Apéndice I-18 Costos de Construcción de la Central Hidroeléctrica Quiula

I. Summary of Construction Cost for Quiula Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**16,482**	
(1) Access Road	7,053	
(2) Facilities for Construction Office	3,677	Cost of Civil Works x 0.05
(3) Transportation cost	5,752	492.55ton x $11.68/ton
2. Cost for Environmental Mesures	**735**	Cost of Civil Works x 0.01
3. Civil Works	**73,555**	
(1) Weir	2,221	
(2) Intake	7,177	
(3) Settling Basin	7,465	
(4) Headrace	4,299	
(5) Head Tank	14,950	
(6) Penstock & Spillway Channel	16,810	
(7) Power House	17,650	
(8) Outlet	2,983	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**46,900**	
(1) Gate & Screen	4,909	
(2) Penstock	0	
(3) PVC (φ600)	26,851	
(4) PVC (φ315)	7,381	
(5) Others	7,759	
5. Electrical Equipment	**53,900**	
6. Direct Cost	**191,572**	1.+2.+3.+4.+5.
7. Engineering Cost	**19,157**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**18,271**	6. x 0.095
9. IGV	**43,510**	19.00%
10. Total Cost	**272,510**	

II. Detailed Statement of Transportation Cost for Quiula 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	**65.27**	
a. Gate		0.37	
b. Screen		0.18	
c. Cements		13.48	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		49.93	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.30	
(3) Settling Basin	ton	**50.40**	
a. Cements		10.16	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		37.64	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.59	
(4) Headrace	ton	**5.99**	
a. PVC (φ600)		5.99	Weight: 450m x 79.8kg/6m
(5) Head Tank	ton	**82.50**	
a. Cements		16.86	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		62.45	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.19	
(6) Penstock & Spillway Channel	ton	**154.84**	
a. Penstock Steel (φ300)		0.00	
b. Penstock PVC (φ315)		3.48	Weight: 170m x 122.833kg/6m
c. Cements		32.18	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		119.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**104.83**	
a. Cements		21.33	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		78.99	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		4.52	
(8) Outlet	ton	**11.68**	
a. Cements		2.27	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		8.39	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.02	
(9) Subtotal		**492.55**	
(10) Transportation Cost		**5,753**	(9) x $11.68/ton

III. Detailed Statement of Civil Works Cost for Quiula 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				**7,177**	
a. Excavation	m^3	5.53	37.0	204	
b. Concrete	m^3	93.05	49.9	4,645	
c. Reinforcement Bars	ton	1,070.00	1.3	1,392	
d. Others	-			936	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**7,465**	
a. Excavation	m^3	5.53	92.5	511	
b. Concrete	m^3	93.05	37.6	3,502	
c. Reinforcement Bars	ton	1,070.00	2.6	2,774	
d. Others	-			678	(a+b+c) x 0.10 (including other works)
(4) Headrace				**4,299**	
a. Excavation	m^3	5.53	648.0	3,583	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			716	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**14,950**	
a. Excavation	m^3	5.53	264.1	1,460	
b. Concrete	m^3	93.05	62.5	5,811	
c. Reinforcement Bars	ton	1,070.00	3.2	3,408	
d. Others	-			4,271	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**16,810**	
a. Excavation	m^3	5.53	758.4	4,193	
b. Concrete	m^3	93.05	119.2	11,089	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,528	(a+b+c) x 0.10 (including filling works)
(7) Power House				**17,650**	
a. Excavation	m^3	5.53	251.7	1,391	
b. Concrete	m^3	93.05	79.0	7,349	
c. Reinforcement Bars	ton	1,070.00	4.5	4,837	
d. Others	-			4,073	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,983**	
a. Excavation	m^3	5.53	131.4	726	
b. Concrete	m^3	93.05	8.4	780	
c. Reinforcement Bars	ton	1,070.00	1.0	1,088	
d. Others	-			389	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**73,555**	

IV. Detailed Statement of Hydraulic Equipment Cost for Quiula 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				**4,909**	
a. Gate	ton	8,811.04	0.37	3,288	
b. Screen	ton	8,811.04	0.18	1,621	
(3) Penstock Steel (φ315)	ton	3,100.00	0.00	**0**	
(4) PVC (φ600) for headrace	m	59.67	450	**26,851**	
(5) Penstock PVC (φ315) C-10	m	43.42	170	**7,381**	
(6) Subtotal				**39,141**	
(7) Others				**7,759**	19.82%
(8) Total				**46,900**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**37.02**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**49.93**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**1.30**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.37**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.18**	(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 =	**0.201**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**92.52**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**37.64**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**2.59**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.34**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.25**	(ton)

Where,

Q:	Maximum Discharge =	0.201	(m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**648.00**	(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 =	0.201	(m^3/s)	
L:	Length of Channel =	**450.00**	(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 =	$808 \times Q^{0.697}$	=	**264.08**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**62.45**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**3.19**	(ton)

Where,

Q:	Maximum Discharge =	0.201	(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 =	**78.00**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ315:

Excavation:	V_e =	$B \times H \times L$	=	143.89	(m^3)

Where,

Q:	Maximum Discharge =	0.201	(m^3/s)	
L:	Length of Channel =	**170.00**	(m)	
B:	Width of Channel =	**0.92**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.92**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)$^0.5 =	$1.09 \times Q^{0.379}$	=	0.59	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	614.48	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	119.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.201	(m^3/s)
L:	Length of Channel =	**170.00**	(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 =	$V_{e1} + V_{e2}$	=	**758.37**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**119.18**	(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 =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**251.65**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**78.99**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**4.52**	(ton)

Where,

Q:	Maximum Discharge =	0.201	(m^3/s)
He:	Effective Head =	78.00	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	131.41	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	8.39	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	1.02	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.201	(m^3/s)	

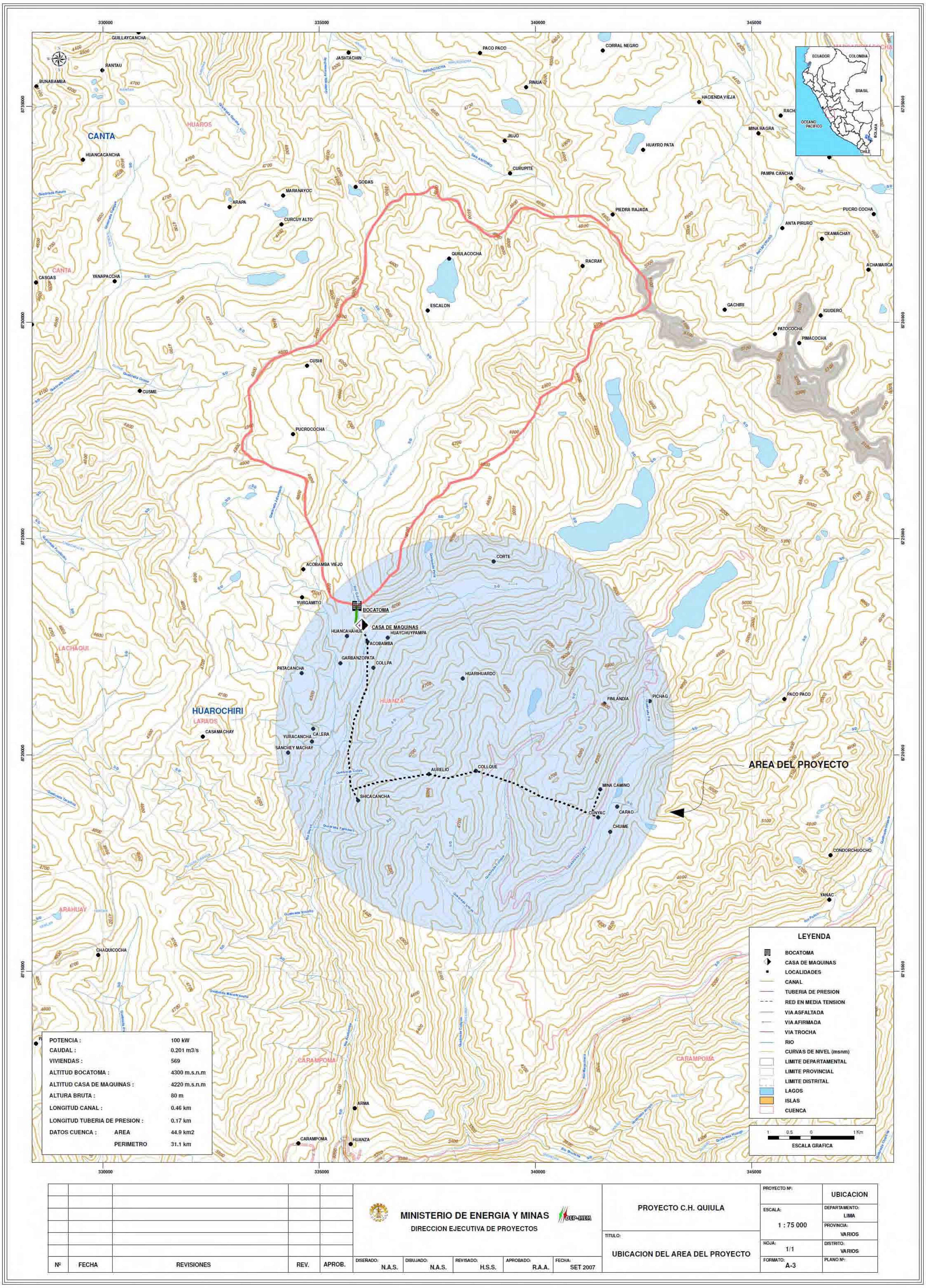
: Input Cell
: Calculation Cell
: Reference Cell

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$/ton)	including installation
PVC (φ600)		**59.67**	(US$/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				
Lima to the site	:	**11.68**	(US$/ton)	94 km (road)

Quiula Map



CANTA
HUAROS
HUAROCHIRI
LARAOS
LACHAQUI
HUANZA
ARAHUAY
CARAMPOMA
QUIULACOCHA
PUCROCOCHA
BOCATOMA
CASA DE MAQUINAS
AREA DEL PROYECTO
ACOBAMBA VIEJO
YURGAMITO
HUANCAHAHUE
HUAYCHUYPAMPA
ACOBAMBA
GARBANZOPATA
COLLPA
PATACANCHA
HUARIHUARDO
FINLANDIA
PICHAG
YURACANCHA
CALERA
SANCHEY MACHAY
CASAMACHAY
AURELIO
COLLQUE
SHICACANCHA
MINA CAMINO
CUNYAC
CARAO
CHUIME
CORTE
PACO PACO
CONDORCHUCCHO
YANAC
CHAQUICOCHA
ARMA
CARAMPOMA
HUANZA
POTENCIA : 100 kW
CAUDAL : 0.201 m3/s
VIVIENDAS : 569
ALTITUD BOCATOMA : 4300 m.s.n.m
ALTITUD CASA DE MAQUINAS : 4220 m.s.n.m
ALTURA BRUTA : 80 m
LONGITUD CANAL : 0.46 km
LONGITUD TUBERIA DE PRESION : 0.17 km
DATOS CUENCA : AREA 44.9 km2
PERIMETRO 31.1 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
1 0.5 0 1 Km
ESCALA GRAFICA
330000
335000
340000
345000
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: SET 2007
PROYECTO C.H. QUIULA
TITULO:
UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:
ESCALA: 1 : 75 000
HOJA: 1/1
FORMATO: A-3
UBICACION
DEPARTAMENTO: LIMA
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Apéndice I-19 Costos de Construcción de la Central Hidroeléctrica Aichiyacu

I. Summary of Construction Cost for Aichiyacu Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**58,604**	
(1) Access Road	0	
(2) Facilities for Construction Office	3,058	Cost of Civil Works x 0.05
(3) Transportation cost	55,546	463.70ton x $119.79/ton
2. Cost for Environmental Mesures	**611**	Cost of Civil Works x 0.01
3. Civil Works	**61,171**	
(1) Weir	2,221	
(2) Intake	3,347	
(3) Settling Basin	3,487	
(4) Headrace	5,574	
(5) Head Tank	8,089	
(6) Penstock & Spillway Channel	30,349	
(7) Power House	6,744	
(8) Outlet	1,360	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**58,200**	
(1) Gate & Screen	2,092	
(2) Penstock	0	
(3) PVC (φ500)	35,002	
(4) PVC (φ200)	11,464	
(5) Others	9,642	
5. Electrical Equipment	**24,800**	
6. Direct Cost	**203,386**	1.+2.+3.+4.+5.
7. Engineering Cost	**20,339**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**20,275**	6. x 0.100
9. IGV	**46,360**	19.00%
10. Total Cost	**290,360**	

II. Detailed Statement of Transportation Cost for Aichiyacu 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	**31.35**	
a. Gate		0.16	
b. Screen		0.07	
c. Cements		6.49	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		24.05	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.56	
(3) Settling Basin	ton	**22.67**	
a. Cements		4.54	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		16.82	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.31	
(4) Headrace	ton	**7.21**	
a. PVC (φ500)		7.21	Weight: 840m x 51.522kg/6m
(5) Head Tank	ton	**44.55**	
a. Cements		9.11	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		33.72	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.72	
(6) Penstock & Spillway Channel	ton	**296.35**	
a. Penstock Steel (φ200)		0.00	
b. Penstock PVC (φ200)		2.75	Weight: 330m x 50.000kg/6m
c. Cements		62.42	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		231.18	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.00	
(7) Power House	ton	**40.31**	
a. Cements		8.22	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		30.43	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.66	
(8) Outlet	ton	**4.21**	
a. Cements		0.78	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.90	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.53	
(9) Subtotal		**463.70**	
(10) Transportation Cost		**55,546**	(9) x $119.79/ton

III. Detailed Statement of Civil Works Cost for Aichiyacu 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				**3,347**	
a. Excavation	m^3	5.53	13.2	72	
b. Concrete	m^3	93.05	24.1	2,238	
c. Reinforcement Bars	ton	1,070.00	0.6	601	
d. Others	-			436	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**3,487**	
a. Excavation	m^3	5.53	36.8	203	
b. Concrete	m^3	93.05	16.8	1,565	
c. Reinforcement Bars	ton	1,070.00	1.3	1,402	
d. Others	-			317	(a+b+c) x 0.10 (including other works)
(4) Headrace				**5,574**	
a. Excavation	m^3	5.53	840.0	4,645	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			929	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**8,089**	
a. Excavation	m^3	5.53	144.9	801	
b. Concrete	m^3	93.05	33.7	3,137	
c. Reinforcement Bars	ton	1,070.00	1.7	1,840	
d. Others	-			2,311	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**30,349**	
a. Excavation	m^3	5.53	1099.4	6,079	
b. Concrete	m^3	93.05	231.2	21,511	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			2,759	(a+b+c) x 0.10 (including filling works)
(7) Power House				**6,744**	
a. Excavation	m^3	5.53	105.2	581	
b. Concrete	m^3	93.05	30.4	2,831	
c. Reinforcement Bars	ton	1,070.00	1.7	1,776	
d. Others	-			1,556	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,360**	
a. Excavation	m^3	5.53	62.4	345	
b. Concrete	m^3	93.05	2.9	269	
c. Reinforcement Bars	ton	1,070.00	0.5	569	
d. Others	-			177	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**61,171**	

IV. Detailed Statement of Hydraulic Equipment Cost for Aichiyacu 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				**2,092**	
a. Gate	ton	8,811.04	0.16	1,436	
b. Screen	ton	8,811.04	0.07	656	
(3) Penstock Steel (φ200)	ton	3,100.00	0.00	**0**	
(4) PVC (φ500) for headrace	m	41.67	840	**35,002**	
(5) Penstock PVC (φ200) C-10	m	34.74	330	**11,464**	
(6) Subtotal				**48,558**	
(7) Others				**9,642**	19.86%
(8) Total				**58,200**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**13.15**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**24.05**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.56**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.16**	(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
Q:	Maximum Discharge =	**0.085**	(m^3/s)	

Assumption; Waterway Gradient = 1/1,000

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**36.84**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**16.82**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.31**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.20**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.13**	(ton)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)

(4) Headrace

In the case of PVCφ500:

Excavation:	$V_e = B \times H \times L$	=	**840.00**	(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 =	0.085	(m^3/s)	
L:	Length of Channel =	**840.00**	(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 =	$808 \times Q^{0.697}$	=	**144.95**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**33.72**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.72**	(ton)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

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 =	**46.90**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ200:

Excavation:	$V_e = B \times H \times L$	=	249.78	(m^3)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)	
L:	Length of Channel =	**330.00**	(m)	
B:	Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{0.5} = 1.09 \times Q^{0.379}$	=	0.43	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	849.66	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	231.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)
L:	Length of Channel =	**330.00**	(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 =	$V_{e1} + V_{e2}$	=	**1,099.44**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**231.18**	(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:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**105.19**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**30.43**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**1.66**	(ton)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)
He:	Effective Head =	46.90	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	62.43	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.90	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.53	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.085	(m^3/s)	

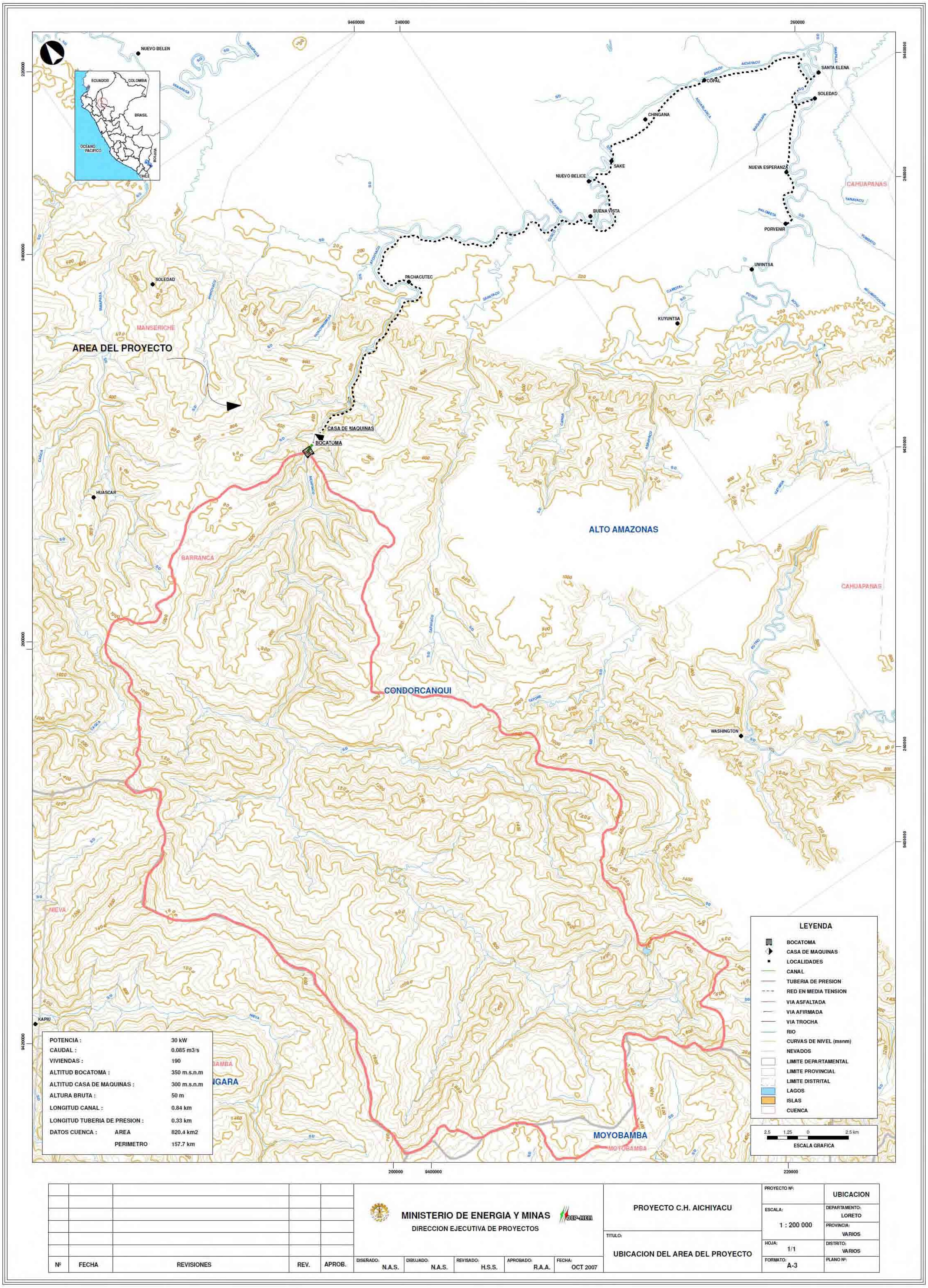
: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

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

(1) Civil Works				
Excavation				
Open	:	**5.53**	$(\text{US\$/m}^3)$	* (8.70+2.35) x 0.5 = $\$5.53/\text{m}^3$, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	$(\text{US\$/m}^3)$	
Concrete				
Open	:	**93.05**	$(\text{US\$/m}^3)$	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	$(\text{US\$/m}^3)$	
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$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.8 = 34.74
(3) Others				
Access Road	:	-	(US$/m)	-
(4) Transportation Cost				
Chachapoyas to the site	:	**119.79**	(US$/ton)	367 km (road) + 117km (river) = 21.12 + 98.67 = 119.79 US$/ton

Aichiyacu Map



Appendix I-4 Apéndice I-20 Costos de Construcción de la Central Hidroeléctrica Balsapuerto (en el caso de PVC para Aducción)

I. Summary of Construction Cost for Balsapuerto Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**123,973**	
(1) Service Road	65,597	
(2) Facilities for Construction Office	4,199	Cost of Civil Works x 0.05
(3) Transportation cost	54,177	Tarapoto to the site, 410ton x $132/ton
2. Cost for Environmental Mesures	**839**	Cost of Civil Works x 0.01
3. Civil Works	**83,995**	
(1) Weir	3,248	
(2) Intake	4,919	
(3) Settling Basin	3,811	
(4) Headrace	28,563	
(5) Head Tank	9,109	
(6) Penstock & Spillway Channel	19,551	
(7) Power House	12,483	
(8) Outlet	2,311	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**150,000**	
(1) Gate & Screen	3,158	
(2) Penstock	1,751	
(3) PVC (φ630)	113,373	
(4) PVC (φ315)	6,816	
(5) Others	24,902	
5. Electrical Equipment	**57,800**	
6. Direct Cost	**416,607**	1.+2.+3.+4.+5.
7. Engineering Cost	**41,661**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**40,732**	6. x 0.098
9. IGV	**94,810**	19.00%
10. Total Cost	**593,810**	

II. Detailed Statement of Transportation Cost for Balsapuerto Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**24.68**	
a. Cements		5.18	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		19.18	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.32	
(2) Intake	ton	**44.67**	
a. Gate		0.24	
b. Screen		0.12	
c. Cements		9.24	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		34.22	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.84	
(3) Settling Basin	ton	**23.91**	
a. Cements		4.79	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		17.74	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.37	
(4) Headrace	ton	**25.27**	
a. PVC (φ600)		25.27	Weight: 1,900m x 79.8kg/6m = 17.3ton
(5) Head Tank	ton	**46.41**	
a. Cements		9.49	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		35.13	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.79	
(6) Penstock & Spillway Channel	ton	**168.65**	
a. Penstock Steel (φ300)		0.57	
b. Penstock PVC (φ315)		3.21	Weight: 157m x 122.833kg/6m = 3.2ton
c. Cements		35.03	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		129.74	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.10	
(7) Power House	ton	**69.97**	
a. Cements		14.25	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		52.76	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.96	
(8) Outlet	ton	**6.88**	
a. Cements		1.31	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		4.84	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.73	
(9) Subtotal		**410.44**	
(10) Transportation Cost		**54,177**	(9) x $132/ton: Tarapoto to Balsa Puerto

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

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**3,248**	
a. Excavation	m^3	8.70	67.0	582	
b. Concrete	m^3	93.05	19.2	1,784	
c. Reinforcement Bars	ton	1,075.00	0.3	341	
d. Others	-			541	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**4,919**	
a. Excavation	m^3	8.70	21.7	188	
b. Concrete	m^3	93.05	34.2	3,184	
c. Reinforcement Bars	ton	1,075.00	0.8	906	
d. Others	-			641	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**3,811**	
a. Excavation	m^3	8.70	39.2	340	
b. Concrete	m^3	93.05	17.7	1,651	
c. Reinforcement Bars	ton	1,075.00	1.4	1,474	
d. Others	-			346	(a+b+c) x 0.10 (including other works)
(4) Headrace				**28,563**	
a. Excavation	m^3	8.70	2736.0	23,803	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,075.00	0.0	0	
d. Others	-			4,760	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**9,109**	
a. Excavation	m^3	8.70	150.8	1,312	
b. Concrete	m^3	93.05	35.1	3,269	
c. Reinforcement Bars	ton	1,075.00	1.8	1,926	
d. Others	-			2,602	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**19,551**	
a. Excavation	m^3	8.70	643.0	5,593	
b. Concrete	m^3	93.05	129.7	12,072	
c. Reinforcement Bars	ton	1,075.00	0.1	109	
d. Others	-			1,777	(a+b+c) x 0.10 (including filling works)
(7) Power House				**12,483**	
a. Excavation	m^3	8.70	174.0	1,513	
b. Concrete	m^3	93.05	52.8	4,909	
c. Reinforcement Bars	ton	1,075.00	3.0	3,181	
d. Others	-			2,880	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,311**	
a. Excavation	m^3	8.70	89.4	778	
b. Concrete	m^3	93.05	4.8	450	
c. Reinforcement Bars	ton	1,075.00	0.7	782	
d. Others	-			301	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**83,995**	

IV. Detailed Statement of Hydraulic Equipment Cost for Balsapuerto 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				**3,158**	
a. Gate	ton	8,811.04	0.24	2,142	
b. Screen	ton	8,811.04	0.12	1,016	
(3) Penstock Steel (φ315）	ton	3,100.00	0.57	**1,751**	
(4) PVC (φ600）for headrace	m	59.67	1,900	**113,373**	
(5) Penstock PVC (φ315) C-10	m	43.42	157	**6,816**	
(6) Subtotal				**125,098**	
(7) Others				**24,902**	19.91%
(8) Total				**150,000**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**19.18**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.32**	(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 =	**12.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**21.68**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**34.22**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.84**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.24**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.12**	(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 =	**0.090**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**39.16**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**17.74**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.37**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.21**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.13**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**2,736.00**	(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 =	0.090	(m^3/s)	
L:	Length of Channel =	**1,900.00**	(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 =	$808 \times Q^{0.697}$	=	**150.84**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**35.13**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.79**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ315:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	43.96	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	5.66	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.10	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.30**	(m)
L:	Length of Penstock =	**20.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.57	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	3.32	(mm)

Where,

W_{p1}:	Weight of Penstock	0.57	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	3.32	(mm)	
D_m:	Avg. Diameter of Penstock =	0.30	(m)	
H:	Design Head =	**121.60**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	20.00	(m)	

Penstock (PVC)φ315

Excavation:	$V_e = B \times H \times L$	=	132.88	(m^3)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)	
L:	Length of Channel =	**157.00**	(m)	
B:	Width of Channel =	**0.92**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.92**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{\wedge}0.5 = 1.09 \times Q^{0.379}$	=	0.44	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	466.11	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	124.08	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)
L:	Length of Channel =	**177.00**	(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 =	$V_{e1} + V_{e2}$	=	**642.96**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**129.74**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.10**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.57**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**174.01**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**52.76**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**2.96**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)
He:	Effective Head =	121.60	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	89.43	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	4.84	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.73	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.090	(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	:	**8.70**	(US$/m³)	* $8.70/m³, from CAPECO <only Human power excavation>
Tunnel	:	-	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m³)	
Reinforcement Bar	:	**1,075.00**	(US$/ton)	* $1.075/kg, from CAPAECO

(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Penstock & Conductior	:	**3,100.00**	(US$/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. 157m/6m =25 (joint), 25 x $2.7 =67.5$, 67.5$/157m =0.43$/m, 42.99$/m (PVC) + 0.43$/m (joint) = 43.42$/m

(3) Others				
Access Road (1)	:	**979.65**	(US$/m)	Balsa Puerto - Canoa Puerto
Access Road (2)	:	**5,877.89**	(US$/m)	Canoa Puerto - Powerhouse
Access Road (3)	:	**2,938.94**	(US$/m)	Powerhouse - Intake Site

(4) Transportation Cost				
Tarapoto to the site	:	**132.00**	(US$/ton)	US$33.33/ton (Tarapoto-Yurimaguas) + US$98.67/ton (Yurimaguas-Balsa Puerto) =132US$/ton

(1) Balsapuerto

TRANSPORTATION COST TO BALSAPUERTO truck by 10ton

1ST STAGE: (by road)

LIMA - LAMBAYEQUE -TARAPOTO - YURIMAGUAS - alternative 1	103.05	US$/TON
LIMA - CAJAMARCA -TARAPOTO - YURIMAGUAS - alternative 2	128.42	US$/TON
TARAPOTO - YURIMAGUAS - alternative 3	33.33	US$/TON

2ND STAGE: (by river)

YURIMAGUAS - BALSAPUERTO	98.67	US$/TON

TOTAL		
FROM LIMA TO BALSAPUERTO	201.72	US$/TON
FROM TARAPOTO TO BALSAPUERTO	132.00	US$/TON

BY ROAD:

ALTERNATIVE 1:

ROUTE	DISTANCE KM	ACCUM. DISTANCE KM	COST S/./ton	ACCUM. COST S/./ton	COST US$/ton	ACCUM. COST US$/ton
Lima - Lambayeque	775.64	775.64	128.09	128.09	42.70	42.70
Lambayeque - Tarapoto	889.63	1665.27	146.91	275.00	48.97	91.67
Tarapoto - Yurimaguas	206.90	1872.17	34.16	309.16	11.39	**103.05**

Source: Ministry of Trasnport and Communications MTC Upgraded up to June 2007

ALTERNATIVE 2:

ROUTE	DISTANCE KM	ACCUM. DISTANCE KM	COST S/./ton	ACCUM. COST S/./ton	COST US$/ton	ACCUM. COST US$/ton
Lima - Trujillo	557.24	557.24	92.01	92.02	30.67	30.67
Trujillo - Cajamarca	317.87	875.11	52.49	144.51	17.50	48.17
Cajamarca - Chachapoyas	841.35	1716.46	138.94	283.45	46.31	94.48
Chachapoyas - Moyobamba	299.35	2015.81	49.44	332.89	16.48	110.96
Moyobamba - Tarapoto	110.95	2126.76	18.32	351.21	6.11	117.07
Tarapoto - Yurimaguas	206.12	2332.88	34.04	385.25	11.35	**128.42**

Source: Ministry of Trasnport and Communications MTC Upgraded up to June 2007

ALTERNATIVE 3:

ROUTE	DISTANCE KM	ACCUM. DISTANCE KM	COST S/./ton	ACCUM. COST S/./ton	COST US$/ton	ACCUM. COST US$/ton
Tarapoto - Yurimaguas	206.12	206.12	100.00	100.00	33.33	**33.33**

SOURCE: Upner Av- Tours de la selva - Tarapoto Telf. (042) 531489

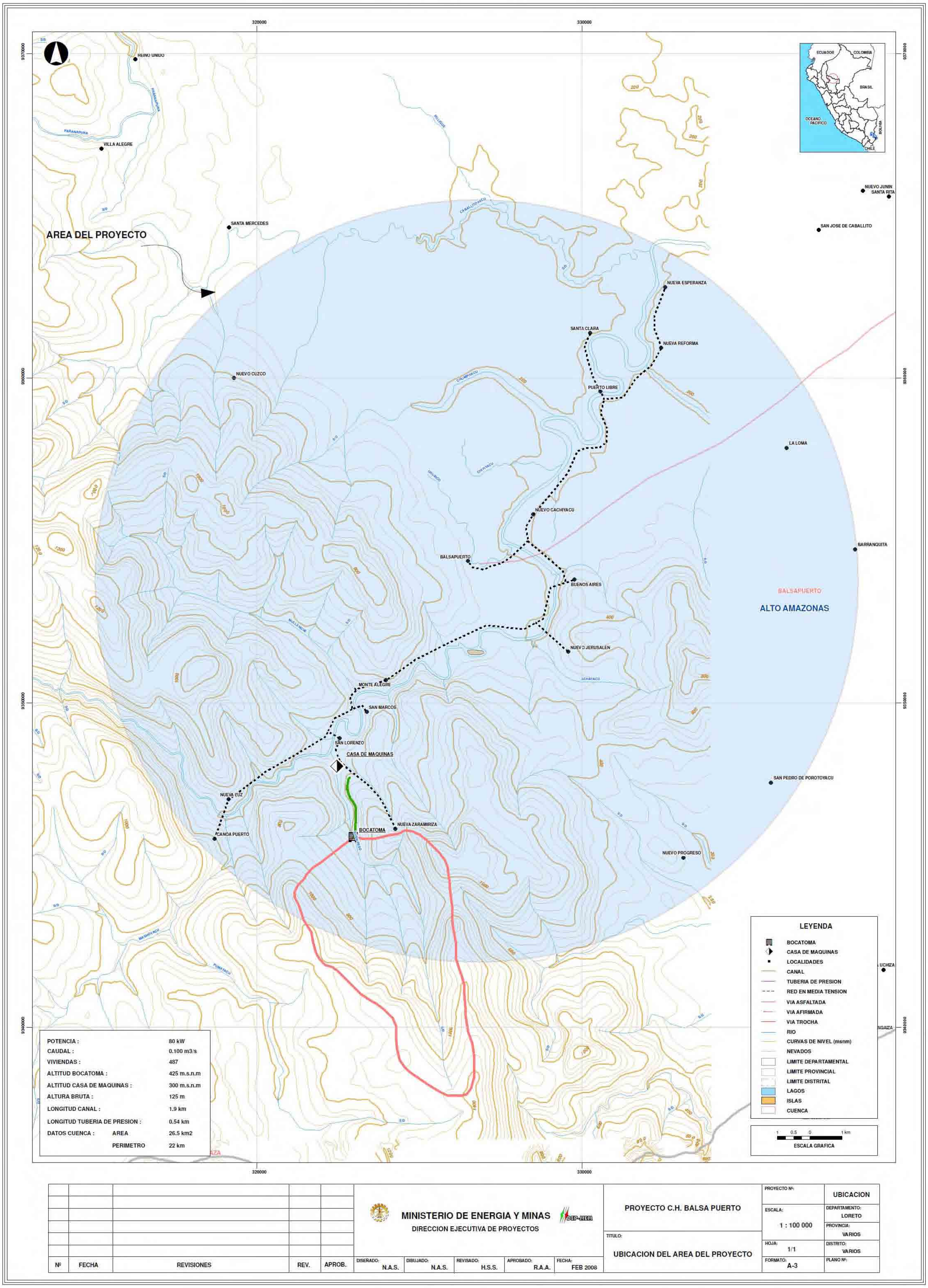
BY RIVER:

ROUTE	DISTANCE KM	ACCUM. DISTANCE KM	COST S/./ton	ACCUM. COST S/./ton	COST US$/ton	ACCUM. COST US$/ton
Yurimaguas - Balsapuerto	136.00	136.00	296.00	296.00	98.67	**98.67**

SOURCE: Agencia Fluvial Dos Mil EIRL - Yurimaguas. Telf. (065) 352174

US$ 1.00 = S/. 3.00

Balsapuerto Map



Apéndice I-21 Costos de Construcción de la Central Hidroeléctrica San Antonio

I. Summary of Construction Cost for San Antonio Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**219,084**	
(1) Access Road	105,801	
(2) Facilities for Construction Office	7,384	Cost of Civil Works x 0.05
(3) Transportation cost	105,899	1,073.27ton x $98.67/ton
2. Cost for Environmental Mesures	**1,476**	Cost of Civil Works x 0.01
3. Civil Works	**147,687**	
(1) Weir	2,221	
(2) Intake	7,159	
(3) Settling Basin	7,432	
(4) Headrace	13,855	
(5) Head Tank	14,896	
(6) Penstock & Spillway Channel	74,690	
(7) Power House	24,458	
(8) Outlet	2,976	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**157,400**	
(1) Gate & Screen	4,896	
(2) Penstock	20,717	
(3) PVC (φ600)	86,521	
(4) PVC (φ315)	19,104	
(5) Others	26,162	
5. Electrical Equipment	**107,800**	
6. Direct Cost	**633,447**	1.+2.+3.+4.+5.
7. Engineering Cost	**63,345**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**63,208**	6. x 0.100
9. IGV	**144,400**	19.00%
10. Total Cost	**904,400**	

II. Detailed Statement of Transportation Cost for San Antonio 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	**65.11**	
a. Gate		0.37	
b. Screen		0.18	
c. Cements		13.45	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		49.81	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.30	
(3) Settling Basin	ton	**50.17**	
a. Cements		10.12	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		37.47	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.58	
(4) Headrace	ton	**19.29**	
a. PVC (φ600)		19.29	Weight: 1,450m x 79.8kg/6m
(5) Head Tank	ton	**82.21**	
a. Cements		16.80	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		62.23	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.17	
(6) Penstock & Spillway Channel	ton	**682.89**	
a. Penstock Steel (φ300)		6.68	
b. Penstock PVC (φ315)		9.01	Weight: 440m x 122.833kg/6m
c. Cements		141.61	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		524.47	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.12	
(7) Power House	ton	**144.93**	
a. Cements		29.46	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		109.12	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		6.35	
(8) Outlet	ton	**11.64**	
a. Cements		2.26	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		8.36	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.02	
(9) Subtotal		**1,073.27**	
(10) Transportation Cost		**105,900**	(9) x $98.67/ton

III. Detailed Statement of Civil Works Cost for San Antonio 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				**7,159**	
a. Excavation	m^3	5.53	36.9	204	
b. Concrete	m^3	93.05	49.8	4,634	
c. Reinforcement Bars	ton	1,070.00	1.3	1,388	
d. Others	-			933	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**7,432**	
a. Excavation	m^3	5.53	92.0	508	
b. Concrete	m^3	93.05	37.5	3,486	
c. Reinforcement Bars	ton	1,070.00	2.6	2,763	
d. Others	-			675	(a+b+c) x 0.10 (including other works)
(4) Headrace				**13,855**	
a. Excavation	m^3	5.53	2088.0	11,546	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			2,309	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**14,896**	
a. Excavation	m^3	5.53	263.2	1,455	
b. Concrete	m^3	93.05	62.2	5,790	
c. Reinforcement Bars	ton	1,070.00	3.2	3,395	
d. Others	-			4,256	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**74,690**	
a. Excavation	m^3	5.53	3236.9	17,900	
b. Concrete	m^3	93.05	524.5	48,801	
c. Reinforcement Bars	ton	1,070.00	1.1	1,199	
d. Others	-			6,790	(a+b+c) x 0.10 (including filling works)
(7) Power House				**24,458**	
a. Excavation	m^3	5.53	338.2	1,870	
b. Concrete	m^3	93.05	109.1	10,153	
c. Reinforcement Bars	ton	1,070.00	6.3	6,791	
d. Others	-			5,644	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,976**	
a. Excavation	m^3	5.53	131.1	724	
b. Concrete	m^3	93.05	8.4	778	
c. Reinforcement Bars	ton	1,070.00	1.0	1,086	
d. Others	-			388	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**147,687**	

IV. Detailed Statement of Hydraulic Equipment Cost for San Antonio 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				**4,896**	
a. Gate	ton	8,811.04	0.37	3,279	
b. Screen	ton	8,811.04	0.18	1,617	
(3) Penstock Steel (φ315)	ton	3,100.00	6.68	**20,717**	
(4) PVC (φ600) for headrace	m	59.67	1,450	**86,521**	
(5) Penstock PVC (φ315) C-10	m	43.42	440	**19,104**	
(6) Subtotal				**131,238**	
(7) Others				**26,162**	19.93%
(8) Total				**157,400**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**36.90**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**49.81**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**1.30**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.37**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.18**	(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 =	**0.200**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**92.03**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**37.47**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**2.58**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.34**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.25**	(ton)

Where,

Q:	Maximum Discharge =	0.200	(m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**2,088.00**	(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 =	0.200	(m^3/s)	
L:	Length of Channel =	**1,450.00**	(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 =	$808 \times Q^{0.697}$	=	**263.17**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**62.23**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**3.17**	(ton)

Where,

Q:	Maximum Discharge =	0.200	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ315:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	483.53	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	62.29	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	1.12	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.30**	(m)
L:	Length of Penstock =	**220.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	6.68	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	3.57	(mm)

Where,

W_{p1}:	Weight of Penstock	6.68	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	3.57	(mm)	
D_m:	Avg. Diameter of Penstock =	0.30	(m)	
H:	Design Head =	**144.60**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	220.00	(m)	

Penstock (PVC)φ315:

Excavation:	$V_e = B \times H \times L$	=	372.42	(m^3)

Where,

Q:	Maximum Discharge =	0.200	(m^3/s)	
L:	Length of Channel =	**440.00**	(m)	
B:	Width of Channel =	**0.92**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.92**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)$^0.5 $= 1.09 \times Q^{0.379}$	=	0.59	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	2,380.96	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	462.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.200	(m^3/s)
L:	Length of Channel =	**660.00**	(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 =	$V_{e1} + V_{e2}$	=	**3,236.90**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**524.47**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**1.12**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**6.68**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**338.18**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**109.12**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**6.35**	(ton)

Where,

Q:	Maximum Discharge =	0.200	(m^3/s)
He:	Effective Head =	144.60	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	131.10	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	8.36	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	1.02	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.200	(m^3/s)	

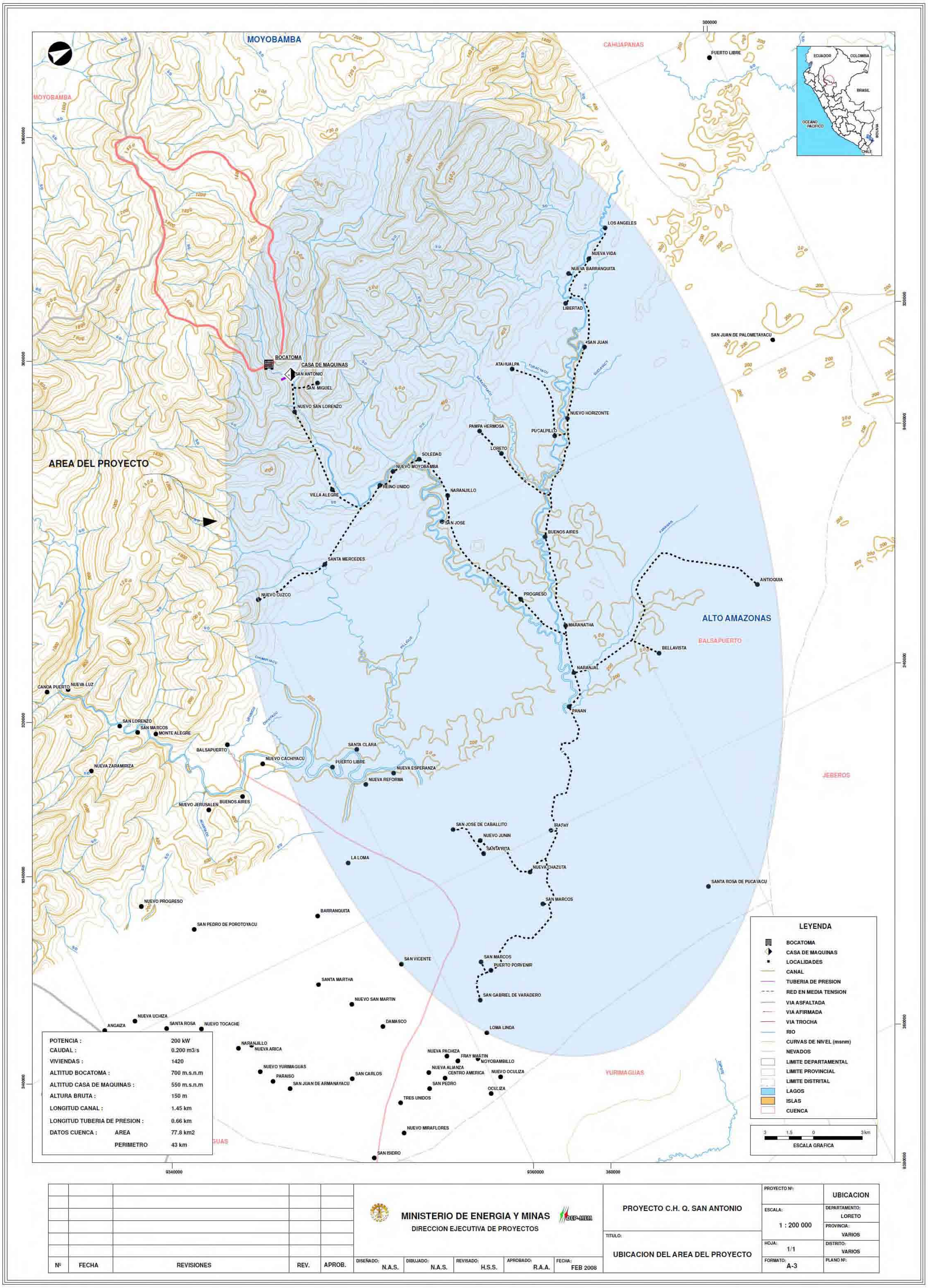
: Input Cell
: Calculation Cell
: Reference Cell

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$/ton)	including installation
PVC (φ600)		**59.67**	(US$/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				
Yurimaguas to the site	:	**98.67**	(US$/ton)	75 km (river)

San Antonio Map



Apéndice I-22 Costos de Construcción de la Central Hidroeléctrica Santa Catalina

I. Summary of Construction Cost for Santa Catalina Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**693,643**	
(1) Access Road	176,336	
(2) Facilities for Construction Office	78,346	Cost of Civil Works x 0.05
(3) Transportation cost	438,961	4,448.78ton x $98.67/ton
2. Cost for Environmental Mesures	**15,669**	Cost of Civil Works x 0.01
3. Civil Works	**1,566,932**	
(1) Weir	11,523	
(2) Intake	22,080	
(3) Settling Basin	39,664	
(4) Headrace	1,083,303	
(5) Head Tank	56,635	
(6) Penstock & Spillway Channel	265,592	
(7) Power House	78,174	
(8) Outlet	9,961	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**69,900**	
(1) Gate & Screen	17,126	
(2) Penstock	41,179	
(3) PVC for Headrace	0	
(4) PVC for Penstock	0	
(5) Others	11,595	
5. Electrical Equipment	**291,200**	
6. Direct Cost	**2,637,344**	1.+2.+3.+4.+5.
7. Engineering Cost	**263,734**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**258,922**	6. x 0.098
9. IGV	**600,400**	19.00%
10. Total Cost	**3,760,400**	

II. Detailed Statement of Transportation Cost for Santa Catalina Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**97.57**	
a. Cements		20.53	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		76.04	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.00	
(2) Intake	ton	**190.87**	
a. Gate		1.25	
b. Screen		0.69	
c. Cements		39.22	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		145.26	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		4.44	
(3) Settling Basin	ton	**285.76**	
a. Cements		58.33	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		216.04	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		11.39	
(4) Headrace	ton	**2223.51**	
a. Cements		318.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		1179.90	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		725.04	
(5) Head Tank	ton	**314.02**	
a. Cements		64.18	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		237.71	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		12.12	
(6) Penstock & Spillway Channel	ton	**825.10**	
a. Penstock Steel (φ700)		13.28	
b. Penstock PVC		0.00	
c. Cements		136.65	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		506.11	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		169.05	
(7) Power House	ton	**458.89**	
a. Cements		93.05	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		344.61	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		21.23	
(8) Outlet	ton	**53.05**	
a. Cements		10.72	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		39.71	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.63	
(9) Subtotal		**4,448.78**	
(10) Transportation Cost		**438,961**	(9) x $98.67/ton

III. Detailed Statement of Civil Works Cost for Santa Catalina Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**11,523**	
a. Excavation	m^3	5.53	264.4	1,461	
b. Concrete	m^3	93.05	76.0	7,075	
c. Reinforcement Bars	ton	1,070.00	1.0	1,067	
d. Others	-			1,920	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**22,080**	
a. Excavation	m^3	5.53	168.1	929	
b. Concrete	m^3	93.05	145.3	13,516	
c. Reinforcement Bars	ton	1,070.00	4.4	4,755	
d. Others	-			2,880	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**39,664**	
a. Excavation	m^3	5.53	681.9	3,770	
b. Concrete	m^3	93.05	216.0	20,102	
c. Reinforcement Bars	ton	1,070.00	11.4	12,187	
d. Others	-			3,605	(a+b+c) x 0.10 (including other works)
(4) Headrace				**1,083,303**	
a. Excavation	m^3	5.53	3,105.0	17,170	
b. Concrete	m^3	93.05	1,179.9	109,789	
c. Reinforcement Bars	ton	1,070.00	725.0	775,794	
d. Others	-			180,550	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**56,635**	
a. Excavation	m^3	5.53	970.1	5,364	
b. Concrete	m^3	93.05	237.7	22,119	
c. Reinforcement Bars	ton	1,070.00	12.1	12,971	
d. Others	-			16,181	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**265,592**	
a. Excavation	m^3	5.53	2,435.6	13,468	
b. Concrete	m^3	93.05	506.1	47,093	
c. Reinforcement Bars	ton	1,070.00	169.1	180,887	
d. Others	-			24,144	(a+b+c) x 0.10 (including filling works)
(7) Power House				**78,174**	
a. Excavation	m^3	5.53	967.9	5,352	
b. Concrete	m^3	93.05	344.6	32,066	
c. Reinforcement Bars	ton	1,070.00	21.2	22,716	
d. Others	-			18,040	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**9,961**	
a. Excavation	m^3	5.53	390.2	2,158	
b. Concrete	m^3	93.05	39.7	3,694	
c. Reinforcement Bars	ton	1,070.00	2.6	2,810	
d. Others	-			1,299	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**1,566,932**	

IV. Detailed Statement of Hydraulic Equipment Cost for Santa Catalina 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				**17,126**	
a. Gate	ton	8,811.04	1.25	11,040	
b. Screen	ton	8,811.04	0.69	6,086	
(3) Penstock Steel (φ700)	ton	3,100.00	13.28	**41,179**	
(4) PVC for headrace	m	-	0	**0**	
(5) Penstock PVC	m	-	0	**0**	
(6) Subtotal				**58,305**	
(7) Others				**11,595**	19.89%
(8) Total				**69,900**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**264.36**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**76.04**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**1.00**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**1.00**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**168.14**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**145.26**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**4.44**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**1.25**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.69**	(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 =	**1.300**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**681.91**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**216.04**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**11.39**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**1.07**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**1.08**	(ton)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)

(4) Headrace

In the case of Opoen Channel (1,500 x 1,000):

Excavation:	$V_e = B \times H \times L$	=	**3,105.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**1,179.90**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**725.04**	(ton)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)	
L:	Length of Channel =	**2,070.00**	(m)	
B:	Width of Channel =	**1.50**	(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 =	$808 \times Q^{0.697}$	=	**970.13**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**237.71**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**12.12**	(ton)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ700:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	1,153.07	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	199.81	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	3.60	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.70**	(m)
L:	Length of Penstock =	**170.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	13.28	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	3.94	(mm)

Where,

W_{p1}:	Weight of Penstock	13.28	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	3.94	(mm)	
D_m:	Avg. Diameter of Penstock =	0.70	(m)	
H:	Design Head =	**76.40**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	170.00	(m)	

Penstock (PVC):

Excavation:	V_e =	B x H x L	=	0.00	(m^3)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)	
L:	Length of Channel =	**0.00**	(m)	
B:	Width of Channel =	**0.00**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.00**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	1.20	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	1,282.55	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	306.30	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	165.46	(ton)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)
L:	Length of Channel =	**170.00**	(m)
B:	Width of Channel =	**1.50**	(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 =	$V_{e1} + V_{e2}$	=	**2,435.62**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**506.11**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**169.05**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**13.28**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**967.94**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**344.61**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**21.23**	(ton)

Where,

Q:	Maximum Discharge =	1.300	(m^3/s)
He:	Effective Head =	76.40	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	390.24	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	39.71	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	2.63	(ton)

Where,

D:	Diameter of Waterway =	1.50	(m)	
R:	Radius of Waterway =	0.75	(m)	D/2
Q:	Maximum Discharge =	1.300	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

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

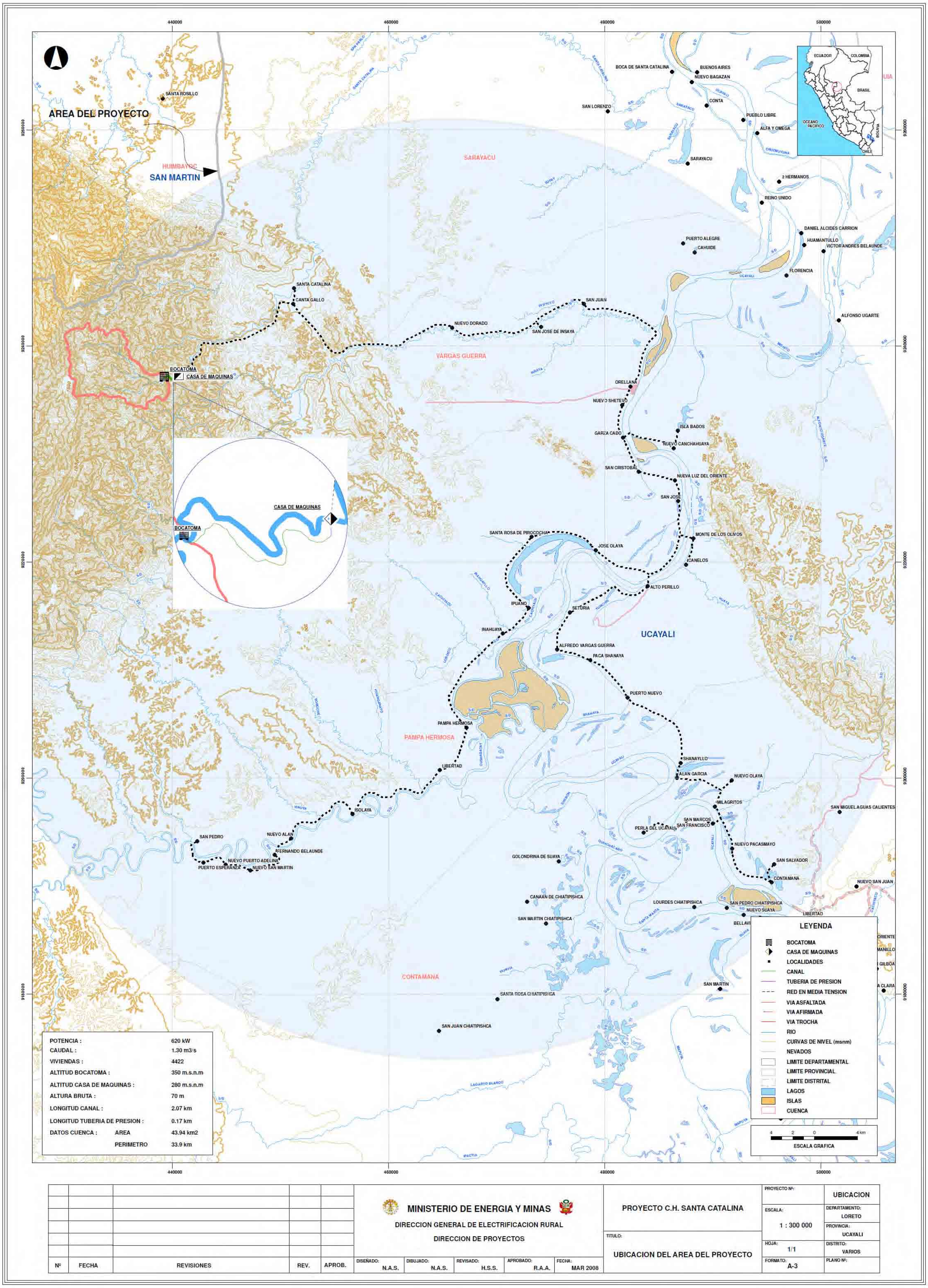
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel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

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

(4) Transportation Cost				
Iquitos to the site	:	**98.67**	(US$/ton)	745 km (river)

Santa Catalina Map



Apéndice I-23 Costos de Construcción de la Central Hidroeléctrica Challapampa

I. Summary of Construction Cost for Challapampa Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**20,442**	
(1) Access Road	11,755	
(2) Facilities for Construction Office	2,447	Cost of Civil Works x 0.05
(3) Transportation cost	6,240	385.46ton x $16.45/ton
2. Cost for Environmental Mesures	**489**	Cost of Civil Works x 0.01
3. Civil Works	**48,952**	
(1) Weir	2,221	
(2) Intake	2,823	
(3) Settling Basin	2,565	
(4) Headrace	2,972	
(5) Head Tank	6,309	
(6) Penstock & Spillway Channel	22,974	
(7) Power House	7,943	
(8) Outlet	1,145	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**35,000**	
(1) Gate & Screen	1,729	
(2) Penstock	1,123	
(3) PVC (φ400)	18,431	
(4) PVC (φ200)	7,885	
(5) Others	5,832	
5. Electrical Equipment	**35,000**	
6. Direct Cost	**139,883**	1.+2.+3.+4.+5.
7. Engineering Cost	**13,988**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**13,129**	6. x 0.094
9. IGV	**31,730**	19.00%
10. Total Cost	**198,730**	

II. Detailed Statement of Transportation Cost for Challapampa 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	**26.60**	
a. Gate		0.14	
b. Screen		0.06	
c. Cements		5.51	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		20.42	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.47	
(3) Settling Basin	ton	**16.41**	
a. Cements		3.28	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		12.14	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.99	
(4) Headrace	ton	**4.81**	
a. PVC (φ400)		4.81	Weight: 700m x 41.214kg/6m
(5) Head Tank	ton	**34.72**	
a. Cements		7.10	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		26.28	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.34	
(6) Penstock & Spillway Channel	ton	**228.98**	
a. Penstock Steel (φ200)		0.36	
b. Penstock PVC (φ200)		1.89	Weight: 227m x 50.000kg/6m
c. Cements		48.19	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		178.48	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.06	
(7) Power House	ton	**47.42**	
a. Cements		9.66	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		35.79	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.97	
(8) Outlet	ton	**3.36**	
a. Cements		0.62	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.28	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.46	
(9) Subtotal		**379.34**	
(10) Transportation Cost		**6,240**	(9) x $16.45/ton

III. Detailed Statement of Civil Works Cost for Challapampa 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				**2,823**	
a. Excavation	m^3	5.53	10.4	57	
b. Concrete	m^3	93.05	20.4	1,900	
c. Reinforcement Bars	ton	1,070.00	0.5	498	
d. Others	-			368	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,565**	
a. Excavation	m^3	5.53	25.4	140	
b. Concrete	m^3	93.05	12.1	1,129	
c. Reinforcement Bars	ton	1,070.00	1.0	1,063	
d. Others	-			233	(a+b+c) x 0.10 (including other works)
(4) Headrace				**2,972**	
a. Excavation	m^3	5.53	448.0	2,477	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			495	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**6,309**	
a. Excavation	m^3	5.53	113.7	628	
b. Concrete	m^3	93.05	26.3	2,445	
c. Reinforcement Bars	ton	1,070.00	1.3	1,434	
d. Others	-			1,802	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**22,974**	
a. Excavation	m^3	5.53	762.4	4,216	
b. Concrete	m^3	93.05	178.5	16,607	
c. Reinforcement Bars	ton	1,070.00	0.1	63	
d. Others	-			2,088	(a+b+c) x 0.10 (including filling works)
(7) Power House				**7,943**	
a. Excavation	m^3	5.53	122.0	674	
b. Concrete	m^3	93.05	35.8	3,330	
c. Reinforcement Bars	ton	1,070.00	2.0	2,106	
d. Others	-			1,833	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,145**	
a. Excavation	m^3	5.53	52.8	292	
b. Concrete	m^3	93.05	2.3	212	
c. Reinforcement Bars	ton	1,070.00	0.5	492	
d. Others	-			149	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**48,952**	

IV. Detailed Statement of Hydraulic Equipment Cost for Challapampa 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				**1,729**	
a. Gate	ton	8,811.04	0.14	1,193	
b. Screen	ton	8,811.04	0.06	536	
(3) Penstock Steel (φ200)	ton	3,100.00	0.36	**1,123**	
(4) PVC (φ400) for headrace	m	26.33	700	**18,431**	
(5) Penstock PVC (φ200) C-10	m	34.74	227	**7,885**	
(6) Subtotal				**29,168**	
(7) Others				**5,832**	19.99%
(8) Total				**35,000**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**10.43**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**20.42**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.47**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.14**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.06**	(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 =	**0.060**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**25.38**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**12.14**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.99**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.16**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.10**	(ton)

Where,

Q:	Maximum Discharge =	0.060	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	V_e =	$B \times H \times L$	=	**448.00**	(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 =	0.060	(m^3/s)	
L:	Length of Channel =	**700.00**	(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 =	$808 \times Q^{0.697}$	=	**113.71**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**26.28**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.34**	(ton)

Where,

Q:	Maximum Discharge =	0.060	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	29.48	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	3.30	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.06	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**23.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.36	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.78	(mm)

Where,

W_{p1}:	Weight of Penstock	0.36	(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 =	**107.40**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	23.00	(m)	

Penstock (PVC)φ200:

Excavation:	$V_e = B \times H \times L$		=	171.82	(m^3)

Where,

Q:	Maximum Discharge =	0.060	(m^3/s)	
L:	Length of Channel =	**227.00**	(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 =	$1.09 \times Q^{0.379}$	=	0.38	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	561.11	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	175.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.060	(m^3/s)
L:	Length of Channel =	**250.00**	(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 =	$V_{e1} + V_{e2}$	=	**762.41**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**178.48**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.06**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.36**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**122.02**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**35.79**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**1.97**	(ton)

Where,

Q:	Maximum Discharge =	0.060	(m^3/s)
He:	Effective Head =	107.40	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	52.84	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.28	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.46	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.060	(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	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road

(4) Transportation Cost				
Juliaca to the site	:	**16.45**	(US$/ton)	232 km (road)

Challapampa Map