Japan International Cooperation Agency
Ministry of Energy and Mines of the Republic of Peru

Master Plan Study
for Rural Electrification
by Renewable Energy
in the Republic of Peru

Appendix

Final Report

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Electric Power Development Co., Ltd.
Nippon Koei Co., Ltd.
Tokyo - Japan

Contents

Appendix I　Construction Cost Estimation

Appendix I-1 Construction Cost for Cachiyacu Power Station

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$/$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

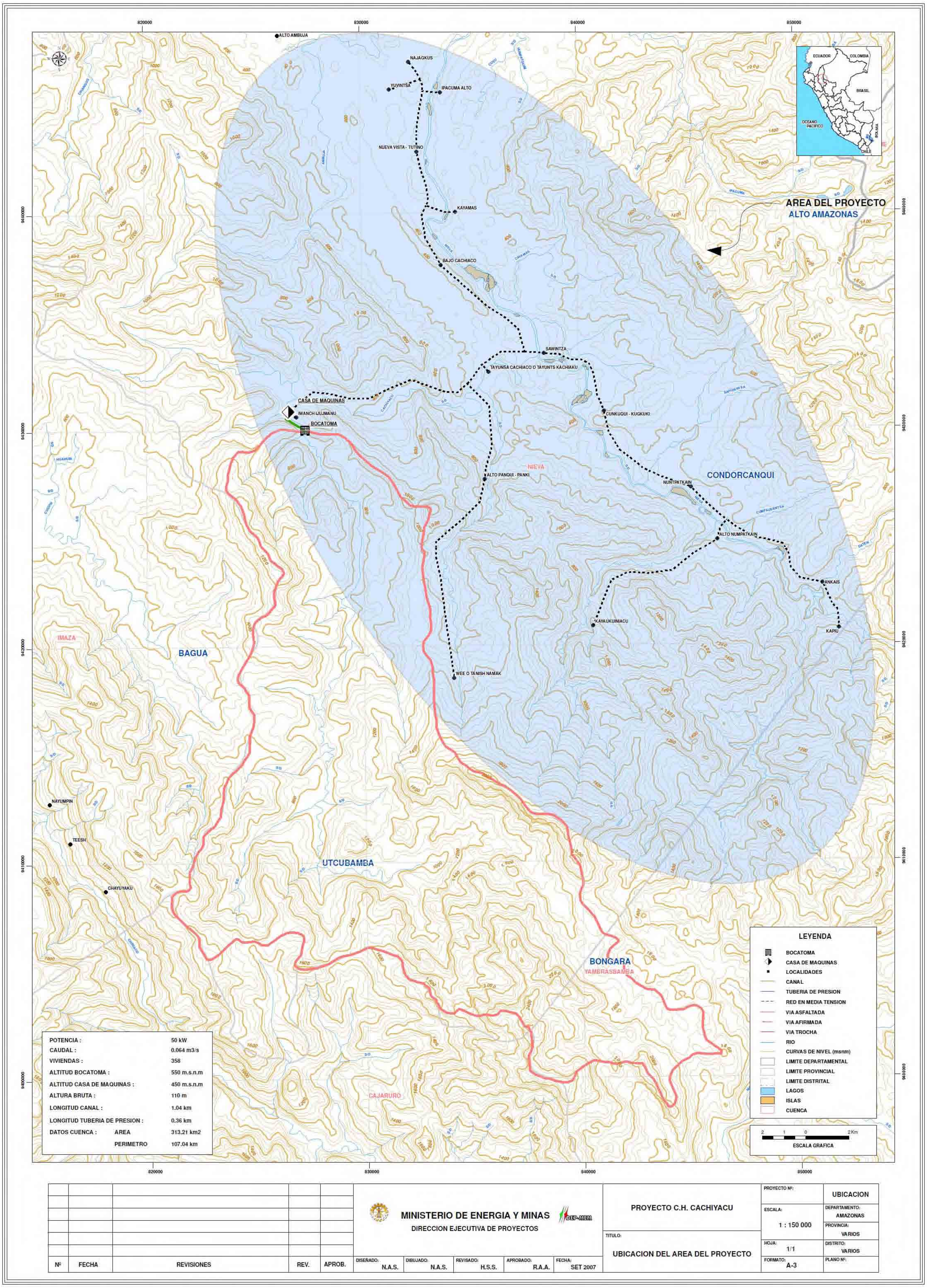
(3) Others

Access Road	:	**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



Appendix I-2 Construction Cost for Palcapampa Power Station

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/cm²)
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:

	$(B \times H)$^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)

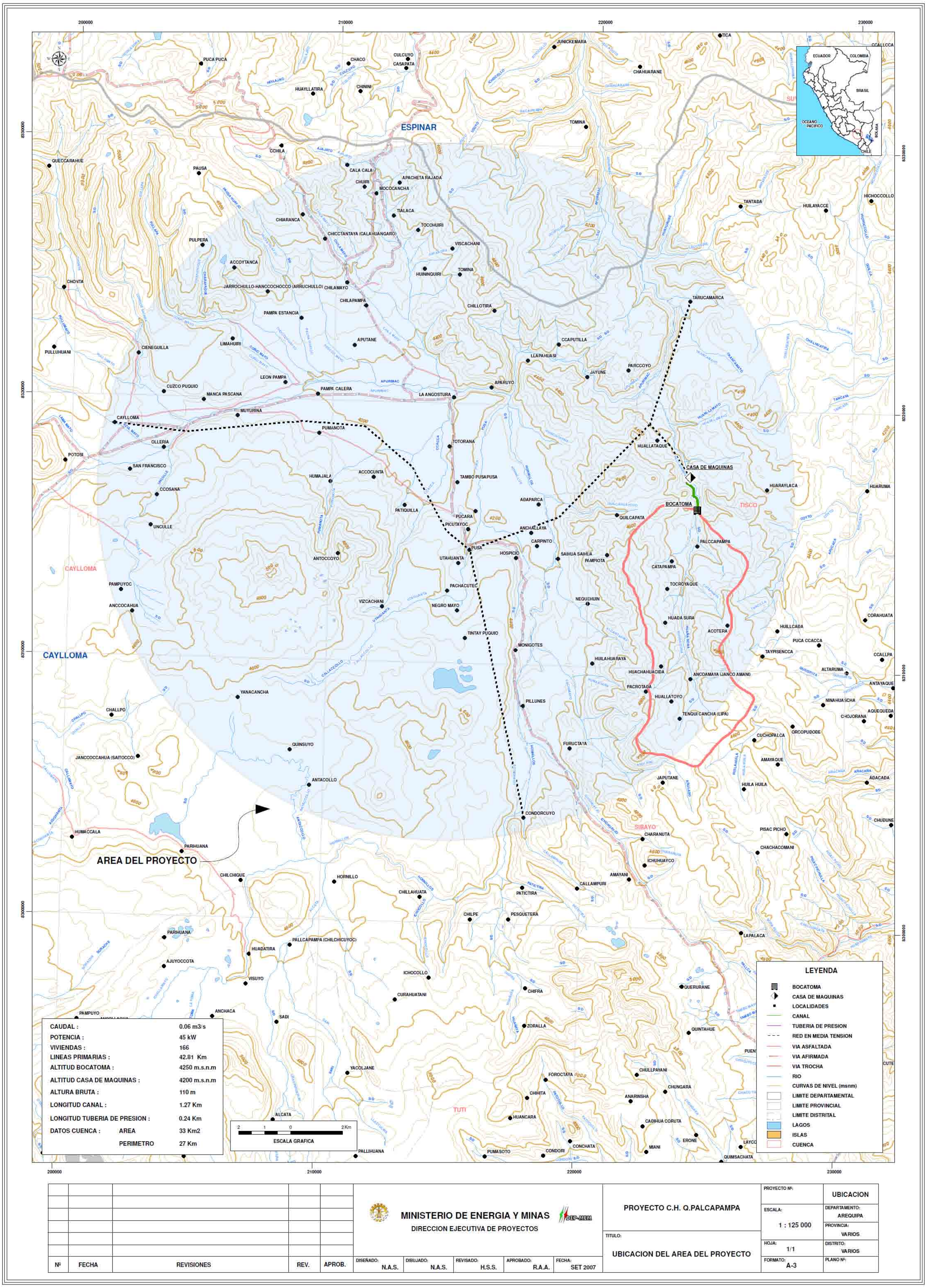
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US\$/m^3)	* (8.70+2.35) x 0.5 = \$5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US\$/m^3)	
Concrete				
Open	:	**93.05**	(US\$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)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



Appendix I-3 Construction Cost for La Majada Power Station

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:

	$(B \times H)^{\wedge}0.5 = 1.09 \times Q^{0.379}$	=	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)

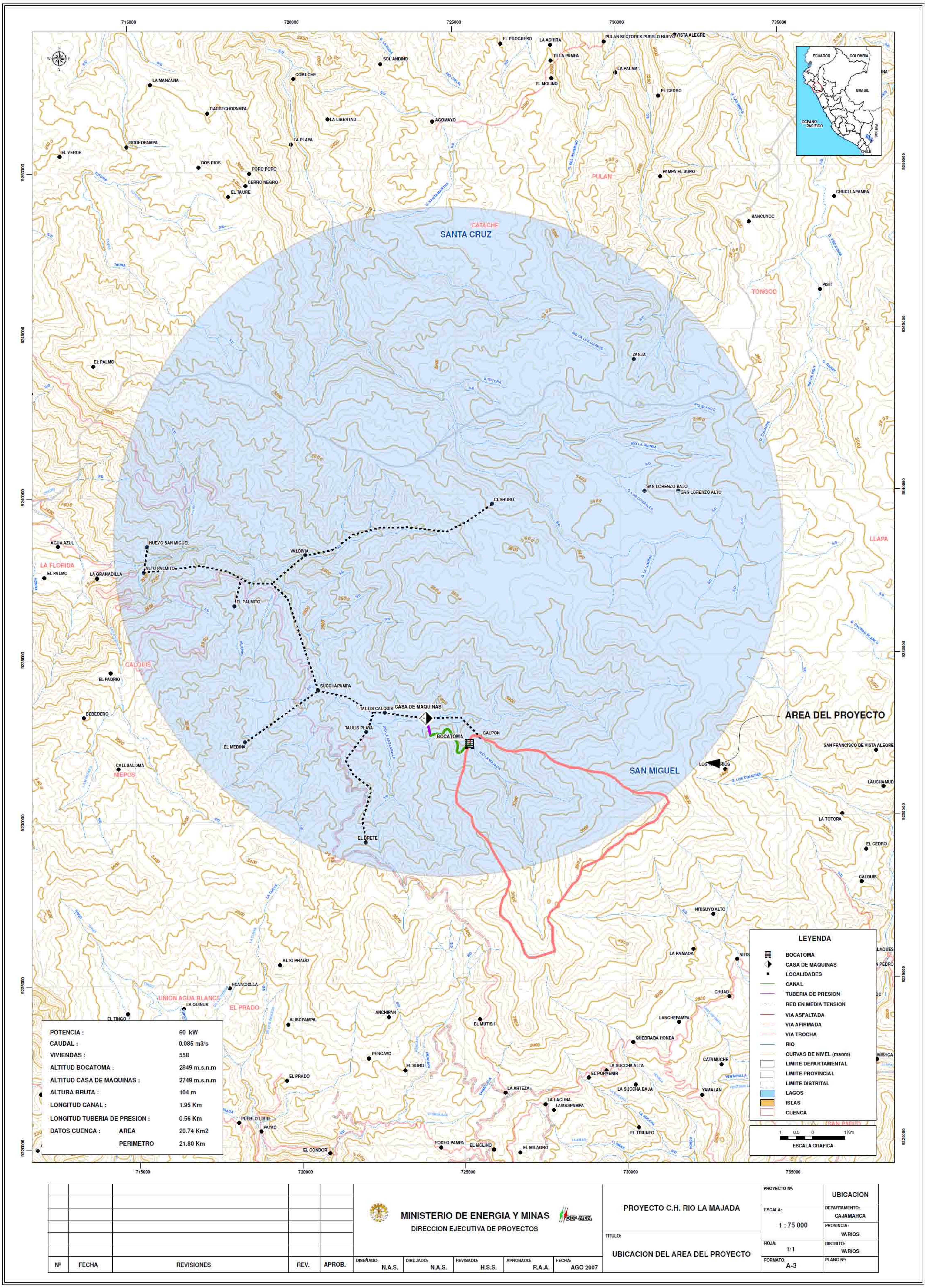
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel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



Appendix I-4 Construction Cost for Quebrada Honda Power Station

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:

	$(B \times H)^{0.5}$ =	$1.09 \times Q^{0.379}$	=	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)

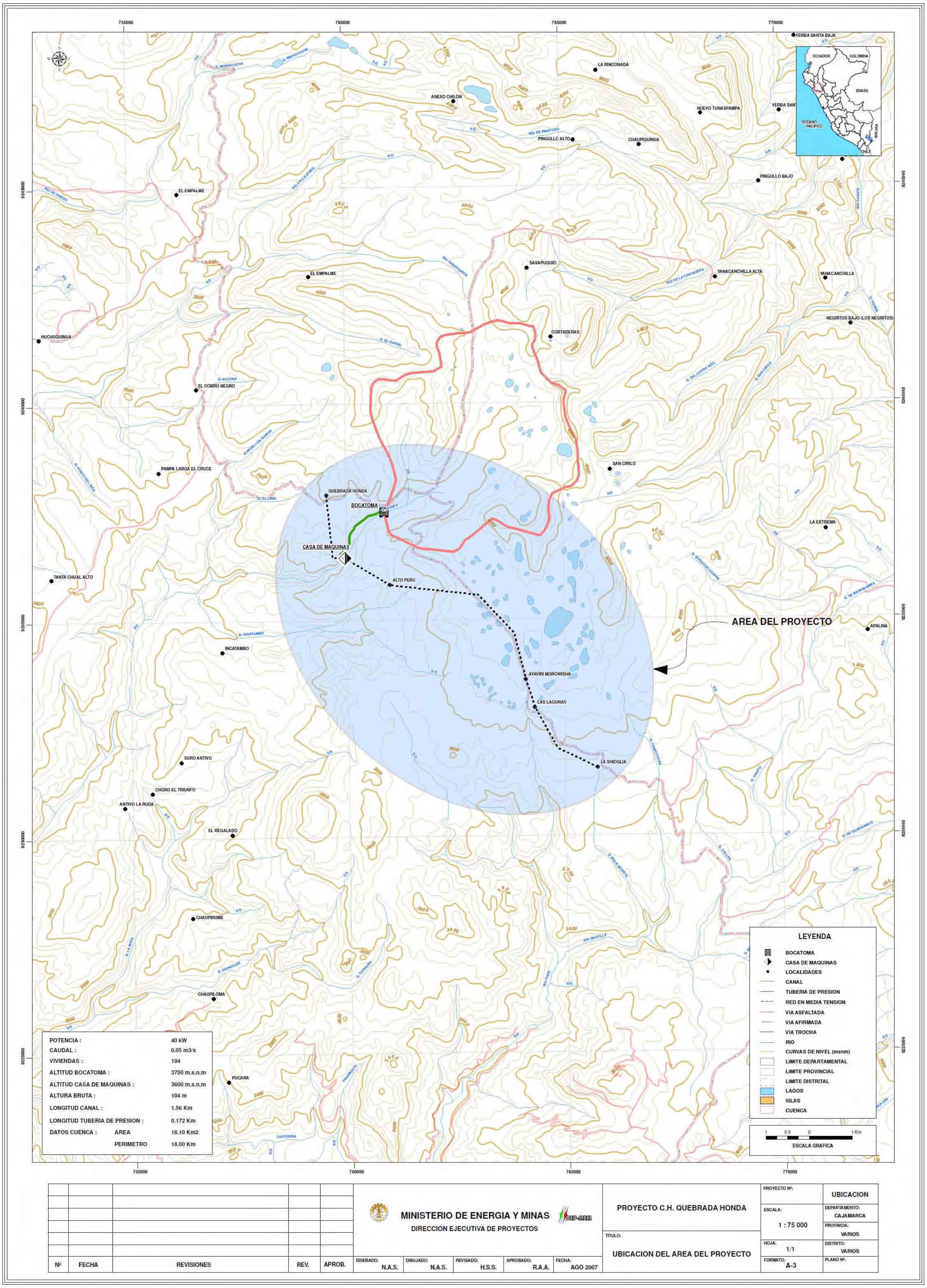
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/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-5 Construction Cost for Yerba Buena Power Station (in the case of PVC for Headrace)

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 x H x 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 x t x 2 + (B + 2t) x 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$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

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

(3) Others				
Access Road	:	**-**	(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
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**

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

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