.00	0.6	631	
d. Others	-			456	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**3,774**	
a. Excavation	m^3	5.53	40.6	224	
b. Concrete	m^3	93.05	18.3	1,702	
c. Reinforcement Bars	ton	1,070.00	1.4	1,505	
d. Others	-			343	(a+b+c) x 0.10 (including other works)
(4) Headrace				**5,972**	
a. Excavation	m^3	5.53	900.0	4,977	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			995	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**8,625**	
a. Excavation	m^3	5.53	154.3	853	
b. Concrete	m^3	93.05	36.0	3,346	
c. Reinforcement Bars	ton	1,070.00	1.8	1,962	
d. Others	-			2,464	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**17,943**	
a. Excavation	m^3	5.53	659.6	3,647	
b. Concrete	m^3	93.05	135.6	12,619	
c. Reinforcement Bars	ton	1,070.00	0.0	46	
d. Others	-			1,631	(a+b+c) x 0.10 (including filling works)
(7) Power House				**11,291**	
a. Excavation	m^3	5.53	167.9	928	
b. Concrete	m^3	93.05	50.7	4,720	
c. Reinforcement Bars	ton	1,070.00	2.8	3,038	
d. Others	-			2,605	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,422**	
a. Excavation	m^3	5.53	65.2	360	
b. Concrete	m^3	93.05	3.1	286	
c. Reinforcement Bars	ton	1,070.00	0.6	591	
d. Others	-			185	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**54,746**	

IV. Detailed Statement of Hydraulic Equipment Cost for Huari Huari Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**2,198**	
a. Gate	ton	8,811.04	0.17	1,507	
b. Screen	ton	8,811.04	0.08	691	
(3) Penstock Steel (φ200）	ton	3,100.00	0.27	**830**	
(4) PVC (φ500）for headrace	m	41.67	900	**37,503**	
(5) Penstock PVC (φ200) C-10	m	34.74	173	**6,010**	
(6) Subtotal				**46,541**	
(7) Others				**9,259**	19.89%
(8) Total				**55,800**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**13.96**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**25.09**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.59**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.17**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.08**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.093**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**40.56**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**18.30**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.41**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.21**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.14**	(ton)

Where,

Q: Maximum Discharge = 0.093 (m^3/s)

(4) Headrace

In the case of PVCφ500:

Excavation:	$V_e = B \times H \times L$	=	**900.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.093	(m^3/s)	
L:	Length of Channel =	**900.00**	(m)	
B:	Width of Channel =	**1.00**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**1.00**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**154.33**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**35.97**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.83**	(ton)

Where,

Q: Maximum Discharge = 0.093 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	21.79	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	2.44	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.04	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**17.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.27	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.78	(mm)

Where,

W_{p1}:	Weight of Penstock	0.27	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.78	(mm)	
D_m:	Avg. Diameter of Penstock =	0.20	(m)	
H:	Design Head =	**107.50**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	17.00	(m)	

Penstock (PVC)φ200:

Excavation:	V_e =	$B \times H \times L$	=	130.94	(m^3)

Where,

Q:	Maximum Discharge =	0.093	(m^3/s)	
L:	Length of Channel =	**173.00**	(m)	
B:	Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)$^0.5 =	$1.09 \times Q^{0.379}$	=	0.44	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	506.86	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	133.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.093	(m^3/s)
L:	Length of Channel =	**190.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**659.59**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**135.62**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.04**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.27**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**167.87**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**50.73**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.84**	(ton)

Where,

Q:	Maximum Discharge =	0.093	(m^3/s)
He:	Effective Head =	107.50	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	65.18	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	3.08	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.55	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.093	(m^3/s)	

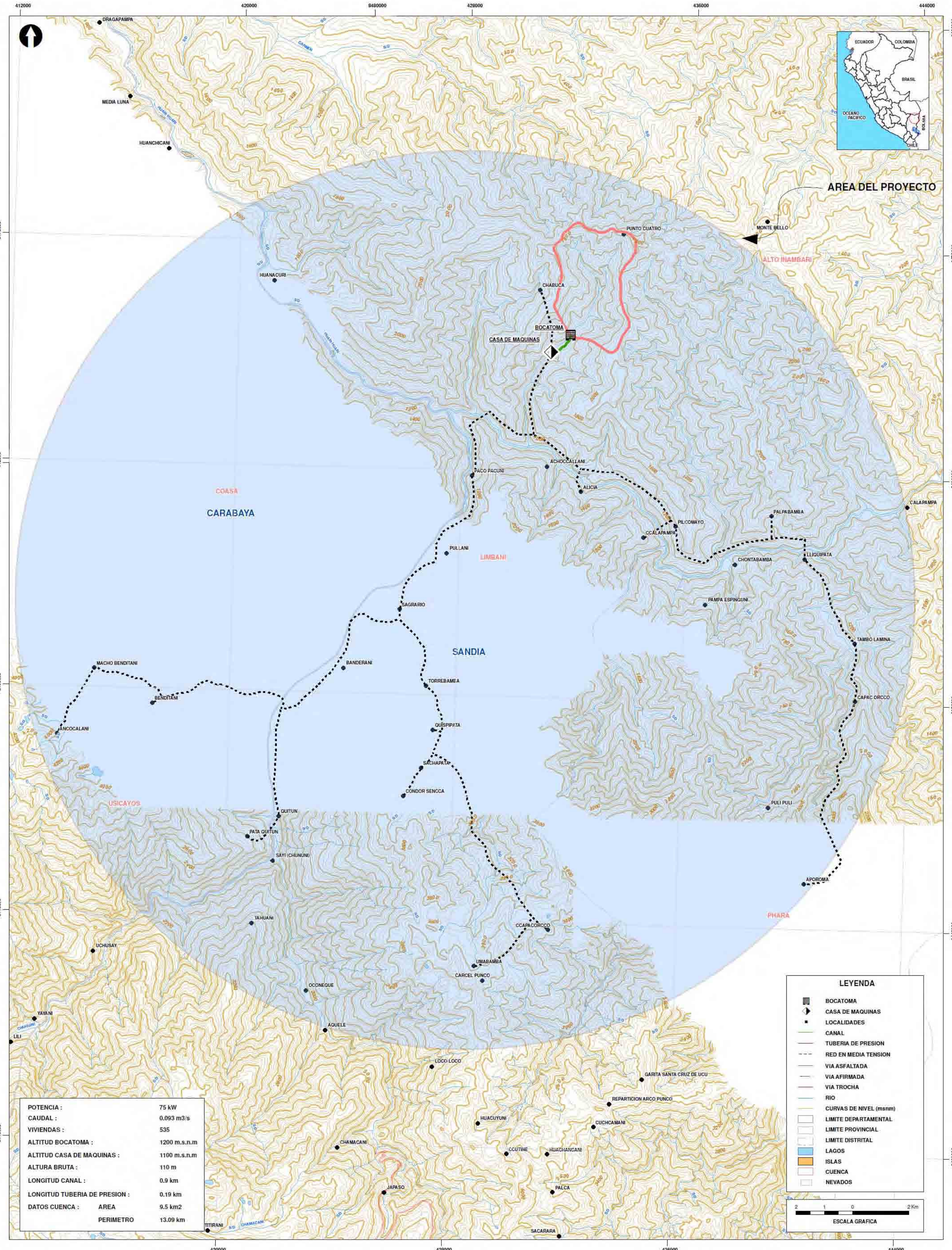
: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO
(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ500)		**41.67**	(US$/m)	RIB LOC for Headrace
PVC (φ200)	:	**34.74**	(US$/m)	80% of TUBOPLAST(φ 315) for Penstock (C-10) = 43.42 x 0.8 = 34.74
(3) Others				
Access Road	:	**5,877.89**	(US$/m)	Constrruction of Footpath from Powerhous to Intake Site (1.0m Width)
(4) Transportation Cost				
Juliaca to the site	:	**16.62**	(US$/ton)	237 km (road)

Huari Huari Map



Nº	FECHA	REVISIONES	REV.	APROB.

MINISTERIO DE ENERGIA Y MINAS DIRECCION EJECUTIVA DE PROYECTOS	PROYECTO C.H. Q. HUARI HUARI
DISEÑADO: N.A.S. / DIBUJADO: N.A.S. / REVISADO: H.S.S. / APROBADO: R.A.A. / FECHA: SET 2007	TITULO: UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:	UBICACION
ESCALA: 1 : 125 000	DEPARTAMENTO: PUNO
	PROVINCIA: VARIOS
HOJA: 1/1	DISTRITO: VARIOS
FORMATO: A-3	PLANO Nº:

Appendix I-25 Construction Cost for Porotongo Power Station

I. Summary of Construction Cost for Porotongo Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**22,011**	
(1) Access Road	14,106	
(2) Facilities for Construction Office	3,221	Cost of Civil Works x 0.05
(3) Transportation cost	4,684	413.07ton x $11.34/ton
2. Cost for Environmental Mesures	**644**	Cost of Civil Works x 0.01
3. Civil Works	**64,437**	
(1) Weir	2,221	
(2) Intake	5,859	
(3) Settling Basin	5,176	
(4) Headrace	10,510	
(5) Head Tank	11,134	
(6) Penstock & Spillway Channel	17,205	
(7) Power House	9,917	
(8) Outlet	2,415	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**92,800**	
(1) Gate & Screen	3,913	
(2) Penstock	0	
(3) PVC (φ600)	65,637	
(4) PVC (φ315)	7,815	
(5) Others	15,435	
5. Electrical Equipment	**35,000**	
6. Direct Cost	**214,892**	1.+2.+3.+4.+5.
7. Engineering Cost	**21,489**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**20,619**	6. x 0.096
9. IGV	**48,830**	19.00%
10. Total Cost	**305,830**	

II. Detailed Statement of Transportation Cost for Porotongo Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.23	
(2) Intake	ton	**53.71**	
a. Gate		0.30	
b. Screen		0.14	
c. Cements		11.10	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		41.12	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.04	
(3) Settling Basin	ton	**34.35**	
a. Cements		6.91	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		25.57	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.87	
(4) Headrace	ton	**14.63**	
a. PVC (φ600)		14.63	Weight: 1,100m x 79.8kg/6m
(5) Head Tank	ton	**61.38**	
a. Cements		12.55	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		46.47	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.37	
(6) Penstock & Spillway Channel	ton	**163.93**	
a. Penstock Steel (φ300)		0.00	
b. Penstock PVC (φ315)		3.68	Weight: 180m x 122.833kg/6m
c. Cements		34.07	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		126.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**59.13**	
a. Cements		12.04	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		44.60	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.48	
(8) Outlet	ton	**8.89**	
a. Cements		1.71	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		6.33	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.86	
(9) Subtotal		**413.07**	
(10) Transportation Cost		**4,684**	(9) x $11.34/ton

III. Detailed Statement of Civil Works Cost for Porotongo Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			**370**	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**5,859**	
a. Excavation	m^3	5.53	28.1	155	
b. Concrete	m^3	93.05	41.1	3,826	
c. Reinforcement Bars	ton	1,070.00	1.0	1,114	
d. Others	-			764	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**5,176**	
a. Excavation	m^3	5.53	59.5	328	
b. Concrete	m^3	93.05	25.6	2,379	
c. Reinforcement Bars	ton	1,070.00	1.9	1,999	
d. Others	-			470	(a+b+c) x 0.10 (including other works)
(4) Headrace				**10,510**	
a. Excavation	m^3	5.53	1584.0	8,759	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,751	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**11,134**	
a. Excavation	m^3	5.53	198.0	1,095	
b. Concrete	m^3	93.05	46.5	4,323	
c. Reinforcement Bars	ton	1,070.00	2.4	2,535	
d. Others	-			3,181	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**17,205**	
a. Excavation	m^3	5.53	705.2	3,900	
b. Concrete	m^3	93.05	126.2	11,741	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,564	(a+b+c) x 0.10 (including filling works)
(7) Power House				**9,917**	
a. Excavation	m^3	5.53	149.2	825	
b. Concrete	m^3	93.05	44.6	4,150	
c. Reinforcement Bars	ton	1,070.00	2.5	2,654	
d. Others	-			2,288	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,415**	
a. Excavation	m^3	5.53	107.8	596	
b. Concrete	m^3	93.05	6.3	588	
c. Reinforcement Bars	ton	1,070.00	0.9	916	
d. Others	-			315	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**64,437**	

IV. Detailed Statement of Hydraulic Equipment Cost for Porotongo Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**3,913**	
a. Gate	ton	8,811.04	0.30	2,638	
b. Screen	ton	8,811.04	0.14	1,275	
(3) Penstock Steel (φ315)	ton	3,100.00	0.00	**0**	
(4) PVC (φ600) for headrace	m	59.67	1,100	**65,637**	
(5) Penstock PVC (φ315) C-10	m	43.42	180	**7,815**	
(6) Subtotal				**77,365**	
(7) Others				**15,435**	19.95%
(8) Total				**92,800**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton) (unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**28.12**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**41.12**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**1.04**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.30**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.14**	(ton)

Where,

D:	Diameter of Waterway =	**1.00**	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2 Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.133**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**59.47**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**25.57**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.87**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.26**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.18**	(ton)

Where,

Q:	Maximum Discharge =	0.133	(m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**1,584.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.133	(m^3/s)	
L:	Length of Channel =	**1,100.00**	(m)	
B:	Width of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**198.03**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**46.47**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**2.37**	(ton)

Where,

Q:	Maximum Discharge =	0.133	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ315:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m: Avg. Diameter of Penstock = **0.00** (m)
L: Length of Penstock = **0.00** (m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}: Weight of Penstock 0.00 (ton) (Tensil allowable Stress: 1,150 kgf/cm^2)
tm: Thickness of Penstock 2.00 (mm)
D_m: Avg. Diameter of Penstock = 0.00 (m)
H: Design Head = **49.30** (m) (Intake Water Level - Tailrace Water Level)
L: Length of Penstock = 0.00 (m)

Penstock (PVC)φ315:

Excavation: $V_e = B \times H \times L$ = 152.35 (m^3)

Where,

Q: Maximum Discharge = 0.133 (m^3/s)
L: Length of Channel = **180.00** (m)
B: Width of Channel = **0.92** (m) from TUBOPLAST Brochure
H: Height of Channel = **0.92** (m) from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.51	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	552.90	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	126.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q: Maximum Discharge = 0.133 (m^3/s)
L: Length of Channel = **180.00** (m)
B: Width of Channel = **0.40** (m)
H: Height of Channel = **0.60** (m)
t: Thickness of Concrete = **0.15** (m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**705.25**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**126.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**149.23**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**44.60**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.48**	(ton)

Where,

Q: Maximum Discharge = 0.133 (m^3/s)
He: Effective Head = 49.30 (m)
n: Quantity Unit of Turbine = **1.00**

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	107.83	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	6.33	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.86	(ton)

Where,

D: Diameter of Waterway = 1.00 (m)
R: Radius of Waterway = 0.50 (m) D/2
Q: Maximum Discharge = 0.133 (m^3/s)

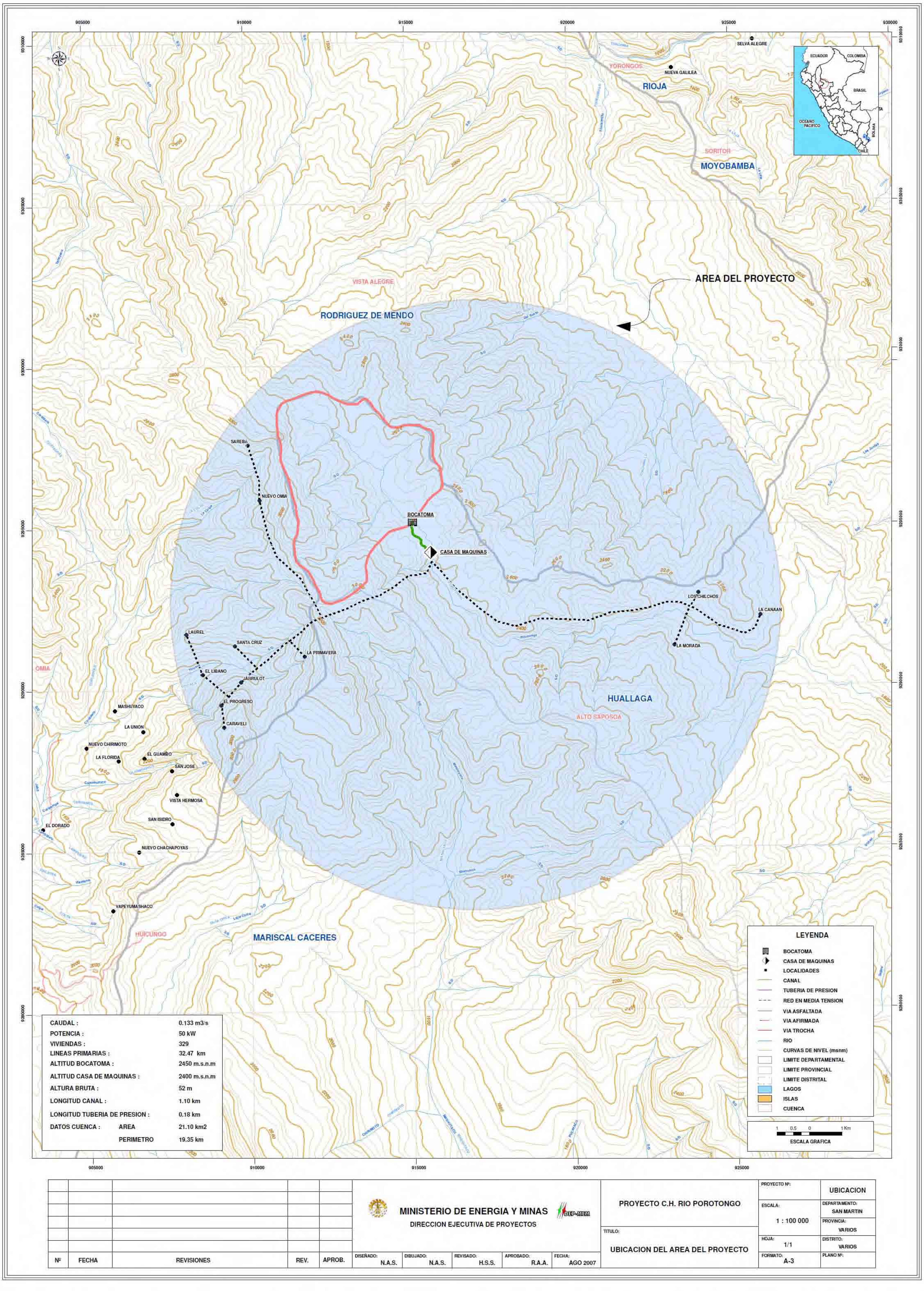
: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO
(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ600)		**59.67**	(US$/m)	RIB LOC for Headrace
PVC (φ315)	:	**43.42**	(US$/m)	TUBOPLAST for Penstock (C-10), The number of joints is 215. This price include joint price. 190m/6m =30 (joint), 30 x $2.7 =81$, 81$/190m =0.43$/m, 42.99$/m (PVC) + 0.43$/m (joint) = 43.42$/m
(3) Others				
Access Road	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road
(4) Transportation Cost				
Chachapoyas to the site	:	**11.34**	(US$/ton)	84 km (road)

Porotongo Map



Appendix I-26 Construction Cost for Selecachi Power Station

I. Summary of Construction Cost for Selecachi Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**9,171**	
(1) Access Road	0	
(2) Facilities for Construction Office	2,918	Cost of Civil Works x 0.05
(3) Transportation cost	6,253	471.28ton x $13.27/ton
2. Cost for Environmental Mesures	**583**	Cost of Civil Works x 0.01
3. Civil Works	**58,369**	
(1) Weir	1,282	
(2) Intake	2,451	
(3) Settling Basin	1,992	
(4) Headrace	6,454	
(5) Head Tank	5,139	
(6) Penstock & Spillway Channel	34,120	
(7) Power House	5,938	
(8) Outlet	993	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**64,000**	
(1) Gate & Screen	1,476	
(2) Penstock	0	
(3) PVC (φ400)	40,021	
(4) PVC (φ150)	11,852	
(5) Others	10,651	
5. Electrical Equipment	**24,800**	
6. Direct Cost	**156,923**	1.+2.+3.+4.+5.
7. Engineering Cost	**15,692**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**15,385**	6. x 0.098
9. IGV	**35,720**	19.00%
10. Total Cost	**223,720**	

II. Detailed Statement of Transportation Cost for Selecachi Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**9.48**	
a. Cements		1.98	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		7.35	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.14	
(2) Intake	ton	**23.22**	
a. Gate		0.12	
b. Screen		0.05	
c. Cements		4.82	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		17.84	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.40	
(3) Settling Basin	ton	**12.57**	
a. Cements		2.50	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		9.27	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.79	
(4) Headrace	ton	**10.44**	
a. PVC (φ400)		10.44	Weight: 1,520m x 41.214kg/6m
(5) Head Tank	ton	**28.25**	
a. Cements		5.77	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		21.39	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.09	
(6) Penstock & Spillway Channel	ton	**349.02**	
a. Penstock Steel (φ150)		0.00	
b. Penstock PVC (φ150)		2.08	Weight: 390m x 32.000kg/6m
c. Cements		73.76	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		273.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**35.51**	
a. Cements		7.24	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		26.81	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.45	
(8) Outlet	ton	**2.79**	
a. Cements		0.51	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		1.88	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.41	
(9) Subtotal		**471.28**	
(10) Transportation Cost		**6,254**	(9) x $13.27/ton

III. Detailed Statement of Civil Works Cost for Selecachi Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Wier				**1,282**	
a. Excavation	m^3	5.53	42.2	233	
b. Concrete	m^3	93.05	7.3	683	
c. Reinforcement Bars	ton	1,070.00	0.1	153	
d. Others	-			213	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**2,451**	
a. Excavation	m^3	5.53	8.6	47	
b. Concrete	m^3	93.05	17.8	1,659	
c. Reinforcement Bars	ton	1,070.00	0.4	426	
d. Others	-			319	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**1,992**	
a. Excavation	m^3	5.53	18.7	103	
b. Concrete	m^3	93.05	9.3	862	
c. Reinforcement Bars	ton	1,070.00	0.8	846	
d. Others	-			181	(a+b+c) x 0.10 (including other works)
(4) Headrace				**6,454**	
a. Excavation	m^3	5.53	972.8	5,379	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,075	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**5,139**	
a. Excavation	m^3	5.53	93.0	514	
b. Concrete	m^3	93.05	21.4	1,990	
c. Reinforcement Bars	ton	1,070.00	1.1	1,167	
d. Others	-			1,468	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**34,120**	
a. Excavation	m^3	5.53	1012.7	5,600	
b. Concrete	m^3	93.05	273.2	25,419	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			3,101	(a+b+c) x 0.10 (including filling works)
(7) Power House				**5,938**	
a. Excavation	m^3	5.53	93.7	518	
b. Concrete	m^3	93.05	26.8	2,495	
c. Reinforcement Bars	ton	1,070.00	1.5	1,555	
d. Others	-			1,370	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**993**	
a. Excavation	m^3	5.53	46.0	254	
b. Concrete	m^3	93.05	1.9	174	
c. Reinforcement Bars	ton	1,070.00	0.4	436	
d. Others	-			129	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**58,369**	

IV. Detailed Statement of Hydraulic Equipment Cost for Selecachi Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,476**	
a. Gate	ton	8,811.04	0.12	1,023	
b. Screen	ton	8,811.04	0.05	453	
(3) Penstock Steel (φ150)	ton	3,100.00	0.00	**0**	
(4) PVC (φ400) for headrace	m	26.33	1,520	**40,021**	
(5) Penstock PVC (φ150) C-10	m	30.39	390	**11,852**	
(6) Subtotal				**53,349**	
(7) Others				**10,651**	19.96%
(8) Total				**64,000**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**42.21**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**7.35**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.14**	(ton)
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton) (unconsidered)

Where,

H_d:	Height of Dam =	**0.20**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**8.61**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**17.84**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.40**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.12**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.05**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2 Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.045**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**18.65**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**9.27**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.79**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.14**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.08**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**972.80**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)	
L:	Length of Channel =	**1,520.00**	(m)	
B:	Width of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**93.05**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**21.39**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.09**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ150:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**95.90**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ150:

Excavation:	V_e =	B x H x L	=	231.23	(m^3)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)	
L:	Length of Channel =	**390.00**	(m)	
B:	Width of Channel =	**0.77**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.77**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.34	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	781.50	(m^3)
Concrete:	V_c =	H x t x 2 + (B + 2t) x L	=	273.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)
L:	Length of Channel =	**390.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**1,012.73**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**273.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**93.70**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**26.81**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**1.45**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)
He:	Effective Head =	95.90	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	46.04	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	1.88	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.41	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.045	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ400)		**26.33**	(US$/m)	RIB LOC for Headrace
PVC (φ150)	:	**30.39**	(US$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.7 = 30.39

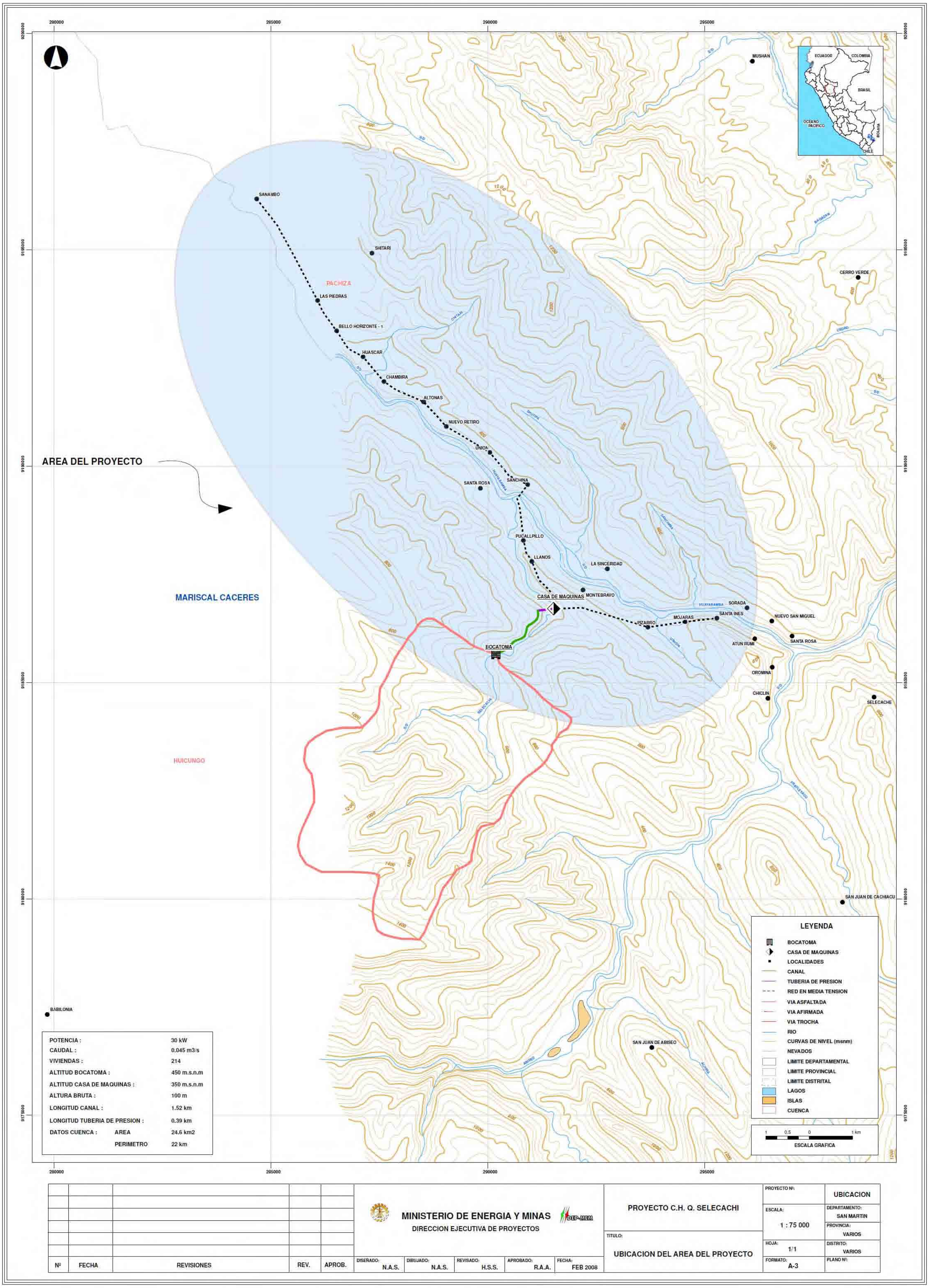
(3) Others

Access Road	:	**-**	(US$/m)	-

(4) Transportation Cost

Tarapoto to the site	:	**13.27**	(US$/ton)	140km

Selecachi Map



Appendix I-27 Construction Cost for Quebrada Tahunia Power Station

I. Summary of Construction Cost for Quebrada Tahunia Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**153,548**	
(1) Access Road	77,588	
(2) Facilities for Construction Office	4,514	Cost of Civil Works x 0.05
(3) Transportation cost	71,446	724.09ton x $98.67/ton
2. Cost for Environmental Mesures	**902**	Cost of Civil Works x 0.01
3. Civil Works	**90,283**	
(1) Weir	2,221	
(2) Intake	3,042	
(3) Settling Basin	2,939	
(4) Headrace	9,343	
(5) Head Tank	7,043	
(6) Penstock & Spillway Channel	55,621	
(7) Power House	8,838	
(8) Outlet	1,236	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**97,600**	
(1) Gate & Screen	1,881	
(2) Penstock	2,663	
(3) PVC (φ400)	57,926	
(4) PVC (φ200)	18,933	
(5) Others	16,197	
5. Electrical Equipment	**41,100**	
6. Direct Cost	**383,433**	1.+2.+3.+4.+5.
7. Engineering Cost	**38,343**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**38,224**	6. x 0.100
9. IGV	**87,400**	19.00%
10. Total Cost	**547,400**	

II. Detailed Statement of Transportation Cost for Quebrada Tahunia Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.23	
(2) Intake	ton	**28.60**	
a. Gate		0.15	
b. Screen		0.07	
c. Cements		5.93	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		21.96	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.51	
(3) Settling Basin	ton	**18.94**	
a. Cements		3.79	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		14.02	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.12	
(4) Headrace	ton	**15.11**	
a. PVC (φ400)		15.11	Weight: 2,200m x 41.214kg/6m
(5) Head Tank	ton	**38.77**	
a. Cements		7.92	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		29.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.50	
(6) Penstock & Spillway Channel	ton	**549.18**	
a. Penstock Steel (φ200)		0.86	
b. Penstock PVC (φ200)		4.54	Weight: 545m x 50.000kg/6m
c. Cements		115.58	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		428.06	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.14	
(7) Power House	ton	**52.74**	
a. Cements		10.74	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		39.79	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.20	
(8) Outlet	ton	**3.71**	
a. Cements		0.69	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.54	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.49	
(9) Subtotal		**724.09**	
(10) Transportation Cost		**71,446**	(9) x $98.67/ton

III. Detailed Statement of Civil Works Cost for Quebrada Tahunia Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**3,042**	
a. Excavation	m^3	5.53	11.6	63	
b. Concrete	m^3	93.05	22.0	2,042	
c. Reinforcement Bars	ton	1,070.00	0.5	541	
d. Others	-			396	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,939**	
a. Excavation	m^3	5.53	29.9	165	
b. Concrete	m^3	93.05	14.0	1,305	
c. Reinforcement Bars	ton	1,070.00	1.1	1,202	
d. Others	-			267	(a+b+c) x 0.10 (including other works)
(4) Headrace				**9,343**	
a. Excavation	m^3	5.53	1408.0	7,786	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,557	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**7,043**	
a. Excavation	m^3	5.53	126.6	700	
b. Concrete	m^3	93.05	29.3	2,730	
c. Reinforcement Bars	ton	1,070.00	1.5	1,601	
d. Others	-			2,012	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**55,621**	
a. Excavation	m^3	5.53	1914.0	10,584	
b. Concrete	m^3	93.05	428.1	39,830	
c. Reinforcement Bars	ton	1,070.00	0.1	151	
d. Others	-			5,056	(a+b+c) x 0.10 (including filling works)
(7) Power House				**8,838**	
a. Excavation	m^3	5.53	134.4	743	
b. Concrete	m^3	93.05	39.8	3,702	
c. Reinforcement Bars	ton	1,070.00	2.2	2,354	
d. Others	-			2,039	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,236**	
a. Excavation	m^3	5.53	56.9	314	
b. Concrete	m^3	93.05	2.5	236	
c. Reinforcement Bars	ton	1,070.00	0.5	525	
d. Others	-			161	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**90,283**	

IV. Detailed Statement of Hydraulic Equipment Cost for Quebrada Tahunia Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,881**	
a. Gate	ton	8,811.04	0.15	1,295	
b. Screen	ton	8,811.04	0.07	586	
(3) Penstock Steel (φ200)	ton	3,100.00	0.86	**2,663**	
(4) PVC (φ400) for headrace	m	26.33	2,200	**57,926**	
(5) Penstock PVC (φ200) C-10	m	34.74	545	**18,933**	
(6) Subtotal				**81,403**	
(7) Others				**16,197**	19.90%
(8) Total				**97,600**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**11.56**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**21.96**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.51**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.15**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.07**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.070**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**29.93**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**14.02**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.12**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.18**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.11**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**1,408.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**2,200.00**	(m)	
B:	Width of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**126.60**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**29.35**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.50**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	70.50	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	7.88	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.14	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**55.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.86	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.75	(mm)

Where,

W_{p1}:	Weight of Penstock	0.86	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.75	(mm)	
D_m:	Avg. Diameter of Penstock =	0.20	(m)	
H:	Design Head =	**104.10**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	55.00	(m)	

Penstock (PVC)φ200:

Excavation:	V_e =	$B \times H \times L$	=	412.51	(m^3)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**545.00**	(m)	
B:	Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.40	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	1,431.03	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	420.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
L:	Length of Channel =	**600.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**1,914.04**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**428.06**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.14**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.86**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**134.44**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**39.79**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.20**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
He:	Effective Head =	104.10	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	56.89	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.54	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.49	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.070	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/m³)	* (8.70+2.35) x 0.5 = $5.53/m³, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m³)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ400)		**26.33**	(US$/m)	RIB LOC for Headrace
PVC (φ200)	:	**34.74**	(US$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.8 = 34.74

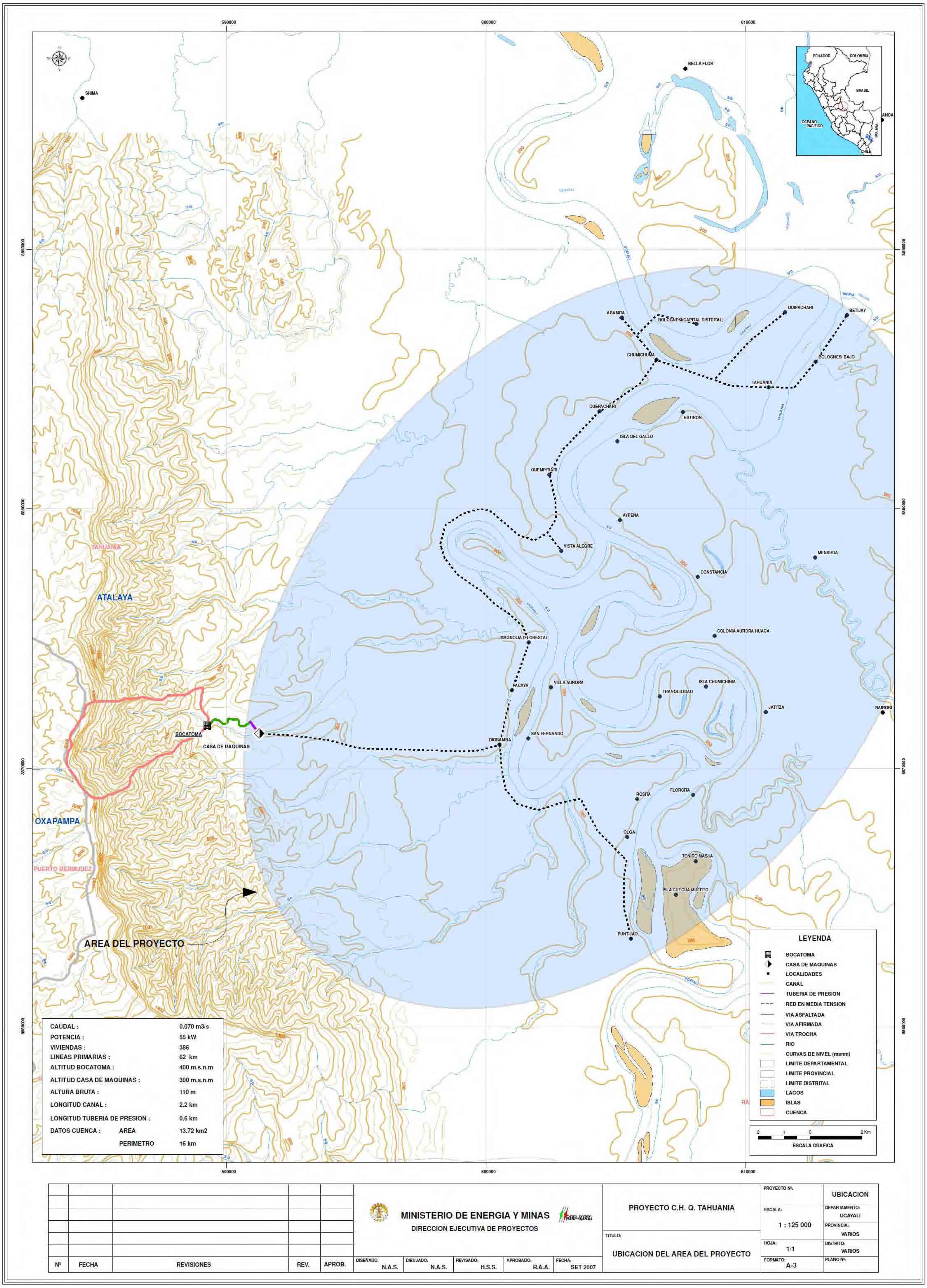
(3) Others

Access Road	:	**5,877.89**	(US$/m)	Constrruction of Unpaved Road (3.0m Width)

(4) Transportation Cost

Pucallpa to the site	:	**98.67**	(US$/ton)	261 km (river)

Quebrada Tahunia Map



Appendix I-28 Construction Cost for Rio Iparia Power Station

I. Summary of Construction Cost for Rio Iparia Power Station

Unit: US$

Work Item	***Construction Cost***	***Remarks***
1. Preliminary Works	**372,766**	
(1) Access Road	47,023	
(2) Facilities for Construction Office	50,127	Cost of Civil Works x 0.05
(3) Transportation cost	275,616	2,793.32ton x $98.67/ton
2. Cost for Environmental Mesures	**10,025**	Cost of Civil Works x 0.01
3. Civil Works	**1,002,551**	
(1) Weir	4,454	
(2) Intake	17,026	
(3) Settling Basin	24,762	
(4) Headrace	256,863	
(5) Head Tank	38,977	
(6) Penstock & Spillway Channel	612,610	
(7) Power House	40,363	
(8) Outlet	7,496	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**203,300**	
(1) Gate & Screen	12,837	
(2) Penstock	0	
(3) PVC for Headrace	0	
(4) PVC (φ630)	156,639	
(5) Others	33,824	
5. Electrical Equipment	**168,000**	
6. Direct Cost	**1,756,642**	1.+2.+3.+4.+5.
7. Engineering Cost	**175,664**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**167,694**	6. x 0.095
9. IGV	**399,000**	19.00%
10. Total Cost	**2,499,000**	

II. Detailed Statement of Transportation Cost for Rio Iparia Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**35.73**	
a. Cements		7.50	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		27.79	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.43	
(2) Intake	ton	**149.03**	
a. Gate		0.95	
b. Screen		0.51	
c. Cements		30.66	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		113.57	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		3.35	
(3) Settling Basin	ton	**175.57**	
a. Cements		35.73	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		132.33	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		7.52	
(4) Headrace	ton	**525.09**	
a. Cements		74.84	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		277.20	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		173.05	
(5) Head Tank	ton	**215.82**	
a. Cements		44.11	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		163.38	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		8.33	
(6) Penstock & Spillway Channel	ton	**1416.44**	
a. Penstock Steel		0.00	
b. Penstock PVC (φ630)		12.08	
c. Cements		207.17	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		767.30	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		429.89	
(7) Power House	ton	**238.26**	
a. Cements		48.38	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		179.20	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		10.68	
(8) Outlet	ton	**37.35**	
a. Cements		7.49	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		27.75	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.11	
(9) Subtotal		**2,793.32**	
(10) Transportation Cost		**275,617**	(9) x $98.67/ton

III. Detailed Statement of Civil Works Cost for Rio Iparia Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Wier				**4,454**	
a. Excavation	m^3	5.53	120.0	663	
b. Concrete	m^3	93.05	27.8	2,586	
c. Reinforcement Bars	ton	1,070.00	0.4	463	
d. Others	-			742	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**17,026**	
a. Excavation	m^3	5.53	118.6	656	
b. Concrete	m^3	93.05	113.6	10,567	
c. Reinforcement Bars	ton	1,070.00	3.3	3,583	
d. Others	-			2,220	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**24,762**	
a. Excavation	m^3	5.53	389.4	2,153	
b. Concrete	m^3	93.05	132.3	12,312	
c. Reinforcement Bars	ton	1,070.00	7.5	8,046	
d. Others	-			2,251	(a+b+c) x 0.10 (including other works)
(4) Headrace				**256,863**	
a. Excavation	m^3	5.53	560.0	3,096	
b. Concrete	m^3	93.05	277.2	25,793	
c. Reinforcement Bars	ton	1,070.00	173.1	185,164	
d. Others	-			42,810	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**38,977**	
a. Excavation	m^3	5.53	673.4	3,724	
b. Concrete	m^3	93.05	163.4	15,202	
c. Reinforcement Bars	ton	1,070.00	8.3	8,915	
d. Others	-			11,136	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**612,610**	
a. Excavation	m^3	5.53	4,618.1	25,537	
b. Concrete	m^3	93.05	767.3	71,397	
c. Reinforcement Bars	ton	1,070.00	429.9	459,985	
d. Others	-			55,691	(a+b+c) x 0.10 (including filling works)
(7) Power House				**40,363**	
a. Excavation	m^3	5.53	532.3	2,943	
b. Concrete	m^3	93.05	179.2	16,674	
c. Reinforcement Bars	ton	1,070.00	10.7	11,432	
d. Others	-			9,314	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**7,496**	
a. Excavation	m^3	5.53	303.7	1,679	
b. Concrete	m^3	93.05	27.8	2,582	
c. Reinforcement Bars	ton	1,070.00	2.1	2,258	
d. Others	-			977	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**1,002,551**	

IV. Detailed Statement of Hydraulic Equipment Cost for Rio Iparia Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**12,837**	
a. Gate	ton	8,811.04	0.95	8,350	
b. Screen	ton	8,811.04	0.51	4,487	
(3) Penstock Steel	ton	3,100.00	0.00	**0**	
(4) PVC for headrace	m	-	0	**0**	
(5) Penstock PVC (φ630) C-10	m	265.49	590	**156,639**	
(6) Subtotal				**169,476**	
(7) Others				**33,824**	19.96%
(8) Total				**203,300**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**119.96**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**27.79**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.43**	(ton)
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton) (unconsidered)

Where,

H_d:	Height of Dam =	**0.50**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**118.63**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**113.57**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**3.35**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.95**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.51**	(ton)

Where,

D:	Diameter of Waterway =	**1.50**	(m)	
R:	Radius of Waterway =	0.75	(m)	D/2 Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.770**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**389.36**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**132.33**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**7.52**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.78**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.72**	(ton)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)

(4) Headrace

In the case of Opoen Channel (1,000 x 1,000):

Excavation:	V_e =	$B \times H \times L$	=	**560.00**	(m^3)
Concrete:	V_c =	$((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**277.20**	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	**173.05**	(ton)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)	
L:	Length of Channel =	**560.00**	(m)	
B:	Width of Channel =	**1.00**	(m)	for excavation
H:	Height of Channel =	**1.00**	(m)	for excavation
t:	Thickness of Concrete =	**0.15**	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**673.43**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**163.38**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**8.33**	(ton)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel):

Excavation:	V_{e1} =	10.9 x $D_m^{1.33}$ x L	=	0.00	(m^3)
Concrete:	V_{c1} =	2.14 x $D_m^{1.68}$ x L	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	0.018 x V_c	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	W_{p1} =	7.85x π x D_m x t_m x10^{-3}x1.15 x L	=	0.00	(ton)
Thickness of Penstock:	t_m =	0.0362 x H x D_m + 2	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**48.80**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ630:

Excavation:	V_e =	B x H x L	=	997.10	(m^3)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)	
L:	Length of Channel =	**590.00**	(m)	
B:	Width of Channel =	**1.30**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**1.30**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	1.09 x $Q^{0.379}$	=	0.99	
Excavation:	V_e =	6.22 x ($(B x H)^{0.5})^{1.04}$ x L	=	3,620.97	(m^3)
Concrete:	V_c =	H x t x 2 + (B + 2t) x L	=	767.30	(m^3)
Reinforcement Bars	W_r =	0.577 x $(V_c/L)^{0.888}$ x L	=	429.89	(ton)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)
L:	Length of Channel =	**590.00**	(m)
B:	Width of Channel =	**1.00**	(m)
H:	Height of Channel =	**1.00**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	V_{e1} + V_{e2}	=	**4,618.07**	(m^3)
Concrete:	V_c =	V_{c1} + V_{c2}	=	**767.30**	(m^3)
Reinforcement Bars	W_r =	W_{r1} + W_{r2}	=	**429.89**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	V_e =	97.8 x $(Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**532.28**	(m^3)
Concrete:	V_c =	28.1 x $(Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**179.20**	(m^3)
Reinforcement Bars	W_r =	0.046 x $V_c^{1.05}$	=	**10.68**	(ton)

Where,

Q:	Maximum Discharge =	0.770	(m^3/s)
He:	Effective Head =	48.80	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	395 x $(R \times Q)^{0.479}$	=	303.66	(m^3)
Concrete:	V_c =	40.4 x $(R \times Q)^{0.684}$	=	27.75	(m^3)
Reinforcement Bars	W_r =	0.278 x $V_c^{0.610}$	=	2.11	(ton)

Where,

D:	Diameter of Waterway =	1.50	(m)	
R:	Radius of Waterway =	0.75	(m)	D/2
Q:	Maximum Discharge =	0.770	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

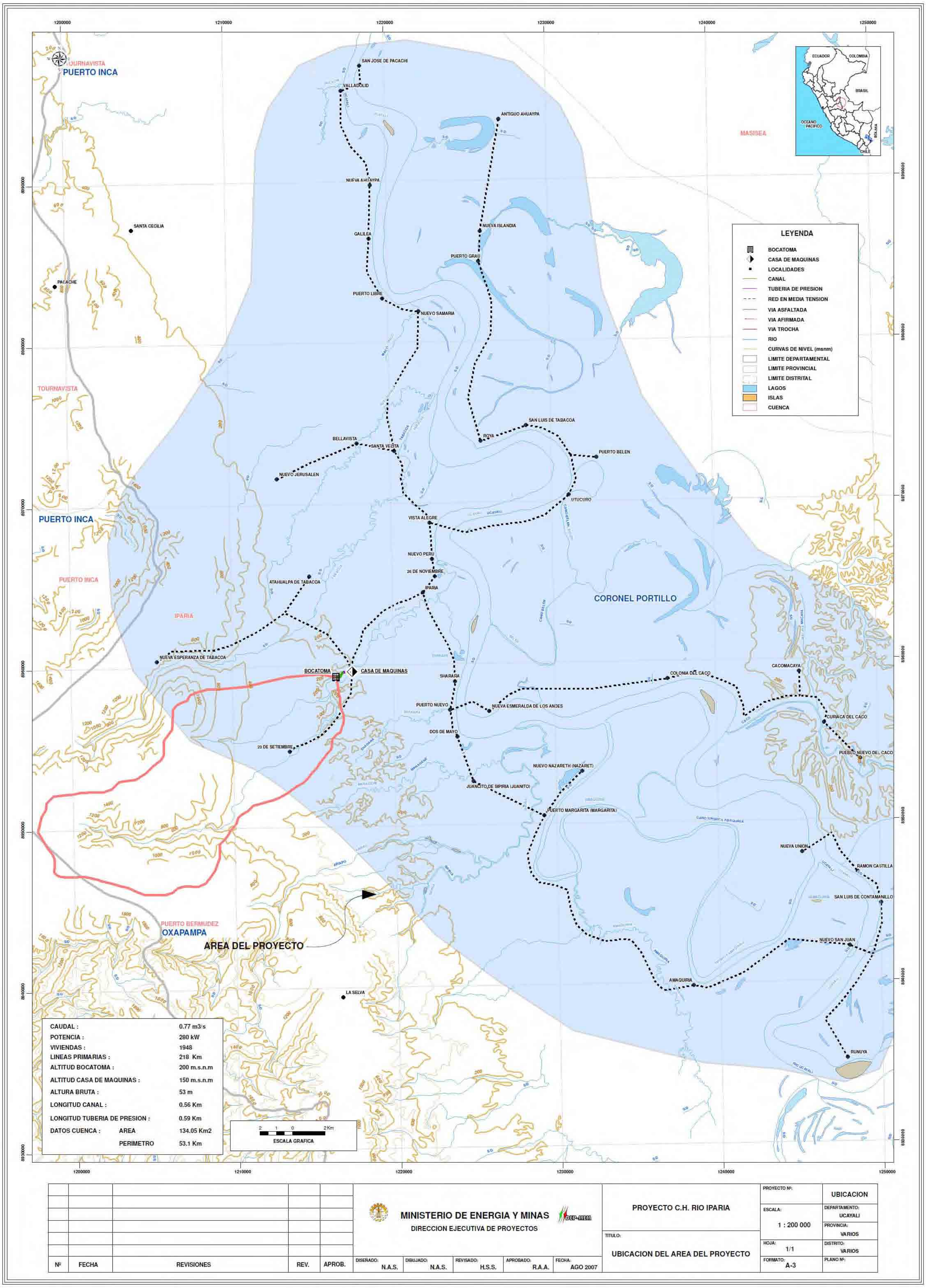
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC for Headrace		**-**	(US$/m)	
PVC (φ630)	:	**265.49**	(US$/m)	611% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 6.11 = 265.49

(3) Others				
Access Road	:	**5,877.89**	(US$/m)	Constrruction of Unpaved Road (3.0m Width)

(4) Transportation Cost				
Pucallpa to the site	:	**98.67**	(US$/ton)	97 km (river)

Rio Iparia Map



Appendix I-29 Construction Cost for Shinipo Power Station

I. Summary of Construction Cost for Shinipo Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**129,591**	
(1) Access Road	77,588	
(2) Facilities for Construction Office	3,863	Cost of Civil Works x 0.05
(3) Transportation cost	48,140	487.90ton x $98.67/ton
2. Cost for Environmental Mesures	**772**	Cost of Civil Works x 0.01
3. Civil Works	**77,268**	
(1) Weir	2,221	
(2) Intake	7,504	
(3) Settling Basin	8,089	
(4) Headrace	9,555	
(5) Head Tank	15,944	
(6) Penstock & Spillway Channel	15,951	
(7) Power House	14,879	
(8) Outlet	3,125	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**86,100**	
(1) Gate & Screen	5,159	
(2) Penstock	0	
(3) PVC (φ600)	59,670	
(4) PVC (φ315)	6,947	
(5) Others	14,324	
5. Electrical Equipment	**45,800**	
6. Direct Cost	**339,531**	1.+2.+3.+4.+5.
7. Engineering Cost	**33,953**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**33,516**	6. x 0.099
9. IGV	**77,330**	19.00%
10. Total Cost	**484,330**	

II. Detailed Statement of Transportation Cost for Shinipo Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.23	
(2) Intake	ton	**68.11**	
a. Gate		0.39	
b. Screen		0.19	
c. Cements		14.06	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		52.09	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.37	
(3) Settling Basin	ton	**54.81**	
a. Cements		11.06	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		40.96	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.79	
(4) Headrace	ton	**13.30**	
a. PVC (φ600)		13.30	Weight: 1,000m x 79.8kg/6m
(5) Head Tank	ton	**88.01**	
a. Cements		17.99	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		66.63	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.40	
(6) Penstock & Spillway Channel	ton	**145.74**	
a. Penstock Steel (φ300)		0.00	
b. Penstock PVC (φ315)		3.28	Weight: 160m x 122.833kg/6m
c. Cements		30.29	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		112.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**88.48**	
a. Cements		18.01	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		66.69	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.78	
(8) Outlet	ton	**12.39**	
a. Cements		2.41	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		8.93	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.06	
(9) Subtotal		**487.90**	
(10) Transportation Cost		**48,141**	(9) x $98.67/ton

III. Detailed Statement of Civil Works Cost for Shinipo Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**7,504**	
a. Excavation	m^3	5.53	39.3	217	
b. Concrete	m^3	93.05	52.1	4,847	
c. Reinforcement Bars	ton	1,070.00	1.4	1,462	
d. Others	-			978	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**8,089**	
a. Excavation	m^3	5.53	101.9	563	
b. Concrete	m^3	93.05	41.0	3,811	
c. Reinforcement Bars	ton	1,070.00	2.8	2,980	
d. Others	-			735	(a+b+c) x 0.10 (including other works)
(4) Headrace				**9,555**	
a. Excavation	m^3	5.53	1440.0	7,963	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,592	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**15,944**	
a. Excavation	m^3	5.53	281.2	1,555	
b. Concrete	m^3	93.05	66.6	6,199	
c. Reinforcement Bars	ton	1,070.00	3.4	3,635	
d. Others	-			4,555	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**15,951**	
a. Excavation	m^3	5.53	734.7	4,063	
b. Concrete	m^3	93.05	112.2	10,438	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,450	(a+b+c) x 0.10 (including filling works)
(7) Power House				**14,879**	
a. Excavation	m^3	5.53	215.6	1,192	
b. Concrete	m^3	93.05	66.7	6,205	
c. Reinforcement Bars	ton	1,070.00	3.8	4,049	
d. Others	-			3,433	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**3,125**	
a. Excavation	m^3	5.53	137.2	758	
b. Concrete	m^3	93.05	8.9	830	
c. Reinforcement Bars	ton	1,070.00	1.1	1,130	
d. Others	-			407	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**77,268**	

IV. Detailed Statement of Hydraulic Equipment Cost for Shinipo Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**5,159**	
a. Gate	ton	8,811.04	0.39	3,450	
b. Screen	ton	8,811.04	0.19	1,709	
(3) Penstock Steel (φ315)	ton	3,100.00	0.00	**0**	
(4) PVC (φ600) for headrace	m	59.67	1,000	**59,670**	
(5) Penstock PVC (φ315) C-10	m	43.42	160	**6,947**	
(6) Subtotal				**71,776**	
(7) Others				**14,324**	19.96%
(8) Total				**86,100**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d{}^2 \times L)^{0.726}$	=	**13.24**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c{}^{0.830}$	=	**0.23**	(ton)
Weight of Gate:	W_g =	$0.145 \times Q_f{}^{0.692}$	=	**0.00**	(ton) (unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**39.32**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**52.09**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c{}^{1.15}$	=	**1.37**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.39**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.19**	(ton)

Where,

D:	Diameter of Waterway =	**1.00**	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2 Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.220**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**101.91**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**40.96**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c{}^{0.847}$	=	**2.79**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.36**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.27**	(ton)

Where,

Q: Maximum Discharge = 0.220 (m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**1,440.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.220	(m^3/s)	
L:	Length of Channel =	**1,000.00**	(m)	
B:	Width of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**281.24**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**66.63**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**3.40**	(ton)

Where,

Q: Maximum Discharge = 0.220 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ315:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**49.50**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ315:

Excavation:	V_e =	$B \times H \times L$	=	135.42	(m^3)

Where,

Q:	Maximum Discharge =	0.220	(m^3/s)	
L:	Length of Channel =	**160.00**	(m)	
B:	Width of Channel =	**0.92**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.92**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.61	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	599.30	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	112.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.220	(m^3/s)
L:	Length of Channel =	**160.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**734.72**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**112.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**215.58**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**66.69**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**3.78**	(ton)

Where,

Q:	Maximum Discharge =	0.220	(m^3/s)
He:	Effective Head =	49.50	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	137.22	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	8.93	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	1.06	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.220	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US\$/m^3)	* (8.70+2.35) x 0.5 = \$5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US\$/m^3)	
Concrete				
Open	:	**93.05**	(US\$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US\$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US\$/ton)	*\$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US\$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US\$/ton)	including installation
PVC (φ600)		**59.67**	(US\$/m)	RIB LOC for Headrace
PVC (φ315)	:	**43.42**	(US\$/m)	TUBOPLAST for Penstock (C-10), The number of joints is 215. This price include joint price. 190m/6m =30 (joint), 30 x \$2.7 =81\$, 81\$/190m =0.43\$/m, 42.99\$/m (PVC) + 0.43\$/m (joint) = 43.42\$/m

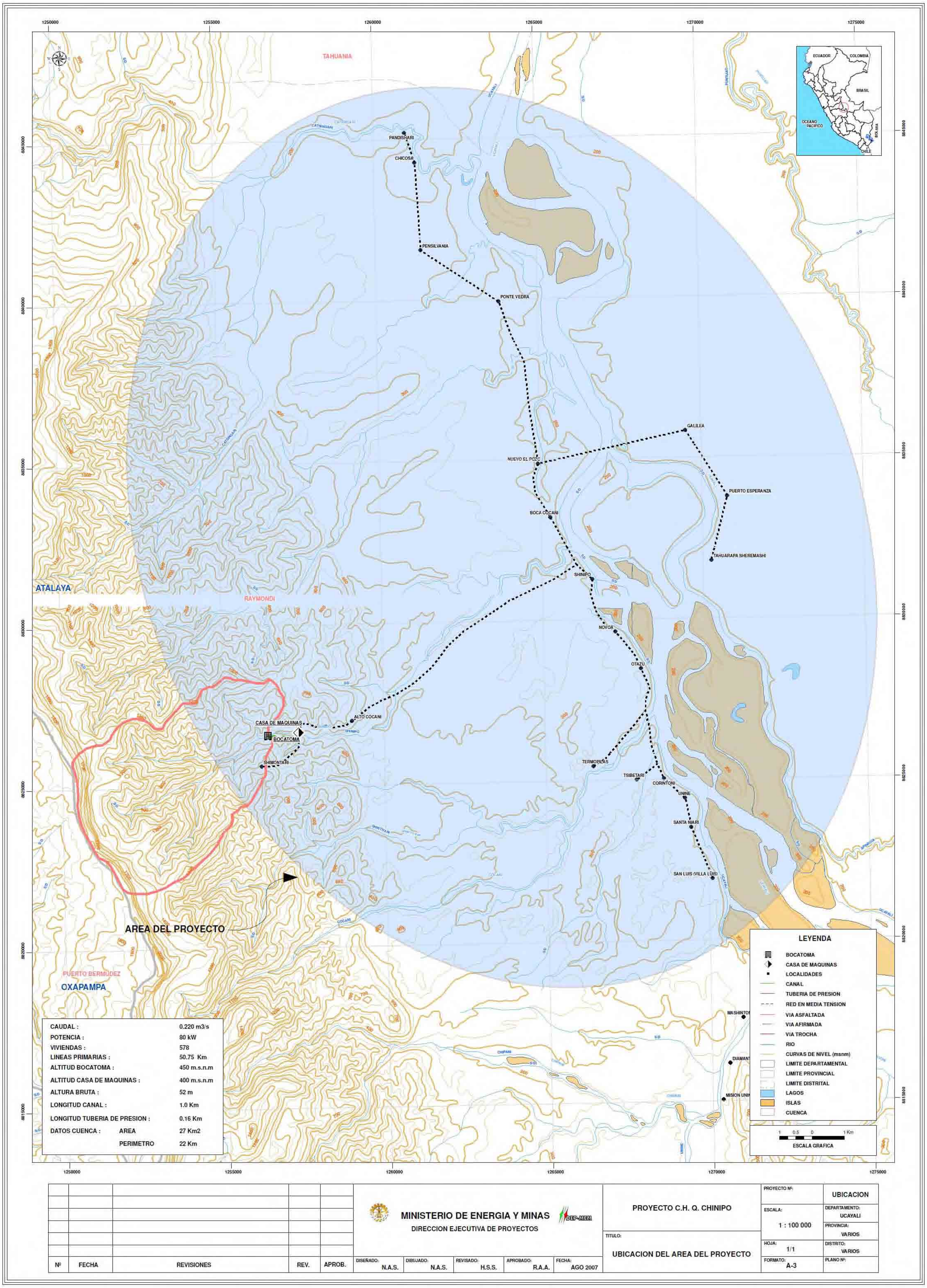
(3) Others

Access Road	:	**5,877.89**	(US\$/m)	Constrruction of Unpaved Road (3.0m Width)

(4) Transportation Cost

Pucallpa to the site	:	**98.67**	(US\$/ton)	272 km (river)

Shinipo Map



TAHUANIA
PANDISHARI
CHICOSA
PENSILVANIA
PONTE VEDRA
GALILEA
NUEVO EL POZO
PUERTO ESPERANZA
BOCA COCANI
TAHUARAPA SHEREMASHI
SHINIPO
NOVOA
OTAZU
ALTO COCANI
CASA DE MAQUINAS
BOCATOMA
SHIMONTARI
TERMOPILAS
TSIBETARI
CORINTONI
UNINI
SANTA MARI
SAN LUIS (VILLA LUIS)
ATALAYA
RAYMONDI
AREA DEL PROYECTO
PUERTO BERMUDEZ
OXAPAMPA
MASHINTONI
DIAMANTE
MISION UNINI
ECUADOR
COLOMBIA
BRASIL
OCEANO PACIFICO
BOLIVIA
CHILE
CAUDAL : 0.220 m3/s
POTENCIA : 80 kW
VIVIENDAS : 578
LINEAS PRIMARIAS : 50.75 Km
ALTITUD BOCATOMA : 450 m.s.n.m
ALTITUD CASA DE MAQUINAS : 400 m.s.n.m
ALTURA BRUTA : 52 m
LONGITUD CANAL : 1.0 Km
LONGITUD TUBERIA DE PRESION : 0.16 Km
DATOS CUENCA : AREA 27 Km2
PERIMETRO 22 Km
LEYENDA
BOCATOMA
CASA DE MAQUINAS
LOCALIDADES
CANAL
TUBERIA DE PRESION
RED EN MEDIA TENSION
VIA ASFALTADA
VIA AFIRMADA
VIA TROCHA
RIO
CURVAS DE NIVEL (msnm)
LIMITE DEPARTAMENTAL
LIMITE PROVINCIAL
LIMITE DISTRITAL
LAGOS
ISLAS
CUENCA
ESCALA GRAFICA
Nº FECHA REVISIONES REV. APROB.
MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS
DEP-MEM
DISEÑADO: N.A.S.
DIBUJADO: N.A.S.
REVISADO: H.S.S.
APROBADO: R.A.A.
FECHA: AGO 2007
PROYECTO C.H. Q. CHINIPO
TITULO:
UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:
ESCALA: 1 : 100 000
HOJA: 1/1
FORMATO: A-3
UBICACION
DEPARTAMENTO: UCAYALI
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº: