Ministerio de Energía y Minas
República del Perú

Estudio del Plan Maestro de Electrificación Rural con Energía Renovable en la República del Perú

Apéndices

Informe Final

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Agencia de Cooperación Internacional de Japón
Electric Power Development Co., Ltd.
Nippon Koei Co., Ltd.

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I. Summary of Construction Cost for Cachiyacu Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**19,646**	
(1) Access Road	7,053	
(2) Facilities for Construction Office	3,078	Cost of Civil Works x 0.05
(3) Transportation cost	9,515	488.20ton x $19.49/ton
2. Cost for Environmental Mesures	**615**	Cost of Civil Works x 0.01
3. Civil Works	**61,577**	
(1) Weir	2,221	
(2) Intake	2,912	
(3) Settling Basin	2,715	
(4) Headrace	4,416	
(5) Head Tank	6,605	
(6) Penstock & Spillway Channel	33,199	
(7) Power House	8,327	
(8) Outlet	1,182	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**50,500**	
(1) Gate & Screen	1,790	
(2) Penstock	1,607	
(3) PVC (φ400)	27,383	
(4) PVC (φ200)	11,359	
(5) Others	8,361	
5. Electrical Equipment	**35,000**	
6. Direct Cost	**167,338**	1.+2.+3.+4.+5.
7. Engineering Cost	**16,734**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**15,928**	6. x 0.095
9. IGV	**38,000**	19.00%
10. Total Cost	**238,000**	

II. Detailed Statement of Transportation Cost for Cachiyacu 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	**27.42**	
a. Gate		0.14	
b. Screen		0.06	
c. Cements		5.68	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		21.05	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.48	
(3) Settling Basin	ton	**17.43**	
a. Cements		3.48	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		12.90	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.05	
(4) Headrace	ton	**7.14**	
a. PVC (φ400)		7.14	Weight: 1,040m x 41.214kg/6m
(5) Head Tank	ton	**36.36**	
a. Cements		7.43	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		27.52	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.40	
(6) Penstock & Spillway Channel	ton	**329.60**	
a. Penstock Steel (φ200)		0.52	
b. Penstock PVC (φ200)		2.73	Weight: 327m x 50.000kg/6m
c. Cements		69.37	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		256.91	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.09	
(7) Power House	ton	**49.70**	
a. Cements		10.13	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		37.51	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.07	
(8) Outlet	ton	**3.51**	
a. Cements		0.64	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.39	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.47	
(9) Subtotal		**488.20**	
(10) Transportation Cost		**9,515**	(9) x $19.49/ton

III. Detailed Statement of Civil Works Cost for Cachiyacu 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				**2,912**	
a. Excavation	m^3	5.53	10.9	60	
b. Concrete	m^3	93.05	21.1	1,958	
c. Reinforcement Bars	ton	1,070.00	0.5	515	
d. Others	-			379	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,715**	
a. Excavation	m^3	5.53	27.2	150	
b. Concrete	m^3	93.05	12.9	1,200	
c. Reinforcement Bars	ton	1,070.00	1.0	1,119	
d. Others	-			246	(a+b+c) x 0.10 (including other works)
(4) Headrace				**4,416**	
a. Excavation	m^3	5.53	665.6	3,680	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			736	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**6,605**	
a. Excavation	m^3	5.53	118.9	657	
b. Concrete	m^3	93.05	27.5	2,560	
c. Reinforcement Bars	ton	1,070.00	1.4	1,501	
d. Others	-			1,887	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**33,199**	
a. Excavation	m^3	5.53	1118.6	6,185	
b. Concrete	m^3	93.05	256.9	23,905	
c. Reinforcement Bars	ton	1,070.00	0.1	91	
d. Others	-			3,018	(a+b+c) x 0.10 (including filling works)
(7) Power House				**8,327**	
a. Excavation	m^3	5.53	127.4	704	
b. Concrete	m^3	93.05	37.5	3,490	
c. Reinforcement Bars	ton	1,070.00	2.1	2,212	
d. Others	-			1,921	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,182**	
a. Excavation	m^3	5.53	54.5	301	
b. Concrete	m^3	93.05	2.4	222	
c. Reinforcement Bars	ton	1,070.00	0.5	505	
d. Others	-			154	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**61,577**	

IV. Detailed Statement of Hydraulic Equipment Cost for Cachiyacu 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				**1,790**	
a. Gate	ton	8,811.04	0.14	1,234	
b. Screen	ton	8,811.04	0.06	556	
(3) Penstock Steel (φ200)	ton	3,100.00	0.52	**1,607**	
(4) PVC (φ400) for headrace	m	26.33	1,040	**27,383**	
(5) Penstock PVC (φ200) C-10	m	34.74	327	**11,359**	
(6) Subtotal				**42,139**	
(7) Others				**8,361**	19.84%
(8) Total				**50,500**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**10.89**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**21.05**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.48**	(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 =	**0.064**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**27.19**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**12.90**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.05**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.17**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.10**	(ton)

Where,

Q:	Maximum Discharge =	0.064	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	V_e =	$B \times H \times L$	=	**665.60**	(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 =	0.064	(m^3/s)	
L:	Length of Channel =	**1,040.00**	(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 =	$808 \times Q^{0.697}$	=	**118.94**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**27.52**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.40**	(ton)

Where,

Q:	Maximum Discharge =	0.064	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	42.30	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	4.73	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.09	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**33.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.52	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.77	(mm)

Where,

W_{p1}:	Weight of Penstock	0.52	(ton)	(Tensil allowable Stress: 1,150 kgf/cm²)
tm:	Thickness of Penstock	2.77	(mm)	
D_m:	Avg. Diameter of Penstock =	0.20	(m)	
H:	Design Head =	**106.50**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	33.00	(m)	

Penstock (PVC)φ200:

Excavation:	V_e =	$B \times H \times L$	=	247.51	(m^3)

Where,

Q:	Maximum Discharge =	0.064	(m^3/s)	
L:	Length of Channel =	**327.00**	(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 =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	828.82	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	252.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.064	(m^3/s)
L:	Length of Channel =	**360.00**	(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 =	$V_{e1} + V_{e2}$	=	**1,118.62**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**256.91**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.09**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.52**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**127.36**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**37.51**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.07**	(ton)

Where,

Q:	Maximum Discharge =	0.064	(m^3/s)
He:	Effective Head =	106.50	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	54.50	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.39	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.47	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.064	(m^3/s)	

VI. Unit Price

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

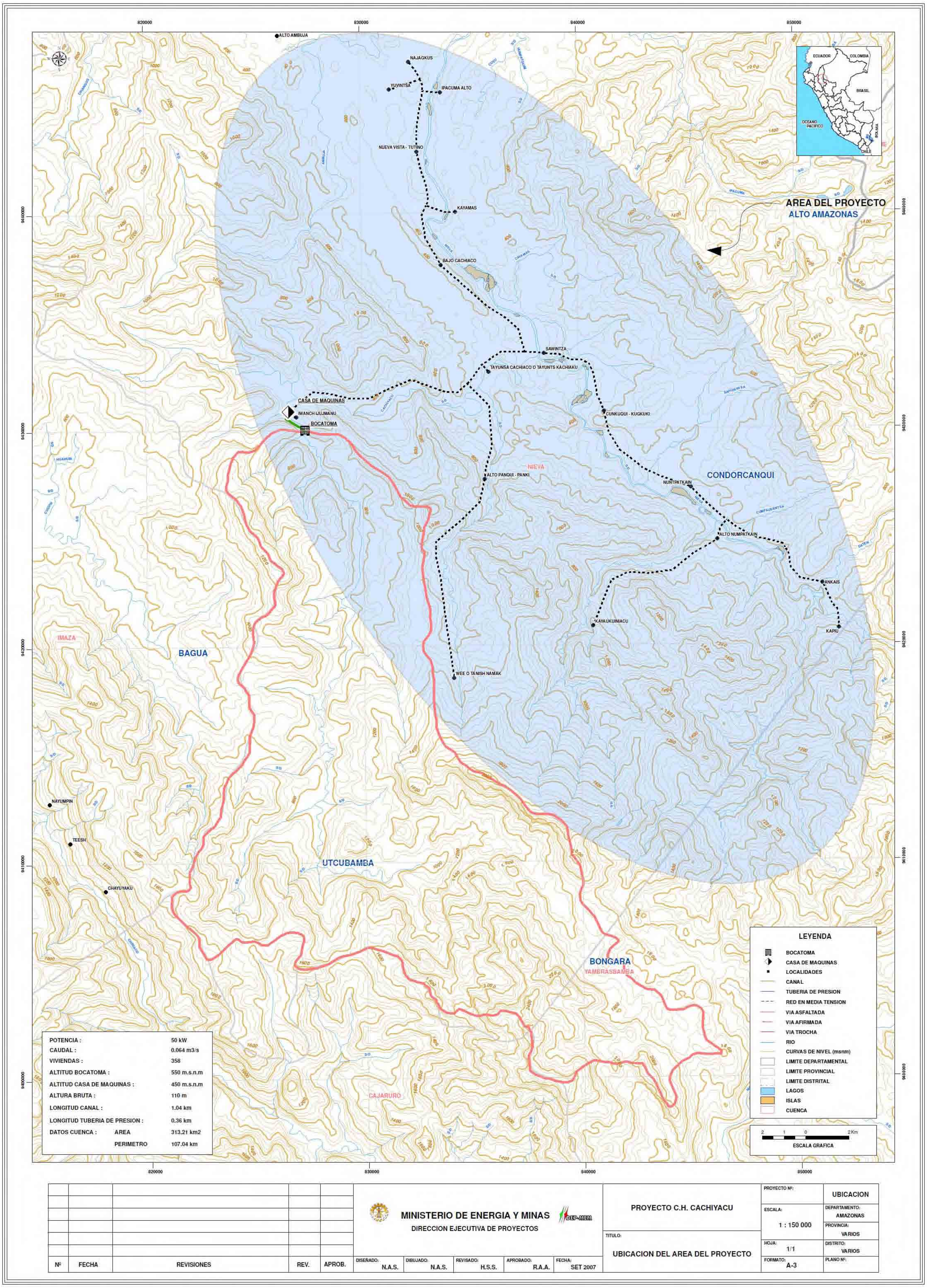
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m³)	* (8.70+2.35) x 0.5 = $5.53/m³, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/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				
Chachapoyas to the site	:	**19.49**	(US$/ton)	320km

Cachiyacu Map



Apéndice I-2 Costos de Construcción de la Central Hidroeléctrica Palcapampa

I. Summary of Construction Cost for Palcapampa Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**21,199**	
(1) Access Road	14,106	
(2) Facilities for Construction Office	2,156	Cost of Civil Works x 0.05
(3) Transportation cost	4,937	373.97ton x $14.83/ton
2. Cost for Environmental Mesures	**431**	Cost of Civil Works x 0.01
3. Civil Works	**43,121**	
(1) Weir	2,221	
(2) Intake	2,168	
(3) Settling Basin	1,598	
(4) Headrace	5,392	
(5) Head Tank	4,293	
(6) Penstock & Spillway Channel	21,426	
(7) Power House	5,144	
(8) Outlet	879	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**52,000**	
(1) Gate & Screen	1,286	
(2) Penstock	1,073	
(3) PVC (φ400)	33,439	
(4) PVC (φ200)	7,573	
(5) Others	8,629	
5. Electrical Equipment	**24,800**	
6. Direct Cost	**141,551**	1.+2.+3.+4.+5.
7. Engineering Cost	**14,155**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**13,294**	6. x 0.094
9. IGV	**32,110**	19.00%
10. Total Cost	**201,110**	

II. Detailed Statement of Transportation Cost for Palcapampa 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	**20.62**	
a. Gate		0.10	
b. Screen		0.04	
c. Cements		4.28	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		15.85	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.35	
(3) Settling Basin	ton	**9.96**	
a. Cements		1.98	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		7.33	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.65	
(4) Headrace	ton	**8.72**	
a. PVC (φ400)		8.72	Weight: 1,270m x 41.214kg/6m
(5) Head Tank	ton	**23.60**	
a. Cements		4.82	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		17.87	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.91	
(6) Penstock & Spillway Channel	ton	**219.81**	
a. Penstock Steel (φ200)		0.35	
b. Penstock PVC (φ200)		1.82	Weight: 218m x 50.000kg/6m
c. Cements		46.26	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		171.33	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.06	
(7) Power House	ton	**30.79**	
a. Cements		6.28	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		23.26	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.25	
(8) Outlet	ton	**2.37**	
a. Cements		0.43	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		1.58	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.37	
(9) Subtotal		**332.93**	
(10) Transportation Cost		**4,937**	(9) x $14.83/ton

III. Detailed Statement of Civil Works Cost for Palcapampa 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				**2,168**	
a. Excavation	m^3	5.53	7.3	40	
b. Concrete	m^3	93.05	15.9	1,474	
c. Reinforcement Bars	ton	1,070.00	0.3	372	
d. Others	-			282	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**1,598**	
a. Excavation	m^3	5.53	14.3	78	
b. Concrete	m^3	93.05	7.3	682	
c. Reinforcement Bars	ton	1,070.00	0.6	693	
d. Others	-			145	(a+b+c) x 0.10 (including other works)
(4) Headrace				**5,392**	
a. Excavation	m^3	5.53	812.8	4,494	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			898	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**4,293**	
a. Excavation	m^3	5.53	78.1	431	
b. Concrete	m^3	93.05	17.9	1,662	
c. Reinforcement Bars	ton	1,070.00	0.9	974	
d. Others	-			1,226	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**21,426**	
a. Excavation	m^3	5.53	628.8	3,477	
b. Concrete	m^3	93.05	171.3	15,942	
c. Reinforcement Bars	ton	1,070.00	0.1	60	
d. Others	-			1,947	(a+b+c) x 0.10 (including filling works)
(7) Power House				**5,144**	
a. Excavation	m^3	5.53	82.3	454	
b. Concrete	m^3	93.05	23.3	2,164	
c. Reinforcement Bars	ton	1,070.00	1.3	1,339	
d. Others	-			1,187	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**879**	
a. Excavation	m^3	5.53	40.8	225	
b. Concrete	m^3	93.05	1.6	147	
c. Reinforcement Bars	ton	1,070.00	0.4	393	
d. Others	-			114	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**43,121**	

IV. Detailed Statement of Hydraulic Equipment Cost for Palcapampa 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				**1,286**	
a. Gate	ton	8,811.04	0.10	895	
b. Screen	ton	8,811.04	0.04	391	
(3) Penstock Steel (φ200）	ton	3,100.00	0.35	**1,073**	
(4) PVC (φ400）for headrace	m	26.33	1,270	**33,439**	
(5) Penstock PVC (φ200) C-10	m	34.74	218	**7,573**	
(6) Subtotal				**43,371**	
(7) Others				**8,629**	19.90%
(8) Total				**52,000**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**7.28**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**15.85**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.35**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.10**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.04**	(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 =	**0.035**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**14.25**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**7.33**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.65**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.12**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.06**	(ton)

Where,

Q: Maximum Discharge = 0.035 (m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**812.80**	(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 =	0.035	(m^3/s)	
L:	Length of Channel =	**1,270.00**	(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 =	$808 \times Q^{0.697}$	=	**78.10**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**17.87**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**0.91**	(ton)

Where,

Q: Maximum Discharge = 0.035 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	28.20	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	3.15	(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 =	**22.00**	(m)	

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.35	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.77	(mm)

Where,

W_{p1}: Weight of Penstock	0.35	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm: Thickness of Penstock	2.77	(mm)	
D_m: Avg. Diameter of Penstock =	0.20	(m)	
H: Design Head =	**106.90**	(m)	(Intake Water Level - Tailrace Water Level)
L: Length of Penstock =	22.00	(m)	

Penstock (PVC)φ200:

Excavation:	V_e =	$B \times H \times L$	=	165.00	(m^3)

Where,

Q: Maximum Discharge =	0.035	(m^3/s)	
L: Length of Channel =	**218.00**	(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 =	$1.09 \times Q^{0.379}$	=	0.31	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	435.57	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	168.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q: Maximum Discharge =	0.035	(m^3/s)
L: Length of Channel =	**240.00**	(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 =	$V_{e1} + V_{e2}$	=	**628.77**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**171.33**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.06**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.35**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**82.27**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**23.26**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**1.25**	(ton)

Where,

Q: Maximum Discharge =	0.035	(m^3/s)
He: Effective Head =	106.90	(m)
n: Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	40.81	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	1.58	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.37	(ton)

Where,

D: Diameter of Waterway =	0.50	(m)	
R: Radius of Waterway =	0.25	(m)	D/2
Q: Maximum Discharge =	0.035	(m^3/s)	

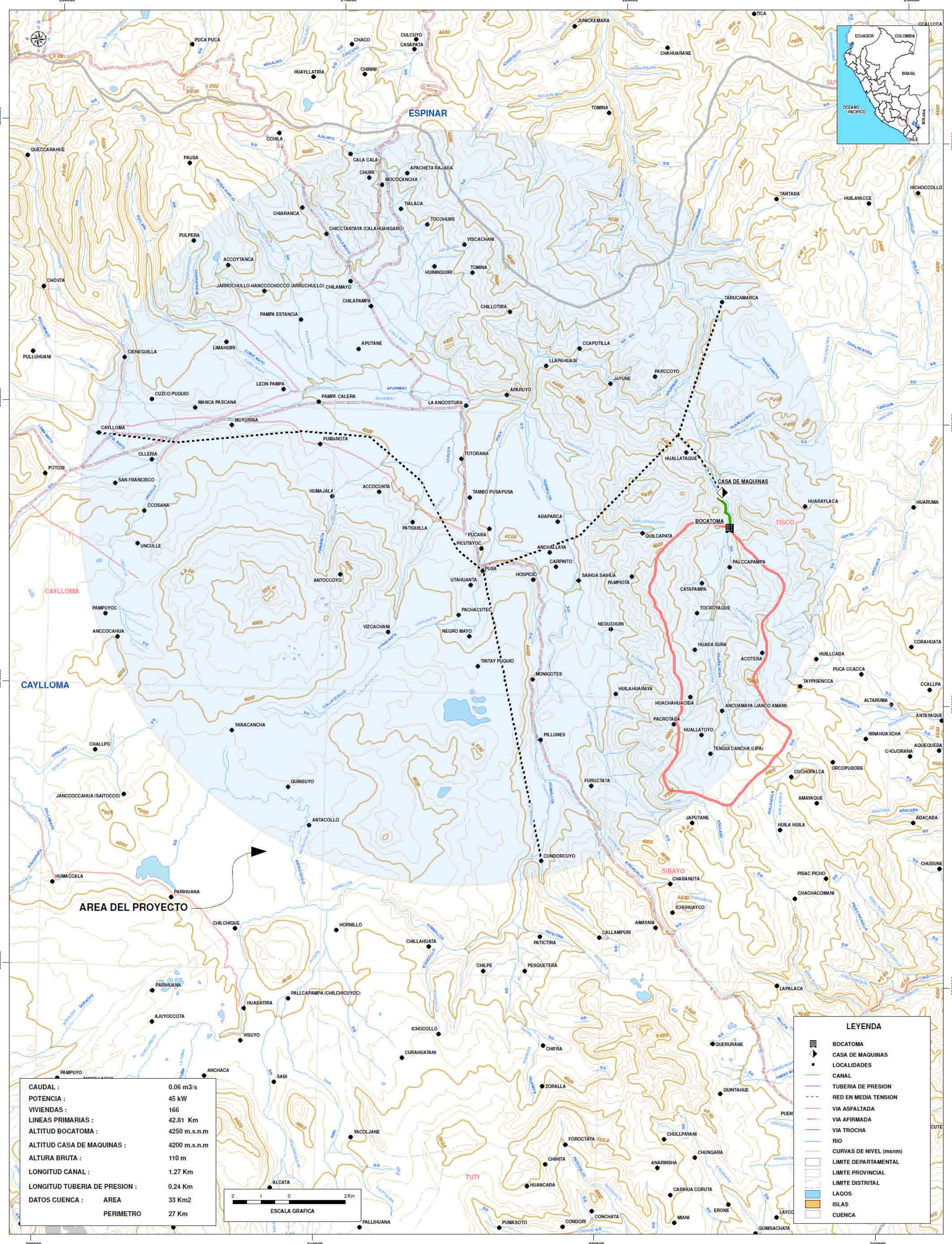
: Input Cell
: Calculation Cell
: Reference Cell

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 (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				
Arequipa to the site	:	**14.83**	(US$/ton)	185km

Palcapampa Map



Nº	FECHA	REVISIONES	REV.	APROB.

MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS

DISEÑADO: N.A.S. | DIBUJADO: N.A.S. | REVISADO: H.S.S. | APROBADO: R.A.A. | FECHA: SET 2007

PROYECTO C.H. Q.PALCAPAMPA

TITULO: UBICACION DEL AREA DEL PROYECTO

PROYECTO Nº:
ESCALA: 1 : 125 000
HOJA: 1/1
FORMATO: A-3

UBICACION
DEPARTAMENTO: AREQUIPA
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Apéndice I-3 Costos de Construcción de la Central Hidroeléctrica La Majada

I. Summary of Construction Cost for La Majada Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**16,152**	
(1) Access Road	3,526	
(2) Facilities for Construction Office	4,620	Cost of Civil Works x 0.05
(3) Transportation cost	8,006	697.39ton x $11.48/ton
2. Cost for Environmental Mesures	**924**	Cost of Civil Works x 0.01
3. Civil Works	**92,414**	
(1) Weir	2,221	
(2) Intake	3,347	
(3) Settling Basin	3,487	
(4) Headrace	12,608	
(5) Head Tank	8,089	
(6) Penstock & Spillway Channel	51,489	
(7) Power House	9,813	
(8) Outlet	1,360	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**120,800**	
(1) Gate & Screen	2,092	
(2) Penstock	0	
(3) PVC (φ500)	79,173	
(4) PVC (φ200)	19,454	
(5) Others	20,081	
5. Electrical Equipment	**41,100**	
6. Direct Cost	**271,390**	1.+2.+3.+4.+5.
7. Engineering Cost	**27,139**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**26,471**	6. x 0.098
9. IGV	**61,750**	19.00%
10. Total Cost	**386,750**	

II. Detailed Statement of Transportation Cost for La Majada 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	**16.32**	
a. PVC (φ500)		16.32	Weight: 1,900m 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	**502.74**	
a. Penstock Steel (φ200)		0.00	
b. Penstock PVC (φ200)		4.67	Weight: 560m x 50.000kg/6m
c. Cements		105.89	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		392.18	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.00	
(7) Power House	ton	**58.51**	
a. Cements		11.92	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		44.14	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.45	
(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		**697.39**	
(10) Transportation Cost		**8,006**	(9) x $11.48/ton

III. Detailed Statement of Civil Works Cost for La Majada 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				**12,608**	
a. Excavation	m^3	5.53	1900.0	10,507	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			2,101	(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				**51,489**	
a. Excavation	m^3	5.53	1865.7	10,317	
b. Concrete	m^3	93.05	392.2	36,492	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			4,680	(a+b+c) x 0.10 (including filling works)
(7) Power House				**9,813**	
a. Excavation	m^3	5.53	147.8	817	
b. Concrete	m^3	93.05	44.1	4,107	
c. Reinforcement Bars	ton	1,070.00	2.5	2,625	
d. Others	-			2,264	(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				**92,414**	

IV. Detailed Statement of Hydraulic Equipment Cost for La Majada 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	1,900	**79,173**	
(5) Penstock PVC (φ200) C-10	m	34.74	560	**19,454**	
(6) Subtotal				**100,719**	
(7) Others				**20,081**	19.94%
(8) Total				**120,800**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**13.15**	(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 Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.085**	(m^3/s)	

(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:	$V_e = B \times H \times L$	=	**1,900.00**	(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 =	0.085	(m^3/s)	
L:	Length of Channel =	**1,900.00**	(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 =	$808 \times Q^{0.697}$	=	**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 =	**94.60**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ200:

Excavation:	$V_e = B \times H \times L$	=	423.86	(m^3)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)	
L:	Length of Channel =	**560.00**	(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 =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	1,441.86	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	392.18	(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 =	**560.00**	(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 =	$V_{e1} + V_{e2}$	=	**1,865.72**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**392.18**	(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 =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**147.80**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**44.14**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.45**	(ton)

Where,

Q:	Maximum Discharge =	0.085	(m^3/s)
He:	Effective Head =	94.60	(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**	(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(φ315) for Penstock (C-10) = 43.42 x 0.8 = 34.74

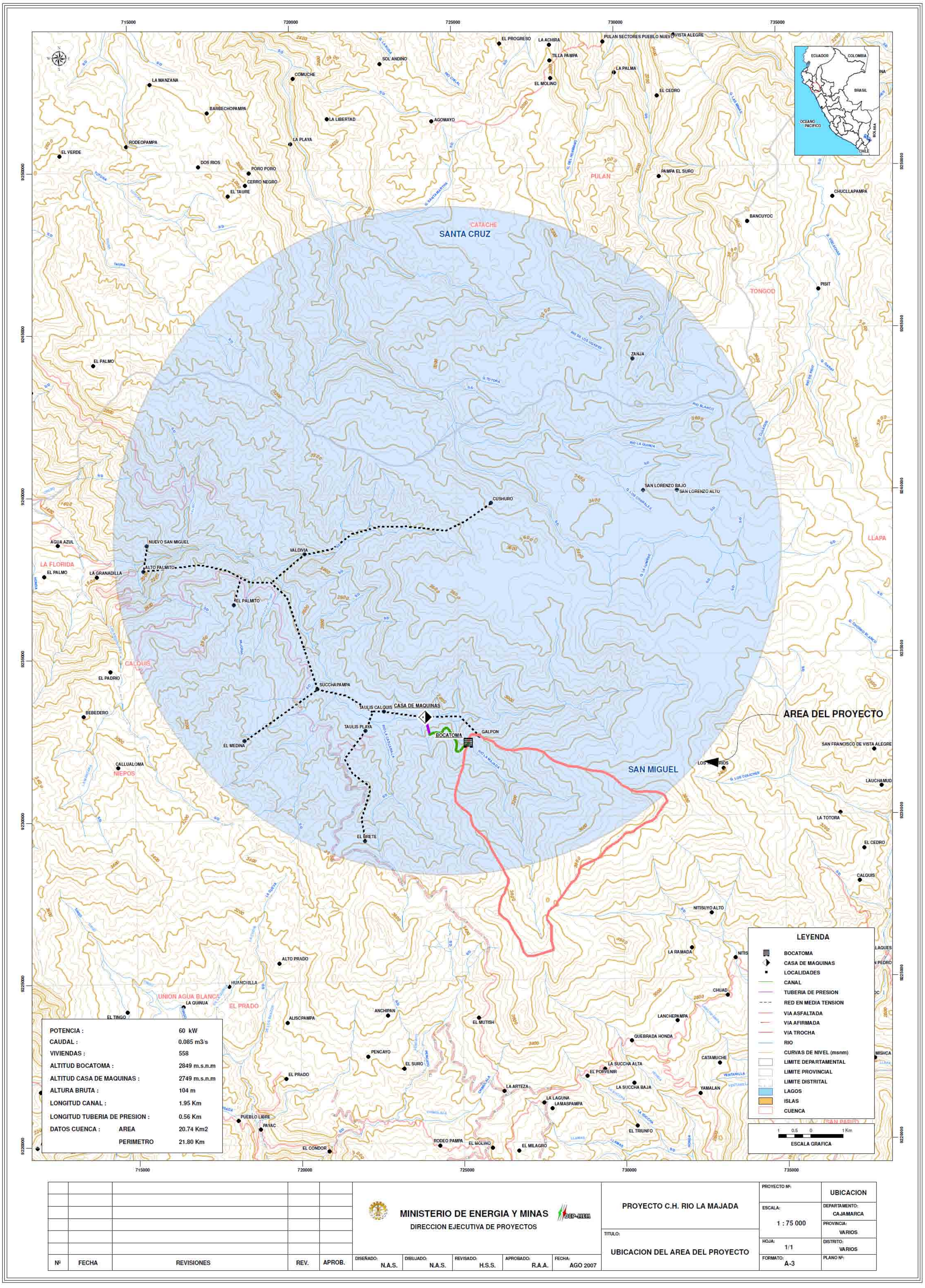
(3) Others

Access Road	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road

(4) Transportation Cost

Cajamarca to the site	:	**11.48**	(US$/ton)	88km

La Majada Map



Apéndice I-4 Costos de Construcción de la Central Hidroeléctrica Quebrada Honda

I. Summary of Construction Cost for Quebrada Honda Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**7,579**	
(1) Access Road	2,351	
(2) Facilities for Construction Office	2,058	Cost of Civil Works x 0.05
(3) Transportation cost	3,170	287.48ton x $11.03/ton
2. Cost for Environmental Mesures	**411**	Cost of Civil Works x 0.01
3. Civil Works	**41,167**	
(1) Weir	1,282	
(2) Intake	2,582	
(3) Settling Basin	2,185	
(4) Headrace	6,625	
(5) Head Tank	5,539	
(6) Penstock & Spillway Channel	15,411	
(7) Power House	6,497	
(8) Outlet	1,046	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**57,500**	
(1) Gate & Screen	1,564	
(2) Penstock	0	
(3) PVC (φ400)	41,074	
(4) PVC (φ150)	5,318	
(5) Others	9,544	
5. Electrical Equipment	**24,800**	
6. Direct Cost	**131,457**	1.+2.+3.+4.+5.
7. Engineering Cost	**13,146**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**12,397**	6. x 0.094
9. IGV	**29,830**	19.00%
10. Total Cost	**186,830**	

II. Detailed Statement of Transportation Cost for Quebrada Honda 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	**24.40**	
a. Gate		0.12	
b. Screen		0.05	
c. Cements		5.06	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		18.74	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.42	
(3) Settling Basin	ton	**13.86**	
a. Cements		2.76	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		10.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.86	
(4) Headrace	ton	**10.72**	
a. PVC (φ400)		10.72	Weight: 1,560m x 41.214kg/6m
(5) Head Tank	ton	**30.47**	
a. Cements		6.23	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		23.06	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.18	
(6) Penstock & Spillway Channel	ton	**156.74**	
a. Penstock Steel (φ150)		0.00	
b. Penstock PVC (φ150)		0.93	Weight: 175m x 32.000kg/6m
c. Cements		33.12	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		122.68	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**38.83**	
a. Cements		7.92	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		29.32	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.60	
(8) Outlet	ton	**2.99**	
a. Cements		0.54	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		2.02	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.43	
(9) Subtotal		**287.48**	
(10) Transportation Cost		**3,171**	(9) x $11.03/ton

III. Detailed Statement of Civil Works Cost for Quebrada Honda 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				**2,582**	
a. Excavation	m^3	5.53	9.2	51	
b. Concrete	m^3	93.05	18.7	1,744	
c. Reinforcement Bars	ton	1,070.00	0.4	451	
d. Others	-			336	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,185**	
a. Excavation	m^3	5.53	20.9	115	
b. Concrete	m^3	93.05	10.2	952	
c. Reinforcement Bars	ton	1,070.00	0.9	920	
d. Others	-			198	(a+b+c) x 0.10 (including other works)
(4) Headrace				**6,625**	
a. Excavation	m^3	5.53	998.4	5,521	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,104	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**5,539**	
a. Excavation	m^3	5.53	100.1	553	
b. Concrete	m^3	93.05	23.1	2,146	
c. Reinforcement Bars	ton	1,070.00	1.2	1,258	
d. Others	-			1,582	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**15,411**	
a. Excavation	m^3	5.53	469.3	2,595	
b. Concrete	m^3	93.05	122.7	11,415	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,401	(a+b+c) x 0.10 (including filling works)
(7) Power House				**6,497**	
a. Excavation	m^3	5.53	101.7	562	
b. Concrete	m^3	93.05	29.3	2,728	
c. Reinforcement Bars	ton	1,070.00	1.6	1,708	
d. Others	-			1,499	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,046**	
a. Excavation	m^3	5.53	48.4	267	
b. Concrete	m^3	93.05	2.0	187	
c. Reinforcement Bars	ton	1,070.00	0.4	456	
d. Others	-			136	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**41,167**	

IV. Detailed Statement of Hydraulic Equipment Cost for Quebrada Honda 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				**1,564**	
a. Gate	ton	8,811.04	0.12	1,082	
b. Screen	ton	8,811.04	0.05	482	
(3) Penstock Steel (φ150)	ton	3,100.00	0.00	**0**	
(4) PVC (φ400) for headrace	m	26.33	1,560	**41,074**	
(5) Penstock PVC (φ150) C-10	m	30.39	175	**5,318**	
(6) Subtotal				**47,956**	
(7) Others				**9,544**	19.90%
(8) Total				**57,500**	

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 =	$171 \times (R \times Q)^{0.666}$	=	**9.24**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**18.74**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.42**	(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 =	**0.050**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**20.88**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**10.24**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.86**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.15**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.08**	(ton)

Where,

Q:	Maximum Discharge =	0.050	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**998.40**	(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 =	0.050	(m^3/s)	
L:	Length of Channel =	**1,560.00**	(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 =	$808 \times Q^{0.697}$	=	**100.14**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**23.06**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.18**	(ton)

Where,

Q:	Maximum Discharge =	0.050	(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 =	**96.90**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ150:

Excavation:	V_e =	$B \times H \times L$	=	103.76	(m^3)

Where,

Q:	Maximum Discharge =	0.050	(m^3/s)	
L:	Length of Channel =	**175.00**	(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 =	$1.09 \times Q^{0.379}$	=	0.35	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	365.54	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	122.68	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.050	(m^3/s)
L:	Length of Channel =	**175.00**	(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 =	$V_{e1} + V_{e2}$	=	**469.30**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**122.68**	(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:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**101.67**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**29.32**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**1.60**	(ton)

Where,

Q:	Maximum Discharge =	0.050	(m^3/s)
He:	Effective Head =	96.90	(m)
n:	uantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	$V_e = 395 \times (R \times Q)^{0.479}$	=	48.42	(m^3)
Concrete:	$V_c = 40.4 \times (R \times Q)^{0.684}$	=	2.02	(m^3)
Reinforcement Bars	$W_r = 0.278 \times V_c^{0.610}$	=	0.43	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.050	(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

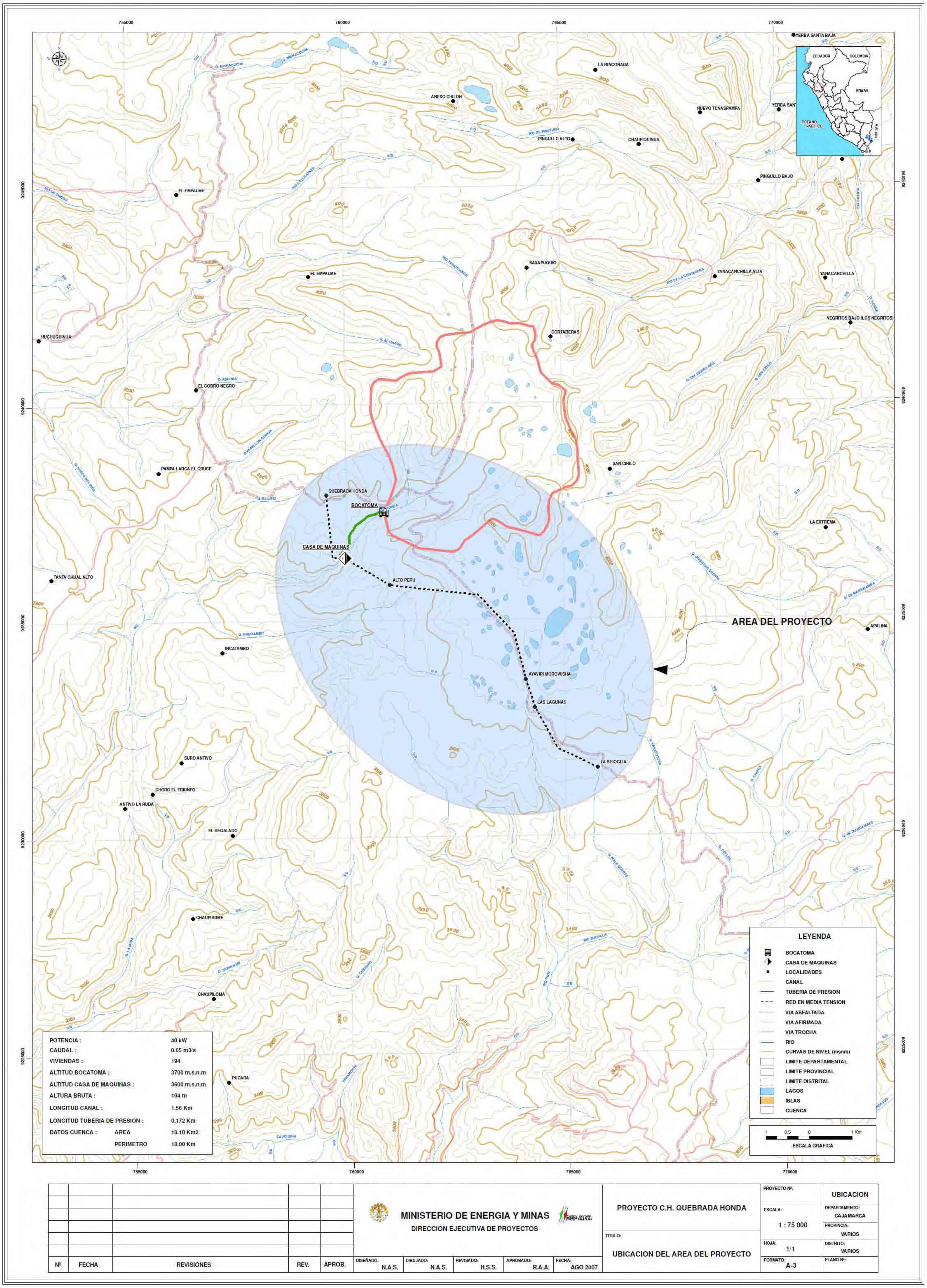
(3) Others

Access Road	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road

(4) Transportation Cost

Cajamarca to the site	:	**11.03**	(US$/ton)	75km

Quebrada Honda Map



Appendix I-2 Apéndice I-5 Costos de Construcción de la Central Hidroeléctrica Yerba Buena (en el caso de PVC para Aducción)

I. Summary of Construction Cost for Yerba Buena Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**8,039**	
(1) Access Road	0	
(2) Facilities for Construction Office	3,318	Cost of Civil Works x 0.05
(3) Transportation cost	4,721	Cajamarca to the site, 454ton x $10.4/ton
2. Cost for Environmental Mesures	**663**	Cost of Civil Works x 0.01
3. Civil Works	**66,373**	
(1) Weir	2,798	
(2) Intake	5,384	
(3) Settling Basin	4,448	
(4) Headrace	8,599	
(5) Head Tank	9,850	
(6) Penstock & Spillway Channel	20,674	
(7) Power House	12,407	
(8) Outlet	2,213	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**109,000**	
(1) Gate & Screen	3,560	
(2) Penstock	1,610	
(3) PVC (φ600)	77,571	
(4) PVC (φ315)	8,249	
(5) Others	18,010	
5. Electrical Equipment	**52,800**	
6. Direct Cost	**236,875**	1.+2.+3.+4.+5.
7. Engineering Cost	**23,688**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**23,438**	6. x 0.099
9. IGV	**53,960**	19.00%
10. Total Cost	**337,960**	

II. Detailed Statement of Transportation Cost for Yerba Buena Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**23.17**	
a. Cements		4.86	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		18.01	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.30	
(2) Intake	ton	**49.52**	
a. Gate		0.27	
b. Screen		0.13	
c. Cements		10.24	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		37.93	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.95	
(3) Settling Basin	ton	**29.28**	
a. Cements		5.88	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		21.77	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.63	
(4) Headrace	ton	**17.29**	
a. PVC (φ600)		17.29	Weight: 1,300m x 79.8kg/6m = 17.3ton
(5) Head Tank	ton	**54.28**	
a. Cements		11.09	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		41.09	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.10	
(6) Penstock & Spillway Channel	ton	**198.62**	
a. Penstock Steel (φ300)		0.52	
b. Penstock PVC (φ315)		3.89	Weight: 190m x 122.833kg/6m = 3.9ton
c. Cements		41.27	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		152.84	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.10	
(7) Power House	ton	**73.87**	
a. Cements		15.04	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		55.70	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.13	
(8) Outlet	ton	**7.94**	
a. Cements		1.52	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		5.63	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.80	
(9) Subtotal		**453.97**	
(10) Transportation Cost		**4,721**	(9) x $10.4/ton: Cajamarca to Yerba Buena

III. Detailed Statement of Civil Works Cost for Yerba Buena Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,798**	
a. Excavation	m^3	5.53	60.7	335	
b. Concrete	m^3	93.05	18.0	1,675	
c. Reinforcement Bars	ton	1,070.00	0.3	322	
d. Others	-			466	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**5,384**	
a. Excavation	m^3	5.53	25.1	138	
b. Concrete	m^3	93.05	37.9	3,529	
c. Reinforcement Bars	ton	1,070.00	0.9	1,015	
d. Others	-			702	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**4,448**	
a. Excavation	m^3	5.53	49.5	273	
b. Concrete	m^3	93.05	21.8	2,026	
c. Reinforcement Bars	ton	1,070.00	1.6	1,745	
d. Others	-			404	(a+b+c) x 0.10 (including other works)
(4) Headrace				**8,599**	
a. Excavation	m^3	5.53	1296.0	7,166	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,433	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**9,850**	
a. Excavation	m^3	5.53	175.7	971	
b. Concrete	m^3	93.05	41.1	3,823	
c. Reinforcement Bars	ton	1,070.00	2.1	2,242	
d. Others	-			2,814	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**20,674**	
a. Excavation	m^3	5.53	807.6	4,465	
b. Concrete	m^3	93.05	152.8	14,221	
c. Reinforcement Bars	ton	1,070.00	0.1	109	
d. Others	-			1,879	(a+b+c) x 0.10 (including filling works)
(7) Power House				**12,407**	
a. Excavation	m^3	5.53	182.8	1,011	
b. Concrete	m^3	93.05	55.7	5,182	
c. Reinforcement Bars	ton	1,070.00	3.1	3,351	
d. Others	-			2,863	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,213**	
a. Excavation	m^3	5.53	99.3	549	
b. Concrete	m^3	93.05	5.6	523	
c. Reinforcement Bars	ton	1,070.00	0.8	853	
d. Others	-			288	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**66,373**	

IV. Detailed Statement of Hydraulic Equipment Cost for Yerba Buena 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				**3,560**	
a. Gate	ton	8,811.04	0.27	2,407	
b. Screen	ton	8,811.04	0.13	1,153	
(3) Penstock Steel (φ315)	ton	3,100.00	0.52	**1,610**	
(4) PVC (φ600) for headrace	m	59.67	1,300	**77,571**	
(5) Penstock PVC (φ315) C-10	m	43.42	190	**8,249**	
(6) Subtotal				**90,990**	
(7) Others				**18,010**	19.79%
(8) Total				**109,000**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**60.68**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**18.01**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.30**	(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 =	**11.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**25.08**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**37.93**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.95**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.27**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.13**	(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 =	**0.112**	(m^3/s)	

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**49.48**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**21.77**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.63**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.24**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.16**	(ton)

Where,

Q:	Maximum Discharge =	0.112	(m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**1,296.00**	(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 =	0.112	(m^3/s)	
L:	Length of Channel =	**900.00**	(m)	Exsisting cannal = 400m among total length of 1,300m
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 =	$808 \times Q^{0.697}$	=	**175.68**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**41.09**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**2.10**	(ton)

Where,

Q:	Maximum Discharge =	0.112	(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} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.52	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	3.05	(mm)

Where,

W_{p1}:	Weight of Penstock	0.52	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	3.05	(mm)	
D_m:	Avg. Diameter of Penstock =	0.30	(m)	
H:	Design Head =	**97.00**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	20.00	(m)	

Penstock (PVC)φ315:

Excavation:	V_e =	$B \times H \times L$	=	160.82	(m^3)

Where,

Q:	Maximum Discharge =	0.112	(m^3/s)	
L:	Length of Channel =	**190.00**	(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 =	$1.09 \times Q^{0.379}$	=	0.48	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	602.80	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	147.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.112	(m^3/s)
L:	Length of Channel =	**210.00**	(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 =	$V_{e1} + V_{e2}$	=	**807.57**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**152.84**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.10**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.52**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**182.83**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**55.70**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**3.13**	(ton)

Where,

Q:	Maximum Discharge =	0.112	(m^3/s)
He:	Effective Head =	97.00	(m)
n:	uantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	$V_e = 395 \times (R \times Q)^{0.479}$	=	99.31	(m^3)
Concrete:	$V_c = 40.4 \times (R \times Q)^{0.684}$	=	5.63	(m^3)
Reinforcement Bars	$W_r = 0.278 \times V_c^{0.610}$	=	0.80	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.112	(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	:	**-**	(US$/m)	

(4) Transportation Cost				
Cajamarca to the site	:	**10.40**	(US$/ton)	

(1) Yerba Buena

TRANSPORTATION COST TO YERBABUENA

ONLY STAGE: (by road)

LIMA - TRUJILLO - CAJAMARCA - YERBABUENA - alternative 1	51.31	US$/TON
CAJAMARCA - YERBABUENA - alternative 2	10.41	US$/TON

TOTAL		
FROM LIMA TO YERBABUENA	51.31	US$/TON
FROM CAJAMARCA TO YERBABUENA	10.41	US$/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 - Trujillo	557.24	557.24	92.01	92.02	30.67	30.67	*Source: Ministry of Trasnport and Communications MTC Upgraded up to June 2007*
Trujillo - Cajamarca	317.87	875.11	52.49	144.51	17.50	**48.17**	
Cajamarca - Yerbabuena	57.00	932.11	9.41	153.92	3.14	**51.31**	

Lima - Cajamarca	57.00	57.00	214.20	214.20	71.40	**71.40**	*Source: Transportes Sanky - Lima. Telf. (01) 98346723*

ALTERNATIVE 2:

ROUTE	DISTANCE KM	ACCUM. DISTANCE KM	COST S/./ton	ACCUM. COST S/./ton	COST US$/ton	ACCUM. COST US$/ton	
Cajamarca - Yerbabuena	57.00	57.00	31.22	31.22	10.41	**10.41**	*Source: Ministry of Trasnport and Communications MTC Upgraded up to March 2007* **Non confirmed*

US$ 1.00 = S/. 3.00

Yerba Buena Map