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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION,
PARANÁ STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

SECTORAL REPORT VOLUME N

COST ESTIMATE, AND ECONOMIC AND FINANCIAL ASSESSMENT

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December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

and

Nippon Koei Co., Ltd.
Tokyo, Japan

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Cost Estimate is Based
on The Price Level of August, 1994,
According to The Following Exchange Rate.

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(as of August, 1994)

COMPOSITION OF FINAL REPORT

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   - II. Master Plan for Iguaçu River Basin
   - III. Master Plan for Tibagi River Basin

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COST ESTIMATES

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List of Abbreviation

CEPA	:	State Commission for Agricultural Planning *Comissão Estadual de Planejamento Agrícola*
COMEC	:	Coordination of the Metropolitan Area of Curitiba *Coordenação da Região Metropolitana de Curitiba*
CONAMA	:	National Council of Environment *Conselho Nacional do Meio Ambiente*
COPATI	:	Inter Municipal Concessionaire for the Environmental Protection of the Tibagi River Basin *Consórcio Intermunicipal para a Proteção Ambiental de Bacia do Rio Tibagi*
COPEL	:	Energy Company of the State of Paraná *Companhia Pananaense de Energia*
CORPRERI	:	Permanent Regional Commission Against Floods in the Iguaçu River *Comissão Regional Permanente Contra as Cheias do Rio Iguaçu*
DAGRI	:	Agricultural Operation Department *Departamento Operacional da Agricultura*
DEPEC	:	Livestock Department *Departamento de Pecuária*
DERAL	:	Economy Department *Departamento de Economia*
DNAEE	:	National Department of Water and Electric Energy *Departamento Nacional de Águas e Energia Elétrica*
ELETROBRAS	:	Brazilian Central Electric Joint-stock Company *Centrais Elétricas Brasileiras S.A.*
ELETROSUL	:	Electric Center of the South *Centrais Elétricas do Sul do Brasil S.A.*
EMATER	:	Paraná State Technical Assistance and Rural Extension Company *Empresa Paranaense de Assistência Técnica e Extensão Rural*
EMBRAPA	:	Brazilian Agriculture and Livestock Research Company *Empresa Brasileira de Pesquisa Agropecuária*

FAMEPAR	:	Institute for Municipal Assistance of Paraná State *Instituto de Assistência aos Municípios do Estado do Paraná*
FAO	:	Food and Agriculture Organization *Fundo das Nações Unidas para Alimentação e Agricultura*
IAP	:	Environmental Institute of Paraná *Instituto Ambiental do Paraná*
IAPAR	:	Agricultural Research Institute of Paraná *Instituto Agronômico do Paraná*
IBAMA	:	Brazilian Institute of Environment and Renewable Natural Resources *Instituto Brasileiro do Meio Ambiente e de Recursos Naturais Renováveis*
IBDF	:	Brazilian Forest Development Institute (current IBAMA) *Instituto Brasileiro de Desenvolvimento Florestal*
IBGE	:	Brazilian Institute of Geography and Statistic *Instituto Brasileiro de Geografia e Estatística*
IPARDES	:	Economic and Social Development Institute of the State of Paraná *Instituto Paranaense de Desenvolvimento Econômico Social*
JICA	:	Japan International Cooperation Agency *Agência de Cooperação Internacional do Japão*
MERCOSUL	:	South Common Market in Brazil, Argentina, Uruguay and Paraguay *Merca do Cone Sul*
MINEROPAR	:	Paraná State Mineral Company *Minerais do Paraná S/A*
PROSAM	:	Environmental Sanitation Program for Curitiba Metropolitan Region *Programa de Saneamento de Região Metropolitan de Curitiba*
SANEPAR	:	Sanitation Company of the State of Paraná *Companhia de Saneamento do Paraná*
SEAB	:	State Secretariat of Agriculture and Supply *Secretaria de Estado da Agricultura e do Abastecimento*
SEDU	:	State Secretariat of Urban Development *Secretaria de Estado do Desenvolvimento Urbano*

SEFA	:	State Secretariat for Treasury Secretaria de Estado da Fazenda
SEID	:	State Secretariat for Industry, Commerce and Economic Development *Secretaria de Estado da Indústria, Comércio e do Desenvolvimento Econômico*
SEMA	:	State Secretariat of Environment *Secretaria de Estado do Meio Ambiente*
SEPL	:	State Secretariat of Planning and General Coordination *Secretaria de Estado do Planejamento e Coordenação Geral*
SETR	:	State Secretariat of Transport *Secretaria de Estado dos Transportes*
SIMEPAR	:	Meteorological System of Paraná *Sistema Meteorológico do Paraná*
SETI	:	State Secretariat of Science, Technology and Higher Education *Secretaria de Estado da Ciência, Technologia e Ensino Superior*
SUCEAM	:	Superintendency of Erosion Control and Environmental Sanitation *Superintendência do Controle de Erosão e Saneamento Ambiental*
SUREHMA	:	Superintendency of Water Resources and Environment *Superintendência dos Recursos Hidricos e Méio Ambriente*
UEL	:	State University of Londrina *Universidade Estadual de Londrina*
UNDP	:	United Nation Development Program *Programa das Nações Unidas para o Desenvolvimento*

CHAPTER 1 COST ESTIMATE

1.1 General

Project costs are estimated by applying the methods used in the relevant entity of the sector. The following general conditions are reviewed at first in cost estimation:

1) Facility plans and implementation schedules formulated in each sector of the Master Plan

2) Composition of project costs

3) Unit price, price escalation and exchange rate

4) Cost estimate standards or other materials for cost estimation

Basic information for the estimation is obtained from the following materials:

a) Table of composite unit price, July 1994, SANEPAR

b) The master plan on water supply in Metropolitan Region of Curitiba, June, 1991, SANEPAR

c) The master plan on sewage treatment in Metropolitan Region of Curitiba, Sep. 1993, SANEPAR

d) Hydroelectric inventory of river basin handbook, Sep. 1984, ELETROBRÁS

e) The study of inventory energy in the Tibagi basin, May 1994, COPEL

1.2 Quantity of Construction Works and Construction Schedule by Sector

Projects proposed in the Master Plan are listed by river basin, and scheduled to be implemented for 20 years from 1996 to 2015. The quantity and the schedule are as follows

1) Water Supply Sector; Table-1.1, and 1.2

2) Sewerage Sector; Table-1.3

Table-1.1 Development Scale and Implementation Schedule of Water Supply Projects in the Iguaçu River Basin

Area	Project	Water Resource	Development Volume (m3/s)	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
<Curitiba Metropolitan Area>																							
		Wells (StageI)	111,000	■	■	■																	
		Wells (StageII)	103,000				■	■	■														
		Irai Dam	121,000						■	■	■	■											
		Piraquara II Dam	65,000									■	■	■	■								
		Pequeno Dam	69,000											■	■	■	■						
		Alto Miringuava Dam	52,000													■	■	■	■				
		Cotia Despique Dam	104,000															■	■	■	■		
<Large Urban Area>																							
	Cascavel	Sao Jose River (I)	13,000	■	■	■	■	■															
		Sao Jose River (II)	13,000						■	■	■	■	■										
		Wells (StageI)	16,000											■	■	■	■	■					
		Wells (StageII)	10,000																■	■	■	■	■
	Foz do Iguacu	Parana River (I)	30,000	■	■	■	■	■															
		Parana River (II)	30,000						■	■	■	■	■										
		Parana River (III)	30,000											■	■	■	■	■					
	Guarapuava	Bananas River (I)	13,000	■	■	■	■	■															
		Bananas River (II)	12,000								■	■	■	■	■								
<Middle Urban Area>																							
	Francisco Beltrao	Marrecas River (I)	10,000	■	■	■	■	■															
		Marrecas River (II)	10,000								■	■	■	■	■								
	Pato Branco	Chopim River	10,000	■	■	■	■	■															
	Medianeira	Wells (Stage II)	11,000	■	■	■	■	■															
	Dois Vizinhos	Chopim River	12,000	■	■	■	■	■															
	Palmas	Caldeiras River	6,000	■	■	■	■	■															
	Uniao da Vitoria	Iguacu River	3,000	■	■	■	■	■															

Table-1.1 Development Scale and Implementation Schedule of Water Supply Projects in the Iguaçu River Basin

Area	Project	Water Resource	Development Volume (m3/s)	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
<Curitiba Metropolitan Area>																							
		Wells (StageI)	111,000	■	■	■																	
		Wells (StageII)	103,000				■	■	■														
		Irai Dam	121,000						■	■	■	■											
		Piraquara II Dam	65,000									■	■	■	■								
		Pequeno Dam	69,000											■	■	■	■						
		Alto Miringuava Dam	52,000													■	■	■	■				
		Cotia Despique Dam	104,000															■	■	■	■		
<Large Urban Area>																							
	Cascavel	Sao Jose River (I)	13,000	■	■	■	■	■															
		Sao Jose River (II)	13,000						■	■	■	■	■										
		Wells (StageI)	16,000											■	■	■	■	■					
		Wells (StageII)	10,000																■	■	■	■	■
	Foz do Iguacu	Parana River (I)	30,000	■	■	■	■	■															
		Parana River (II)	30,000						■	■	■	■	■										
		Parana River (III)	30,000											■	■	■	■	■					
	Guarapuava	Bananas River (I)	13,000	■	■	■	■	■															
		Bananas River (II)	12,000								■	■	■	■	■								
<Middle Urban Area>																							
	Francisco Beltrao	Marrecas River (I)	10,000	■	■	■	■	■															
		Marrecas River (II)	10,000								■	■	■	■	■								
	Pato Branco	Chopim River	10,000	■	■	■	■	■															
	Medianeira	Wells (Stage II)	11,000	■	■	■	■	■															
	Dois Vizinhos	Chopim River	12,000	■	■	■	■	■															
	Palmas	Caldeiras River	6,000	■	■	■	■	■															
	Uniao da Vitoria	Iguacu River	3,000	■	■	■	■	■															

Table-1.2 Development Scale and Implementation Schedule of Water Supply Projects in the Tibagi River Basin

Area	Project	Water Resource	Development Volume (m3/s)	Construction Schedule 96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
<Large Urban Area>																							
	Ponta Grossa	Tibagi River (I)	18,000	■	■	■	■	■															
		Tibagi River (II)	19,000						■	■	■	■	■										
	Londrina & Canbe	Tibagi River (I)	35,000	■	■	■	■	■															
		Tibagi River (II)	35,000						■	■	■	■	■										
		Tibagi River (III)	36,000											■	■	■	■	■					
	Apucarana	Wells (Stage II)	22,000	■	■	■	■	■															
		Wella (Stage I)	23,000						■	■	■	■	■										
<Middle Urban Area>																							
	Castro	Iapo River (I)	11,000	■	■	■	■	■															
		Iapo River (II)	11,000						■	■	■	■	■										
	Telemaco Borba	Tibagi River (I)	9,000	■	■	■	■	■															
		Tibagi River (II)	9,000						■	■	■	■	■										
	Cornelio Procopio	Congonhas River	6,000	■	■	■	■	■															
	Arapongas	Wells (Stage I)	11,000	■	■	■	■	■															
		Pirapo River	9,000														■	■	■	■	■		
	Ibipora	Tibagi River	9,000	■	■	■	■	■															
	Irati	Imbituvinha River	6,000	■	■	■	■	■															

Table-1.2 Development Scale and Implementation Schedule of Water Supply Projects in the Tibagi River Basin

Area	Project	Water Resource	Development Volume (m3/s)	Construction Schedule																			
				96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
<Large Urban Area>																							
	Ponta Grossa	Tibagi River (I)	18,000	—	—	—	—	—															
		Tibagi River (II)	19,000						—	—	—	—	—										
	Londrina & Canbe	Tibagi River (I)	35,000	—	—	—	—	—															
		Tibagi River (II)	35,000						—	—	—	—	—										
		Tibagi River (III)	36,000											—	—	—	—	—					
	Apucarana	Wells (Stage II)	22,000	—	—	—	—	—															
		Wella (Stage I)	23,000						—	—	—	—	—										
<Middle Urban Area>																							
	Castro	Iapo River (I)	11,000	—	—	—	—	—															
		Iapo River (II)	11,000						—	—	—	—	—										
	Telemaco Borba	Tibagi River (I)	9,000	—	—	—	—	—															
		Tibagi River (II)	9,000						—	—	—	—	—										
	Cornelio Procopio	Congonhas River	6,000	—	—	—	—	—															
	Arapongas	Wells (Stage I)	11,000	—	—	—	—	—															
		Pirapo River	9,000														—	—	—	—	—		
	Ibipora	Tibagi River	9,000	—	—	—	—	—															
	Irati	Imbituvinha River	6,000	—	—	—	—	—															

Table-1.3 Treatment Capacity and Implementation Schedule of Sewerage Projects

Basin	Municipality	Treatment Capacity m^3/day	Construction Schedule 1996 ~ 2000	2001 ~ 2005	2006 ~ 2010	2011 ~ 2015
Iguaçu River	Curitiba M.A	420,000	100,000 m^3/d	100,000 m^3/d	100,000 m^3/d	120,000 m^3/d
	Cascavel	45,000	20,000 m^3/d		25,000 m^3/d	
Tibagi River	Ponta Grossa	30,000	30,000 m^3/d			
	Londrina	70,000		40,000 m^3/d		30,000 m^3/d

1.3 Composition of Project Cost

Project Costs are composed of direct costs and indirect costs as shown in Figure-1.1. Contingency is estimated as 15% of the total of direct costs, 1 - 3 in Figure-1.1. Costs for engineering services and administration are calculated as 10% of the total of item 1 - 5 in the figure for water supply and sewerage project, while that for river works construction for flood control is estimated as 30% of the same, referring cost estimate examples of the COPEL.

- Project cost
  - Direct cost
    - ① Preparatory work (access road, clearing quarry site)
    - ② Main construction work (civil work)
    - ③ Equipment cost
  - Indirect cost
    - ④ Land acquisition
    - ⑤ Contingency
    - ⑥ Engineering service and Administration

Figure-1.1 Composition of Project Cost

1.4 Unit Price and Unit Construction Cost in Paraná State

Project costs are estimated applying prices in August, 1994 with an exchange rate of US$ 1=R$ 0.89.

The most up-to-date construction costs in Paraná are shown in "Cost of Construction (Cotacao da Construcao), July, 1994, which includes costs of material, labor and equipment.

As one example, material costs in Paraná State, which is divided into the following three regions, are shown in Table-1.4.

1) South Region: Curitiba, Ponta Grossa
2) North Region: Londrina, Maringa
3) West Region: Cascavel, Foz do Iguaçu

Unit costs applied for the project cost estimate are shown in Table-1.5. The unit costs are estimated through an examination of the a) of the materials listed in Section 1.1 of this chapter.

Table-1.4 Material Cost in Paraná

Unit Price in July 1994

(unit: R$)

Description	Unit	South Region	North Region	West Region
Gravel (stone)	m^3	16.00	14.42	13.00
Gravel (crushed stone)	m^3	20.00	19.00	18.00
Coarse Sand	m^3	20.00	19.00	18.00
Medium Sand	m^3	19.00	17.85	17.00
Fine Sand	m^3	18.00	17.00	16.00
Portland Cement	kg	0.14	0.11	0.12
Reinforced Bar D13	kg CA-50	0.70	0.62	0.60
Reinforced Bar D16	kg CA-50	0.80	0.61	0.50
Reinforced Bar D19	kg CA-50	0.80	0.61	0.50
Concrete pipe Ø 0.40	Ø 0.40 x 1.00	16.00	14.50	13.00
Concrete pipe Ø 0.80	Ø 0.80 x 1.00	56.00	53.20	51.00
Concrete pipe Ø 1.20	Ø 1.20 x 1.00	119.00	114.00	110.00
Gasoline	10 liters	5.40	5.40	5.40
Diesel oil	10 liters	3.40	3.40	3.40
Alcohol	10 liters	4.30	4.30	4.30
Lubricating oil	20 liters	38.00	38.00	38.00

Table-1.5 Unit Cost for the Project

Items	Work Item	Description	Unit	Unit Cost (US$)
Preparatory work	Access Road	in irregular region	m	580
		in way region	m	170
		in flat region	m	100
	Clearing quarry site	small scale	set	700,000
		medium scale	set	800,000
		large scale	set	900,000
Main Construction work	earth Dams dike	excavation	m^3	6
		foundation	m^3	8
		compacted filling	m^3	14
	Spillway, Intake	excavation	m^3	12
		foundation	m^3	23
		concrete	m^3	400
	River bed excavation	rock	m^3	40
	Drilling	Karst (250mm - 60m)*	m	600
		Serra General (north) (200mm - 180m)*	m	150
		Serra General (south) (200mm - 180m)*	m	150
		Furnas (200mm - 150m)*	m	100
		Botucatu (300mm -1000m)*	m	1,000
		Guabirotuba (150mm - 80m)*	m	200

(Note) * diameter (mm) - depth (m)

1.5 Cost Estimate for Surface Water Development Projects

Facilities for surface water development comprise of dams for water storage, intakes pipelines and pump stations.

(1) Dam Construction Cost

Project costs for dam construction are computed through calculation of dam embankment volume and application of correlation curve between project cost and dam embankment volume. The project cost - dam embankment volume correlation curve applied is drawn according to cost estimates for 10 dam construction projects by the SANEPAR, using prices in 1991, given in the material b) of Section 1.1. A price increase ratio of 1.14 is applied based on the increase in unit price of concrete.

- unit price of concrete in July 1991; US$ 350
- unit price of concrete in August 1994; US$ 400
- price increase ratio; 1.14=350/400

Obtained correlation curve is illustrated in Figure-1.2.

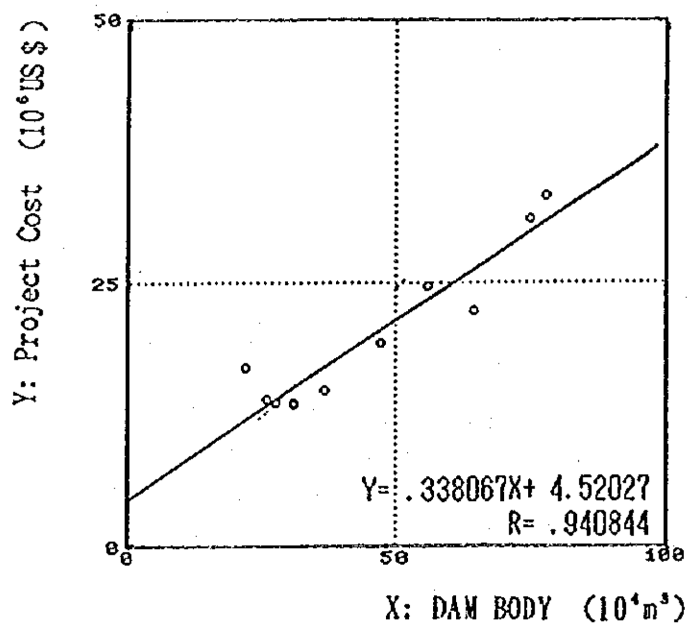
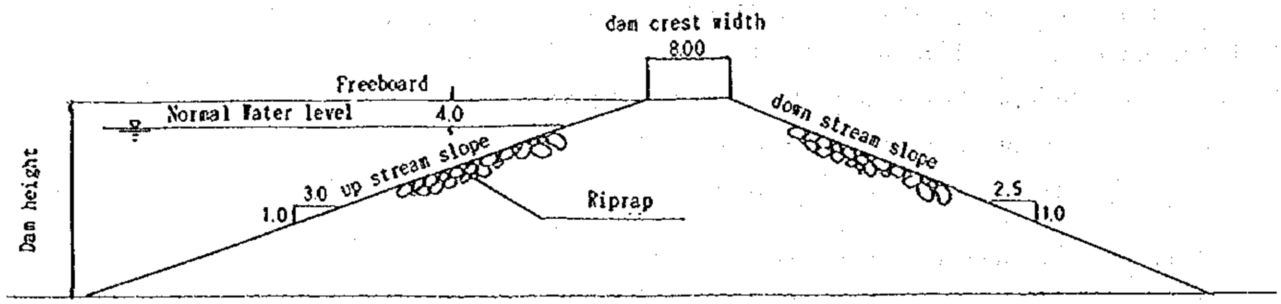


Figure-1.2 Correlation Curve of Project Cost - Dam Embankment Volume

Scales of dams are determined as follows:

- to prepare storage capacity curve by planned site of reservoir
- to calculate required storage corresponding to water developed
- to determine normal water level and dam crest elevation
- to compute dam embankment volume by multiplying crest length with maximum cross section

Outlines of dam plans, embankment volumes, and estimated project costs for dam construction for water supply are shown in Table-1.6. Planned dam sites and storage capacity curves are shown in Appendix-1. The estimated project costs include those for appurtenant facilities such as spillway and intakes.



Assumptions for Dam Plan Criteria

Dam embankment volume (V)

A dam embankment volume is estimated by the empirical formula below

$V = 1/2 \times B \times H \times (L_1 + L_2) + 1/6 \times (m + n) \times H^2 \times (L_1 + 2 \times L_2)$

Where,

B	:	dam crest width (8.00 m)
m	:	upstream slope of dam embankment (3.0)
n	:	downstream slope of dam embankment (2.5)
H	:	dam height (m)
L1	:	dam length at crest (m)
L2	:	dam length at bottom (m)
Freeboard	:	dam 4.0 m

Figure-1.3 Cross Section of Dam

Table-1.6 Scales and Construction Costs of Dams

Site No.	Name	Location	Type	Catchment Area (Km²)	Reservoir						Dam Embankment				
					N.W.L (m)	Development Volume (m/seocnd)	Dead Storage (10^6 m^3)	Active Storage (10^6 m^3)	Gross Storage (10^6 m^3)	Crest (m)	Length (m)	Height (m)	Embankment Volume (x $10^3 m^3$)	Project cost (x10^6US$)
1	Irai	near Curitiba	Earth fill Dam	112.6	891.4	1.40	5.0	52.4	57.4	895.4	1,350	13.3	780	35.2
2	Piraquara‡U	ditto	ditto	58.0	890.3	0.75	1.1	21.9	23.0	894.3	600	11.3	240	14.4
3	Pequeno	ditto	ditto	62.3	895.4	0.80	3.0	25.4	28.4	899.4	250	15.9	140	22.0
4	Alto Miringuava	ditto	ditto	71.9	895.4	0.60	3.2	19.4	22.6	899.4	450	14.7	410	21.0
5	Cotia Despique	ditto	ditto	154.7	879.2	1.20	7.4	38.9	46.3	883.2	880	13.6	608	28.6
6	Alto Mauricio	ditto	ditto	36.0	892.2	0.25	2.4	7.8	10.2	896.2	450	12.2	150	10.9
7	Das Oncas (Mandirituba)	ditto	ditto	29.0	884.3	0.20	1.7	5.8	7.5	888.3	470	11.8	330	17.9
8	Faxinal	ditto	ditto	63.3	878.9	0.50	3.2	14.9	18.1	882.9	590	13.4	343	18.4
9	Das Oncas (Contenda)	ditto	ditto	75.6	871.7	0.60	1.5	16.8	18.3	875.7	380	13.7	250	14.8
10	Piunduva	ditto	ditto	25.4	875.7	0.20	1.1	6.7	7.8	879.7	410	15.7	270	15.6

Note: Project Costs are derived from the figures obtained from the Correlation curve shown in Figure-1.1 multiplied with price escalation ratio of 1.14.

(2) Pipeline and Pump Station Construction Cost

Economical diameter of pipeline can be determined according to volume of water conveyed, distance of conveyance and generating power of a pump. An economical velocity 1.5 - 1.9 m/second of water inside a pipeline is applied as calculated in the material a) of the SANEPAR. Diameters of pipelines in proposed facilities are selected to make the velocity of inside water 1.5 - 1.9 m/second. Project costs for pipeline construction are estimated by applying the correlation curve between pipeline diameter and unit construction cost, shown in Figure-1.4. A ratio of 1.14 is multiplied to adjust for price escalation.

Generating power of a pump is determined with total water head from an intake point to a treatment plant. Project costs for pump station construction are estimated by applying a correlation between a figure of generating power of pump multiplied with volume of water. The price escalation ratio of 1.14 are also applied. The correlation curve between pump generating power x volume of water and construction costs is shown in Figure-1.5.

Project costs for construction pipelines and pump stations for surface water development in the Iguaçu River Basin and the Tibagi River Basin are shown in Table-1.7 and 1.8, respectively.

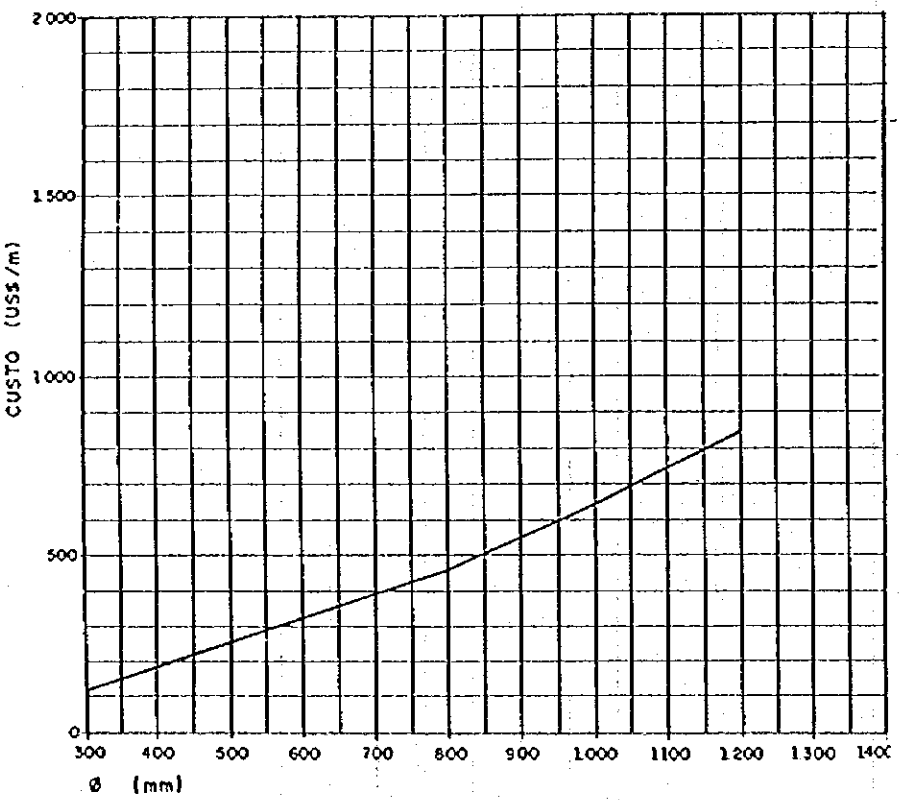
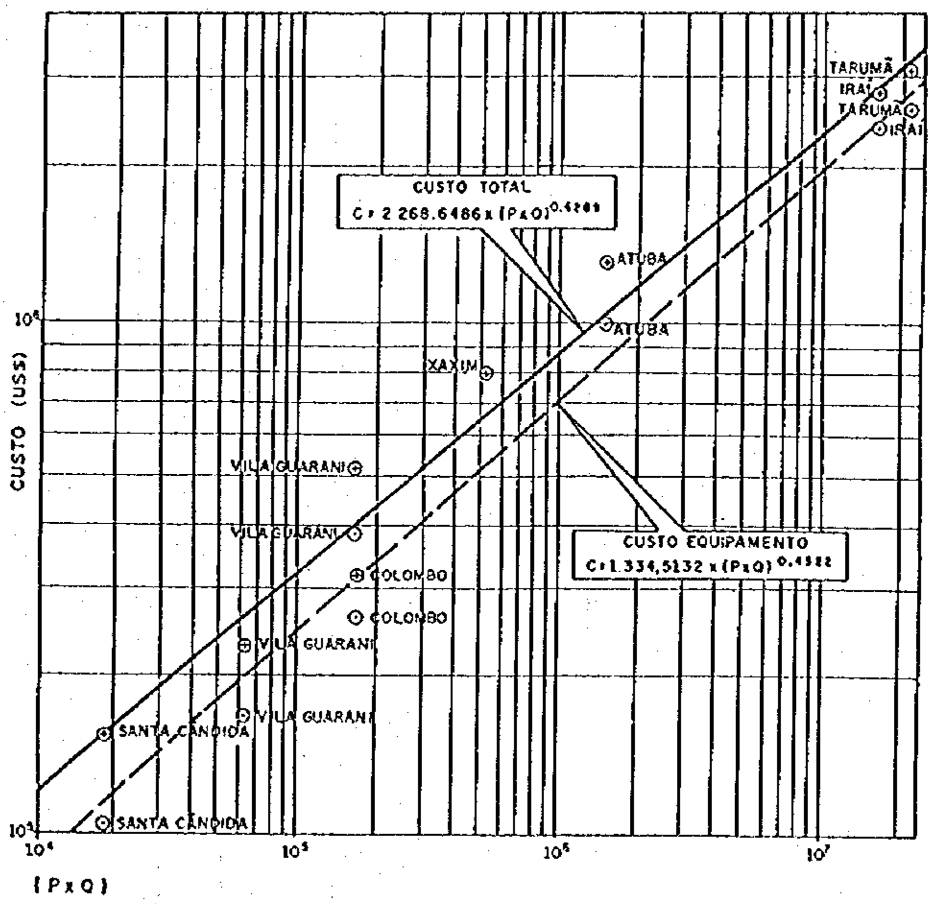


Figure-1.4 Correlation Curve between Diameters of Pipeline and Unit Costs



NOTA:

P - POTÊNCIA (CV) - N.º TOTAL BOMBAS X POTÊNCIA DA BOMBA
Q - VAZÃO (l/s) - N.º TOTAL BOMBAS X VAZÃO DA BOMBA

Figure-1.5 Correlation Curve between Scale of Pump Stations and Project Costs

Table-1.7 Construction Costs of Pipelines and Pump Stations for Surface Water Development (Iguaçu River Basin)

No.	Basin	River	Municipality	Water Developed (m^3/s)	Pipeline Diameter (mm)	Distance (m)	Unit Price US$/m	Construction Cost (10^6US$)	Pump (PS)	Water Developed x P	Construction Cost (10^6US$) (Pump Station)	Project Cost (10^6US$)	PC	Project Cost (10^6US$)
	Iguacu	Irai, Piraquara II	CM.A	2.150	1,200	15,000	980	14.70	4,140	8.90	2.48	17.18		
	ditto	Pequeno	ditto	0.800	800	8,000	530	4.24	1,350	1.08	1.01	5.25		
	ditto	Alto Miringuava	ditto	0.600	700	23,500	450	10.58	870	0.52	0.74	11.32		
	ditto	Cotia Despique	ditto	1.200	900	17,000	630	10.71	1,740	2.09	1.33	12.04		
			ditto	0.450	600	18,000	380	6.84	650	0.29	0.57	7.41		
	ditto	Alto Mauricio	ditto	0.250	400	14,000	210	2.94	430	0.11	0.38	3.32		
		Das Oncas (Mandiritu)	ditto	0.200	400	8,500	210	1.79	290	0.06	0.29	2.08		
	ditto	Faxinal	ditto	0.500	600	13,000	380	4.94	730	0.37	0.64	5.58		
	ditto	Das Oncas (Contenda)	ditto	0.600	700	13,000	450	5.85	1,010	0.61	0.79	6.64		
	ditto	Piunduva	ditto	0.200	400	5,000	210	1.05	340	0.07	0.31	1.36		
S-FI1	Iguacu	Itaipu Reservoir	Foz do Iguacu	0.347	500	1,900	300	0.57	170	0.06	0.29	0.86	3	2.58
S-C1 (c.R.S.i)	ditto	RioSaoJose	Cascavel	0.150	300	13,000	120	1.56	260	0.04	0.25	1.81	2	3.62
S-G1	ditto	Rio Bananas	Guarapuava	0.146	300	4,800	120	0.58	710	0.10	0.37	0.95	2	1.90
S-M1	ditto	Rio Represa Grande	Medianeira	0.013	200	5,900	100	0.59	30	0.0004	0.04	0.63		
S-M2	ditto	Corrego Sango Funda	ditto	0.017	200	4,700	100	0.47	70	0.0012	0.06	0.53		
S-M3	ditto	Corrego Sol de Ouro	ditto	0.010	200	6,900	100	0.69	30	0.0003	0.03	0.72		
S-D3	ditto	Rio Chopim	Dois Vizinhos	0.134	300	7,500	120	0.90	580	0.08	0.33	1.23		
S-F1	ditto	Rio Marrecas	Francisco Beltrao	0.119	300	700	120	0.09	30	0.004	0.10	0.19	2	0.38
S-PB2	ditto	Rio Chopim	Pato Branco	0.112	300	12,500	120	1.50	460	0.05	0.27	1.77		
S-PA1	ditto	Rio das Caldeiras	Palmas	0.065	200	3,400	100	0.34	110	0.01	0.14	0.48		
S-UV1	ditto	Iguacu	Uniao da Vitoria	0.035	200	200	100	0.02	10	0.0004	0.04	0.06		
D-C3	ditto	Baneiro (II)	Cascavel	0.690	700	21,000	450	9.45	4,500	3.11	1.58	11.03		
D-C5	ditto	Antos	ditto	0.690	700	8,000	450	3.60	3,400	2.35	1.40	5.00		

c.R.S.i: combine with Rio do Salto intake

Table-1.8 Construction Costs of Pipelines and Pump Stations for Surface Water Development (Tibagi River Basin)

No.	Basin	River	Municipality	Water Developed (m^3/s)	Pipeline Diameter (mm)	Distance (m)	Unit Price US$/m	Construction Cost (10^6US$)	Pump (PS)	Water Developed x P	Construction Cost (10^6US$) (Pump Station)	Project Cost (10^6US$)	PC	Project Cost (10^6US$)
S-P1	Tibagi	Rio Tibagi	Ponta Grossa	0.217	400	6,000	210	1.26	700	0.15	0.43	1.69	2	3.38
S-L1	ditto	ditto	Londrina and Cambe	0.408	500	13,400	300	4.02	1,800	0.73	0.85	4.87	3	14.61
S-A1	ditto	Riveirao do Cerne	Apucarana	0.041	200	20,000	100	2.00	320	0.01	0.14	2.14		
S-A2	ditto	Rio Xaxim	ditto	0.009	200	13,500	100	1.35	70	0.0006	0.05	1.40		
S-CA1	ditto	Rio Iapo	Castro	0.125	300	1,200	120	0.15	180	0.02	0.19	0.34	2	0.68
S-T1	ditto	Rio Tibagi	Telemaco Borba	0.108	300	2,700	120	0.33	260	0.03	0.22	0.55	2	1.10
S-IR1	ditto	Rio Imbituvinga	Irai	0.075	300	13,200	120	1.59	80	0.01	0.14	1.73		
S-CP1	ditto	Congonhas	Corneiro Precopio	0.069	300	8,500	120	1.02	490	0.03	0.22	1.24		
S-AR1	ditto	Rio Pirapo	Arapongas	0.101	300	11,100	120	1.34	560	0.06	0.29	1.63		
S-CB	ditto	Rio Tibagi	Ibipora	0.105	300	6,900	120	0.83	280	0.03	0.22	1.05		

(3) Intake Construction Cost

Project costs for intake construction to derive surface water are shown in Table-1.9. Although a scale of intake is determined by size of river at the location, the costs are estimated by applying typical models of intake construction costs estimated, because topographic conditions of intake points are not known.

Table-1.9 Project Cost of Intake for Surface Water

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1.Preparatory work					
- access road	m	2,000	170	340	about 2,000 m
- other facilities	set	---			
2.Main construction work					
- Excavation	m^3	1,200	15	18	underwater excavation 1,200 m^3
- concrete	m^3	1,500	400	600	1,500 m^3
3.Equipment					
- well pump (100 kw)	pc			---	
- sub pump (700 kw)	pc			---	
- main pump (2,400 kw)	pc			---	
					Sub total 958 x 10^3 US$
4.Land Acquisition	ha			---	
5.Contingency	pc			144	15%
6.E/S & Administration	ps			110	10%
Total project cost				1,212	

1.6 Cost Estimate for Groundwater Development Projects

Facilities for groundwater development comprise of wells, well pumps, sub-pipelines, sub-pump stations and pipelines. Since the volume water abstracted from a well is small in Curitiba Metropolitan Region, sub-pipelines and sub-pump stations are necessary to convey a bulk of water to the Metropolitan Region.

A facility layout in Curitiba Metropolitan Region for groundwater development is illustrated in Figure-1.6. Because the groundwater development site is located in a hilly area far from existing roads, costs for access road construction and for transportation of equipment are also estimated in project costs. Costs for underwater pumps and other electric equipment as allocated in each of wells are also added into project costs. Costs for main pipelines and pump stations are estimated applying correlations shown in Figure-1.4 and 1.5. Estimated project costs for groundwater development are as follows:

1) Project costs for groundwater development in Curitiba Metropolitan Region; Table-1.10 - 1.13

2) Well Construction Costs in main cities in the Iguaçu River Basin and the Tibagi River Basin; Table-1.13 - 1.14

3) Costs for preparatory works, underwater pumps and electric equipment; Table-1.16 - 1.17

4) Costs for main pipeline and pump station construction in the Iguaçu River Basin and the Tibagi River Basin; Table-1.18 - 1.19

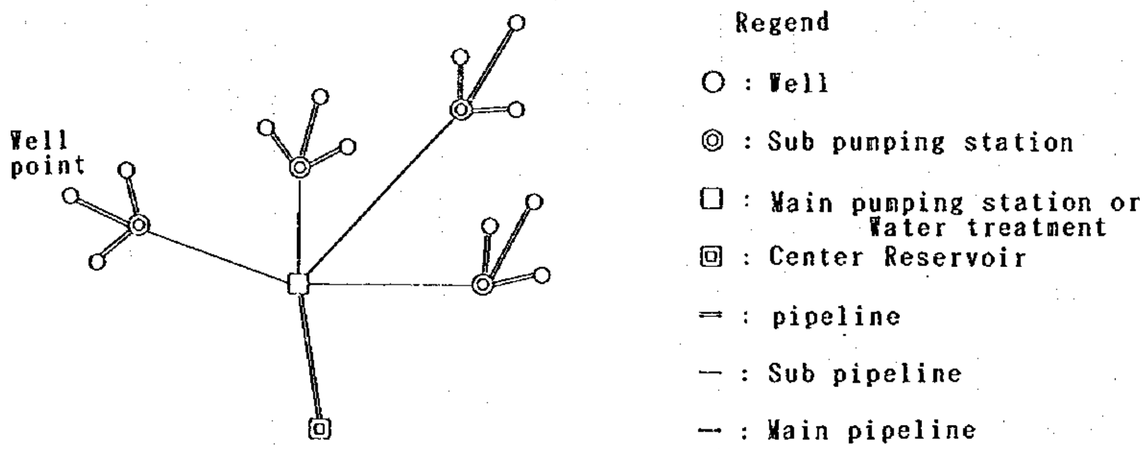


Figure-1.6 Facility Layout Plan for Groundwater Development in Curitiba Metropolitan Region

Table-1.10 Project Cost for Groundwater Development in Curitiva Metropolitan Region (state I)

(Yield 1.290 m^3/s 29 pc)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1.Preparatory work					
- access road	m	7,800	170	1326	200 x 39 = 7,800 m
- other facilities	set	39	5,000	195	electric facility
2.Main construction work					
- drilling	m	2,340	600	1,404	*39 pc x 60 = 2,340 m
- well pipeline (150 mm)	m	24,000	80	1,920	800 (m) x 6 x 5 = 24,000 m
- main pipeline (500 mm)	m	32,000	300	9,600	2.5 + 15 + 6 + 2 + 6.5 = 32.0 km
- main pipeline (1,000 mm)	m	10,000	750	7500	10,000 m
- sub pumping station	set	5	400,000	2,000	concrete 1,000 m^3
- main pumping station or water treatment station	set	---	1,200,000	1,200	concrete 3,000 m^3
3.Equipment					
- well pump (100 kw)	pc	**39	30,000	1,170	
- sub pump (700 kw)	pc	10	350 x 10^3	3,500	
- main pump (2,400 kw)	pc	2	1,000 x 10^3	2,000	
					Sub total US$ 31,815 x 10^3
4.Land Acquisition	ha	30.5	2,500	76	100 x 100 x 29 + 50 x 50 x 6 = 305,000 m^2
5.Contingency	pc			4,773	(1 ~ 3) x 15 %
6.E/S & Administration	ps			3,667	(1 ~ 5) x 10 %
Total project cost				40,331	

(Note) * Against required number of boreholes of 29, the cost of 39 boreholes are contained due to 75% of the success ratio (29 / 0.75 ≒ 39).

** Spare pumps (25 % of the total number) are included.

Table-1.11 Project Cost for Groundwater Development in Curitiva Metropolitan Region (state II)

(Yield 1.066 m^3/s 24 pc)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1.Preparatory work					
- access road	m	6,400	170	1,088	200 x 32 = 6,400 m
- other facilities	set	32	5,000	160	electric facility
2.Main construction work					
- drilling	m	1,920	600	1,152	*32 pc x 60 = 1,920 (m)
- well pipeline (150 mm)	m	28,800	80	2,304	1,200 (m) x 6 x 4 = 28,800 (m)
- main pipeline (500 mm)	m	57,000	300	17,100	18.5 + 19 + 7 + 12.5 = 57.0 (km)
- main pipeline (1,000 mm)	m	13,500	750	10,125	13,500 (m)
- sub pumping station	set	4	400,000	1,600	concrete 1,000 m^3
- main pumping station or water treatment station	set	1	1,200,000	1,200	concrete 3,000 m^3
3.Equipment					
- well pump (100 kw)	pc	**32	30,000	960	
- main pump (700 kw)	pc	2	350 x 10^3	2,800	
- main pump (2,400 kw)	pc	2	1,000 x 10^3	2,000	
					Sub total US$ 40,488 x 10^3
4.Land Acquisition	ha	34	2,500	85	100 x 100 x 32 + 50 + 50 x 5 = 332,500 m^2
5.Contingency	pc			6,074	(1 ~ 3) x 15 %
6.E/S & Administration	ps			4,665	(1 ~ 5) x 10 %
Total project cost				51,312	

(Note) * Against required number of boreholes of 24, the cost of 32 boreholes are contained due to 75 % of the success ratio (24 / 0.75 = 32).

** Spare pumps (25 % of the total number) are included.

Table-1.12 Project Cost for Groundwater Development in Curitiva Metropolitan Region (state III)

(Yield 1.066 m^3/s 24 pc)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1.Preparatory work					
- access road	m	6,400	170	1,088	200 x 32 = 6,400 m
- other facilities	set	32	5,000	160	electric facility
2.Main construction work					
- drilling	m	1,920	600	1,152	*32 pc x 60 = 1,920 (m)
- well pipeline (150 mm)	m	19,200	80	1,536	800 (m) x 6 x 4 = 19,200 (m)
- main pipeline (500 mm)	m	57,000	300	17,100	15 + 22 + 15 + 5 = 57.0 (km)
- main pipeline (1,000 mm)	m	17,000	750	12,750	17,000 (m)
- sub pumping station	set	4	400,000	1,600	concrete 1,000 m^3
- main pumping station or water treatment station	set	1	1,200,000	1,200	concrete 3,000 m^3
3.Equipment					
- well pump (100 kw)	pc	**32	30,000	960	
- sub pump (700 kw)	pc	8	350 x 10^3	2,800	
- main pump (2,400 kw)	pc	2	1,000 x 10^3	2,000	
					Sub total US$ 42,345 x 10^3
4.Land Acquisition	ha	34	2,500	85	100 x 100 x 31 + 50 + 50 x 5 = 332,500 m^2
5.Contingency	pc			6,352	(1 ~ 3) x 15 %
6.E/S & Administration	ps			4,879	(1 ~ 5) x 10 %
Total project cost				53,661	

(Note) * Against required number of boreholes of 24, the cost of 32 boreholes are contained due to 75% of the success ratio (24 / 0.75 = 32).

** Spare pumps (25 % of the total number) are included.

Table-1.13 Project Cost for Groundwater Development in Curitiva Metropolitan Region (state IV)

(Yield 1.066 m^3/s 24 pc)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1.Preparatory work					
- access road	m	6,400	170	1,088	200 x 32 = 6,400 m
- other facilities	set	32	5,000	160	electric facility
2.Main construction work					
- drilling	m	1,920	600	1,152	*32 pc x 60 = 1,920 (m)
- well pipeline (150 mm)	m	24,000	80	1,920	1,000 (m) x 6 x 4 = 24,000 (m)
- main pipeline (500 mm)	m	59,000	300	17,700	12 + 12 + 12 + 23 = 59 (km)
- main pipeline (1,000 mm)	m	17,000	750	12,750	17,000 (m)
- sub pumping station	set	4	400,000	1,600	concrete 1,000 m^3
- main pumping station or water treatment station	set	1	1,200,000	1,200	concrete 3,000 m^3
3.Equipment					
- well pump (100 kw)	pc	**32	30,000	960	
- sub pump (700 kw)	pc	8	350 x 10^3	2,800	
- main pump (2,400 kw)	pc	2	1,000 x 10^3	2,000	
					Sub total US$ 43,329 x 10^3
4.Land Acquisition	ha	34	2,500	85	100 x 100 x 31 + 50 + 50 x 5 = 332,500 m^2
5.Contingency	pc			6,500	(1 ~ 3) x 15 %
6.E/S & Administration	ps			4,992	(1 ~ 5) x 10 %
Total project cost				54,906	

(Note) * Against required number of boreholes of 24, the cost of 32 boreholes are contained due to 75% of the success ratio (24 / 0.75 = 32).

** Spare pumps (25 % of the total number) are included.

Table-1.14 Construction Costs of Wells in the Iguaçu River Basin

Iguaçu Basin (US$)

Municipalities	Stage	Number of Borehole (pc)	Depth/ Borehole (m)	Unit Price (US$)	Drilling Cost (US$ 10³)	Other Cost (US$ 10³)	Construction Cost (US$ 10³)
Cascavel	Stage I -1	5	180	150	189	1,250	1,439
Bortucatu Formations ——— 2 (1300m)	-2	1	1,300	1,000	1,300	350	1,650
Serra Geral Formation north1 - 8 (180m)	Stage II	4	180	150	135	1,000	1,135
	Stage III -1	5	180	150	189	1,250	1,439
	-2	1	1,300	1,000	1,300	350	1,650
	Stage IV	4	180	150	135	1,000	1,135
Guarapuava	Stage I	7	180	150	243	1,750	1,193
Botucatu Formation ——— 1 (800m)	Stage II	7	180	150	243	1,750	1,150
Serra Geral Formation south — 35 (180m)	Stage III -1	7	180	150	243	1,750	1,193
	-2	1	800	1,000	800	350	1,993
	Stage IV	7	180	150	243	1,750	1,150
	Stage V	7	180	150	243	1,750	1,993
Francisco Beltrao	Stage I	5	180	150	189	1,250	1,993
Botucatu Formation ——— 2 (1000m)	Stage II	1	1,000	1,000	1,000	350	1,350
Serra Geral Formation south —— 6 (180m)	Stage III	1	1,000	1,000	1,000	350	1,350
Medianeira	Stage I	5	180	150	189	1,250	1,439
Botucatu Formation ——— 1 (850m)	Stage II	1	850	1,000	850	350	1,200
Serra Geral Formation south —— 5 (180m)							
Dois Vizinhos	Stage I	4	180	150	135	1,000	1,135
Botucatu Formation ——— 1 (1200m)	Stage II -1	3	180	150	108	750	858
Serra Geral Formation south — 7 (180m)	-2	1	1,200	1,000	1,200	350	1,550
Palmas	Stage I	10	180	150	351	2,500	2,851
Serra Geral Formation south — 20 (180m)	Stage II	10	180	150	351	2,500	2,851
Pato Branco	Stage I	6	180	150	216	1,500	1,716
Botucatu Formation ——— 1 (1200m)	Stage II	1	1,200	1,000	1,200	350	1,550
Serra Geral Formation south— 6 (180m)							

Note: Drilling Cost include that for preparatory drilling contingency cost, 25 % for Serra Geral F, and 0 % for Botucatu F.

Other costs comprise these for preparatory work, underwater pumps and electric facilities.

Table-1.15 Construction Costs of Wells in the Tibagi River Basin

Tibagi Basin (US$)

Municipalities		Borehole PC	Depth/ Borehole m	Unit Price US$	Drilling Cost US$ x 10^3	Other Cost US$ x 10^3	Construction Cost US$ x 10^3
Londrina	Stage I -1	6	180	150	216	1,500	1,716
Serra Geral Formations north -- 30 (180m)	-2	1	1,300	1,000	1,300	350	1,650
Bortucatu Formations ——— 4 (1300m)	Stage II -1	6	180	150	216	1,500	1,716
	-2	1	1,300	1,000	1,300	350	1,650
	Stage III -1	6	180	150	216	1,500	1,716
	-2	1	1,300	1,000	1,300	350	1,650
	Stage IV -1	6	180	150	216	1,500	1,716
	-2	1	1,300	1,000	1,300	350	1,650
	Stage V	6	180	150	216	1,500	1,716
Apucarana	Stage I	4	180	150	135	1,000	1,135
Serra Geral Formations north — 8 (180m)	Stage II	4	180	150	135	1,000	1,135
Correlio Procopio	Stage I	4	180	150	135	1,000	1,135
Serra Geral Formation north — 4 (180m)	Stage II	1	800	1,000	800	350	1,135
Botucatu Formation1 ——— 1 (800m)							
Arapongas	Stage I	5	180	150	189	1,250	1,439
Serra Geral Formation north — 5 (180m)	Stage II	1	1,000	1,000	1,000	350	1,350
Botucatu Formation ——— 1 (1000m)							
Ibipora	Stage I	3	180	150	108	750	858
Serra Geral Formation south — 6 (180m)	Stage II	3	180	150	108	750	858
Cambe	Stage I	6	180	150	216	1,500	1,716
Serra Geral Formation ——— 9 (180m)	Stage II	1	1,000	1,000	1,000	350	1,350
Botucatu Formation1 ——— 1 (1000m)	Stage III	3	180	150	108	750	858

Note: Drilling Cost include that for preparatory drilling contingency cost, 25 % for Serra Geral F, and 0 % for Botucatu F.

Table-1.16 Project Cost for Groundwater Development (Botucatu Formation)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1. Preparatory work					
- access road	m	1,000	170	170	1,000 m x 1 = 1.0 km
- other facilities	set	1	5,000	5	electric facility
2. Main construction work					
- drilling	m	---	---	---	
- well pipeline (150 mm)	m	1,000	80	80	
- main pipeline (500 mm)	m	---	---	---	
- main pipeline (1,000 mm)	m	---	---	---	
- sub pimping station	set	---	---	---	
- main pumping station or water treatment station	set	---	---	---	
3. Equipment					
- well pump (100 kw)	pc	2	30,000	60	
- sub pump (700 kw)	pc	---	---	---	
- main pump (2,400 kw)	pc	---	---	---	
4. Land Acquisition	ha	1	2,500	85	100 x 100 x 1 pc = 1.0 ha
5. Contingency	pc				
6. E/S & Administration	ps				
Total project cost				317	≒ 350 US$

Table-1.17 Project Cost for Groundwater Development (Serra Geral Formation)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^3US$)	Remarks
1. Preparatory work					
- access road	m	4,000	170	680	500 x 8 = 4.0 km
- other facilities	set	---	5,000	40	electric facility
2. Main construction work					
- drilling	m	---	---	---	
- well pipeline (150 mm)	m	6,000	80	480	6 pc x 1.0 = 6.0 km
- main pipeline (500 mm)	m	---	---	---	
- main pipeline (1,000 mm)	m	---	---	---	
- sub pimping station	set	---	---	---	
- main pumping station or water treatment station	set	---	---	---	
3. Equipment					
- well pump (100 kw)	pc	8	30,000	240	
- sub pump (700 kw)	pc	---	---	---	
- main pump (2,400 kw)	pc	---	---	---	
4. Land Acquisition	ha	6	2,500	15	100 x 100 x 6 = 6 ha
5. Contingency	pc				
6. E/S & Administration	ps				
Total project cost				1,455	≒ 1,500 US$

Table-1.18 Construction Costs of Pipelines and Pump Stations for Groundwater Development

(Iguaçu River Basin)

Municipalities		Water Developed (m^3/s)	Pipeline Diameter (mm)	Distance (m)	Unit Price (US$/m)	Construction Cost (10^6US$)	Pump (ps)	Water Developed x P (10^6)	Construction Cost (Pump Station) (10^6US$)	Total (10^6US$)
Cascavel	Stage I	0.220	400	11,000	220	2.42	1,060	0.23	0.52	2.94
	Stage II	0.080	300	8,000	130	1.04	290	0.02	0.19	1.23
	Stage III	0.220	400	13,000	220	2.86	1,060	0.23	0.52	3.38
	Stage IV	0.080	300	15,000	130	1.95	450	0.04	0.25	2.20
Guarapuava	Stage I	0.041	200	5,000	100	0.50	100	0.00	0.00	0.50
	Stage II	0.124	300	20,000	130	2.60	450	0.06	0.29	2.89
	Stage III									
	Stage IV									
Francisco Beltrao	Stage I	0.011	200	5,000	100	0.50	30	0.0003	0.03	0.53
	Stage II	0.124	300	4,000	130	0.52	300	0.04	0.25	0.77
	Stage III									
	Stage IV									
Medianeira	Stage I	0.124	300	4,000	130	0.52	300	0.04	0.25	0.77
	Stage II	0.020	200	2,000	100	0.20	50	0.001	0.06	0.26
	Stage III									
	Stage IV									
Dois Vizinhos	Stage I	0.018	200	700	100	0.07	50	0.0009	0.05	0.12
	Stage II	0.138	300	6,000	130	0.78	500	0.07	0.31	1.09
	Stage III									
	Stage IV									
Palmas	Stage I	0.033	200	5,000	100	0.50	80	0.003	0.09	0.59
	Stage II	0.033	200	11,000	100	1.10	80	0.003	0.09	1.19
	Stage III									
	Stage IV									
Pato Branco	Stage I	0.124	300	6,000	130	0.78	300	0.04	0.25	1.03
	Stage II	0.149	400	3,000	220	0.66	360	0.05	0.27	0.93
	Stage III									
	Stage IV									

Table-1.19 Construction Costs of Pipelines and Pump Stations for Groundwater Development

(Tibagi River Basin)

Municipalities		Water Developed (m^3/s)	Pipeline Diameter (mm)	Distance (m)	Unit Price (US$/m)	Construction Cost (10^6US$)	Pump (ps)	Water Developed x P (10^5)	Construction Cost (Pump Station) (10^6US$)	Total (10^6US$)
Londrina	Stage I	0.223	400	5,000	220	1.10	540	0.12	0.40	1.50
	Stage II	0.223	400	7,500	220	1.65	810	0.18	0.47	2.12
	Stage III	0.223	400	8,000	220	1.76	1,080	0.24	0.53	2.29
	Stage IV	0.223	400	11,000	220	2.42	1,350	0.30	0.58	3.00
Apucarana	Stage I	0.132	300	9,000	130	1.17	480	0.06	0.29	1.46
	Stage II	0.132	300	8,000	130	1.04	480	0.06	0.29	1.33
	Stage III									
	Stage IV									
Correlio Procopio	Stage I	0.029	200	6,500	100	0.65	110	0.003	0.09	0.74
	Stage II	0.129	300	14,000	130	1.82	630	0.08	0.33	2.15
	Stage III									
	Stage IV									
Arapongas	Stage I	0.190	400	9,000	220	1.98	920	0.17	0.46	2.44
	Stage II									
	Stage III									
	Stage IV									
Ibipora	Stage I	0.050	200	3,500	100	0.35	130	0.01	0.14	0.49
	Stage II	0.050	200	6,000	100	0.60	130	0.01	0.14	0.74
	Stage III									
	Stage IV									
Cambe	Stage I	0.224	400	5,000	220	1.10	540	0.12	0.40	1.50
	Stage II	0.050	200	2,500	100	0.25	130	0.01	0.14	0.39
	Stage III									
	Stage IV									

1.7 Cost Estimate for Water Supply Projects

Composition of facilities for water supply are shown in Figure-1.7. Project costs for water supply are estimated by applying the costs calculated in Section 1.5 and 1.7 above.

Since the cost estimation for cisterns, distribution network and domestic connections is difficult at the moment, those costs are calculated by the portion based on the plans and practices of the SANEPAR. The portion of the cost by type of facility is as follows.

The total cost for water supply projects in Curitiba Metropolitan Region is given in Table-1.21. Those for major urban areas in the Iguaçu River Basin and the Tibagi River Basin are shown listed in Table-1.22 and 1.23, respectively. The total cost for Curitiba Metropolitan amount to US$ 760.0 million, and those for other major urban areas in the Iguaçu River Basin and those for Tibagi River Basin are US$ 59.1 million and US$ 35.8 million, respectively.

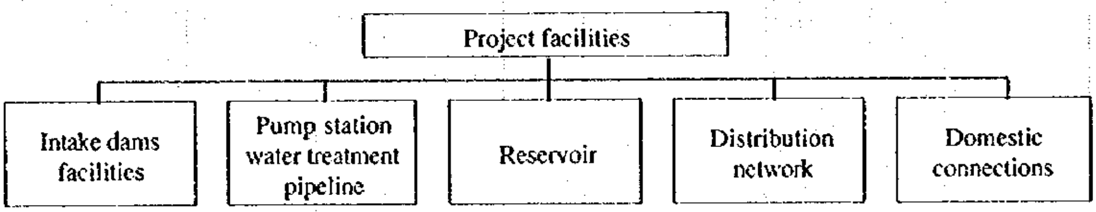


Figure-1.7 Composition of Water Supply Facilities

Table-1.20 Cost Portion of Each Water Supply Facility to the Total Project Cost

Area	Intake Facility	Water Treatment Station, Pipeline	Reservoir	Distribution Network, Domestic Connection	Total Project Cost
Curitiba Metropolitan Area	26.3 %	10.1 %	10.8 %	52.8 %	100.0 %
Other Cities	3.0 %	40.0 %	9.0 %	48.0 %	100.0 %

Table-1.21 Estimated Project Costs for Water Supply in Curitiba Metropolitan Region

No.	River	Yield (m^3/s)	Dams Construction Cost (10^6US$)	Pipe line Construction Cost (10^6US$)	Total Construction Cost (10^6US$)	Project Cost (10^6US$)
	Irai	1.400	35.2	14.1	49.3	135.4
	Piraquara II	0.750	14.4	7.6	22.0	60.4
	Pequeno	0.800	22.0	6.6	28.6	78.5
	Alto Miringuava	0.600	21.0	14.3	35.3	96.9
	Cotia Despique	1.200	28.6	15.2	43.8	120.3
	Alto Mauricio	0.250	10.9	9.1	20.0	54.9
	Das Oncas (Mandirituda)	0.200	17.9	7.5	25.4	69.8
	Faximal	0.500	18.4	7.1	25.5	70.1
	Das Oncas (Contenda)	0.600	14.8	8.3	23.1	63.5
	Piunduva	0.200	15.6	1.8	17.4	47.8
	stage I	1.290	---	---	40.3	110.6
	stage II	1.066	---	---	51.3	140.9
	stage III	1.066	---	---	53.7	147.5
	stage IV	1.066	---	---	54.9	150.8

Table-1.22 Project Costs for Water Supply in the Iguaçu River Basin

(x 10^6US$)

Item		Name	Location	Yield (m^3/s)	Intake of Drilling	ETE and Pipeline	Total Construction Cost	Total Project Cost	
Cascavel	$S\text{-}C_1$	Rio Sao Jose	Cascavel	0.300	1.20	3.62	4.82	14.18	O
0.542m^3/s	$G\text{-}S_1$	Stage I	Cascavel	0.220	3.09	2.94	6.03	17.74	O
	$G\text{-}S_2$	Stage II	Cascavel	0.080	1.14	1.23	2.37	6.97	O
	D-	Antos	Cascavel	0.690					
Foz do Iguaçu	$S\text{-}F_1$	Itaipu Reservor	Foz do Iguacu	1.042	1.20	2.58	3.78	11.12	O
1.043m3/s									
Guarapuaua	$S\text{-}G_1$	Rio Bananas	Guarapuava	0.292	1.20	1.90	3.10	9.12	O
0.292m^3/s	$G\text{-}G_1$	Stage I	Guarapuava	0.040	1.99	0.50	2.49	7.33	
	$G\text{-}G_2$	Stage II	Guarapuava	0.040	1.99	0.50	2.49	7.33	
	$G\text{-}G_3$	Stage III	Guarapuava	0.124	3.14	2.89	6.03	17.74	
Francisco	$S\text{-}F_1$	Rio Marrecas	Francisco	0.237	1.20	0.38	1.58	4.65	O
Beltrao	$G\text{-}F_1$	Stage I	Francisco	0.011	1.44	0.53	1.97	5.80	
0.231m^3/s	$G\text{-}F_2$	Stage II	Francisco	0.124	1.35	0.77	2.12	6.24	
Medianeira	$S\text{-}M_1$	Rio Repreas Grade	Medianeira	0.013	1.20	0.63	1.83	5.38	
0.066m^3/s	$S\text{-}M_2$	Corrego Sango Funda	Medianeira	0.017	1.20	0.53	1.73	5.09	
	$S\text{-}M_3$	Corrego Solde Ouro	Medianeira	0.010	1.20	0.72	1.92	5.65	
	$G\text{-}M_1$	Stage I	Medianeira	0.020	1.44	0.77	2.21	6.50	
	$G\text{-}M_2$	Stage II	Medianeira	0.124	1.20	0.26	1.46	4.30	O
Palmas	$S\text{-}P_1$	Riodas Caldeiras	Palmas	0.065	1.20	0.48	1.68	4.94	O
0.065m^3/s	$G\text{-}P_1$	Stage I	Palmas	0.033	2.85	0.59	3.44	10.12	
	$G\text{-}P_2$	Stage II	Palmas	0.033	2.85	1.19	4.04	11.89	
Dois Vizinhos	$S\text{-}D_3$	Rio Chopim	Dois Vizinhos	0.134	1.20	1.90	3.10	9.12	O
0.134m^3/s	$G\text{-}D_3$	Stage I	Dois Vizinhos	0.018	1.14	0.12	1.26	3.71	
	$G\text{-}D_4$	Stage II	Dois Vizinhos	0.138	2.41	1.09	3.50	10.30	
Pato Branco	$S\text{-}PB_1$	Rio-Chopim	Pato Branco	0.112	1.20	1.90	3.10	9.12	O
0.112m^3/s	$G\text{-}PB_1$	Stage I	Pato Branco	0.025	1.72	1.03	2.75	8.09	
	$G\text{-}PB_2$	Stage II	Pato Branco	0.124	1.55	0.93	2.48	7.30	
Uniaõ da Vitoria		Iguaçu	Uniaõ da Vitoria	0.035	1.20	0.06	1.26	3.71	O
0.035m^3/s									

(Note) O Shows a proposed project.

Project Costs are 1,265 times of the Counstruction Costs. Intake, ETE and Pipeline share 0.43%.

Table-1.23 Project Costs for Water Supply in the Tibagi River Basin

(x 10^6US$)

Item		Name	Location	Yield (m^3/s)	Intake of Drilling	ELE and Pipeline	Total Construction Cost	Total Project Cost	
Londrina	$S\text{-}C_1$	Rio Tibagi	Londrina	1.223	1.20	14.61	15.81	46.51	O
Cambe	$G\text{-}S_1$	Stage I	Londrina	0.223	3.37	1.50	4.87	14.33	
1.223m^3/s	$G\text{-}S_2$	Stage II	Londrina	0.223	3.37	2.12	5.49	16.15	
	$G\text{-}S_3$	Stage III	Londrina	0.223	3.37	2.29	5.66	16.65	
Ponta Grossa	$S\text{-}P_1$	Rio Tibagi	Ponta Grossa	0.433	1.20	3.38	4.58	13.47	O
0.433m^3/s									
Apucarona	$S\text{-}C_1$	Riveirao do Geme	Apucarana	0.041	1.20	2.14	3.34	9.83	
0.232m^3/s	$S\text{-}C_2$	Riveirao do Geme	Apucarana	0.009	1.20	1.40	2.60	7.65	
	$G\text{-}G_1$	Stage I	Apucarana	0.132	1.14	1.46	2.60	7.65	O
	$G\text{-}G_2$	Stage II	Apucarana	0.132	1.14	1.33	2.47	7.27	O
Correlio	$S\text{-}F_1$	Congonnas	Correlio Procopio	0.069	1.20	1.33	2.53	7.44	O
Procopio	$G\text{-}F_1$	Stage I	Correlio Procopio	0.029	1.14	0.74	1.88	5.53	
0.069m^3/s	$G\text{-}F_2$	Stage II	Correlio Procopio	0.129	1.14	2.15	3.29	9.68	
Arapongas	$S\text{-}M_1$	Rio Pirapo	Arapongas	0.101	1.20	1.74	2.94	8.65	O
0.142m^3/s	$G\text{-}M_1$	Stage I	Arapongas	0.066	1.44	2.44	3.88	11.41	
	$G\text{-}M_2$	Stage II	Arapongas	0.124	1.35	1.10	2.45	7.21	O
Ibipora	$S\text{-}P_1$	Rio Tibagi	Ibipora	0.105	1.20	1.33	2.96	7.44	O
0.105m^3/s	$G\text{-}P_1$	Stage I	Ibipora	0.050	0.86	0.49	1.35	3.97	
	$G\text{-}P_2$	Stage II	Ibipora	0.050	0.86	0.74	1.60	4.71	
Castro	$S\text{-}D_A$	Rio Lapo	Castro	0.250	1.20	0.68	1.88	5.53	O
0.250m^3/s									
Telemaco Borba	$S\text{-}PB_1$	Rio Tibagi	Telemaco Borba	0.215	1.20	1.10	2.30	6.77	O
0.215m^3/s									
Irati	$S\text{-}IR_A$	Rio Imbituvinba	Irati	0.075	1.20	1.86	3.06	9.00	O
0.075m^3/s									

(Note) O Shows a proposed project.

Project Costs are 1,265 times of the Counstruction Costs. Intake, ETE and Pipeline share 0.43%.

1.8 Annual Operation and Maintenance Cost for Water Supply

Operation and maintenance (O&M) costs for water supply can be divided into direct O&M costs and indirect O&M costs. The records in the SANEPAR show that the direct costs share 71.4% of the total O&M costs, being broken down to 26.1% of personnel costs, 2.7% of material costs, 16.0% of costs for services and electricity and 28.6% of other O&M costs. The indirect costs are administration costs and account 28.6% of the total O&M costs. Annual O&M costs of water supply systems by source type (surface and under ground water) is shown in Table-1.24.

Table-1.24 Annual Operation and Maintenance Cost by Area in May 1994

	Area	Number of Connections	Indirect Operation Cost (US$/m^3)	Direct operation Cost (US$/m^3)	Total Operation Cost (US$/m^3)
Surface Water	SANTO IZIDORO	110	0.23	1.34	1.57
	CORUMBATAI DO SUL	502	0.22	0.73	0.95
	MARMELEIRO	1,437	0.26	0.67	0.93
	URAI	2,508	0.20	0.90	1.10
	DOIS VIZINHOS	5,095	0.26	0.50	0.76
	TELEMACO BORBA	13,454	0.20	0.61	0.81
	APUCARANA	22,239	0.25	0.55	0.80
	CURITIBA	282,815	0.25	0.30	0.55
	IGATU	110	0.23	0.82	1.05
	PALMEIRINHA	507	0.23	0.49	0.72
Groundwater	ITAMBE	1,568	0.21	0.41	0.62
	TERRA BOA	2,525	0.22	0.52	0.74
	PAICANDU	5,593	0.21	0.58	0.79
	ALAIRANTE TAMANDARE	12,860	0.25	0.78	1.03

The annual O & M costs for water supply are estimated as 9.0% of each project cost for all projects through the following process.

- Among various records the current unit cost of US$ 0.3/m^3 in Curitiba is applied for the estimate.
- The annual O & M costs for newly developed water are estimated with the following formula; 625,000 m^3/day (water developed) x 365 x US$ 0.3/m^3 ≒ US$ 68.4 million.
- The portion of annual O & M costs to the total project costs are calculated as follows:

  US$ 68.4 million / US$ 760 million = 0.090

- The portion of 9.0% is applied to water supply projects in other areas.

1.9 Cost Estimate for Sewerage Projects

Facilities for sewerage services consists of;

- collection system
- pump station
- sewerage treatment plant
- main sewer
- domestic connection

Since cost estimate is possibly made only for sewerage treatment plants in the Study, total project costs are estimated assuming the same portion of each facility in the total costs as the practices of the SANEPAR, as shown in Table-1.25. Basic conditions applied in the cost estimates for sewerage treatment plants are as follows:

1) Project costs are estimated according to the material e) of Section 1.1.
2) A rate of UPF 1 = US$ 8.9 is applied in adjustment for price escalation.
3) Correlation between the volumes of sewage treated and project costs or O&M costs is calculated, examining treated volume per day by each type of treatment in Atuba. The results are shown in Figure-1.8 and 1.9.
4) Costs for construction of sewerage treatment plants are estimated according to the planned volume of treatment for each urban area in the Iguaçu River Basin or the Tibagi River Basin.
5) Project costs are estimated by applying the portion mentioned above and shown in Table-1.25.

Table-1.25 Cost Portion of Each Sewerage Facility to the Total Project Cost

Area	Collecting System	Pumping Station	Sewerage Treatment Plant	Main Sewer	Domestic Connection	Total Project Cost
Curitiba Metropolitan Area	43.2 %	2.0 %	28.9 %	15.9 %	10.0 %	100.0 %
Other Cities	55 %		15 %	20 %	10 %	100 %

Total project cost for sewerage development and its implementation schedule are shown in Table-1.26.

Table-1.26 Sewerage Development Plan

Basin	Municipality	Volume Treated m^3/day	Project Costs x 10^{6}US$	O & M Cost x 10^{6}US$/year	Implementation Schedule 1996 ~ 2000	2001 ~ 2005	2006 ~ 2010	2011 ~ 2015	beyond 2015
Iguaçu River	Curitiba M.A	420,000	293.6	3.60	70.3 (100,000 m^3/d)	70.3 (100,000 m^3/d) 0.87/year	70.3 (100,000 m^3/d) 1.74/year	82.7 (120,000 m^3/d) 2.61/year	3.60/year
	Cascavel	45,000	49.5	0.71	23.4 (20,000 m^3/d)	0.35/year	26.1 (25,000 m^3/d) 0.35/year	0.71/year	
Total		465,000	343.1		93.7 (27.3%)	70.3 (20.5%)	96.4 (28.1%)	82.7 (24.1%)	
Tibagi River	Ponta Grossa	30,000	29.2	0.36	29.2 (20,000 m^3/d)	0.36/year	0.36/year	0.36/year	0.36/year
	Londrina	70,000	59.4	0.98		32.8 (40,000 m^3/d)	0.52/year	26.6 (30,000 m^3/d)) 0.52/year	0.98/year
Total		100,000	88.6		29.2	32.8		26.6	

Upper shading line: Construction Cost in 5 years   Lower line: Annual O & M Cost

① 0.87 + 0.87 + 0.87 + 0.99 = 3.60
② 0.35 + 0.36 = 0.71
③ 0.36
④ 0.52 + 0.46 = 0.98

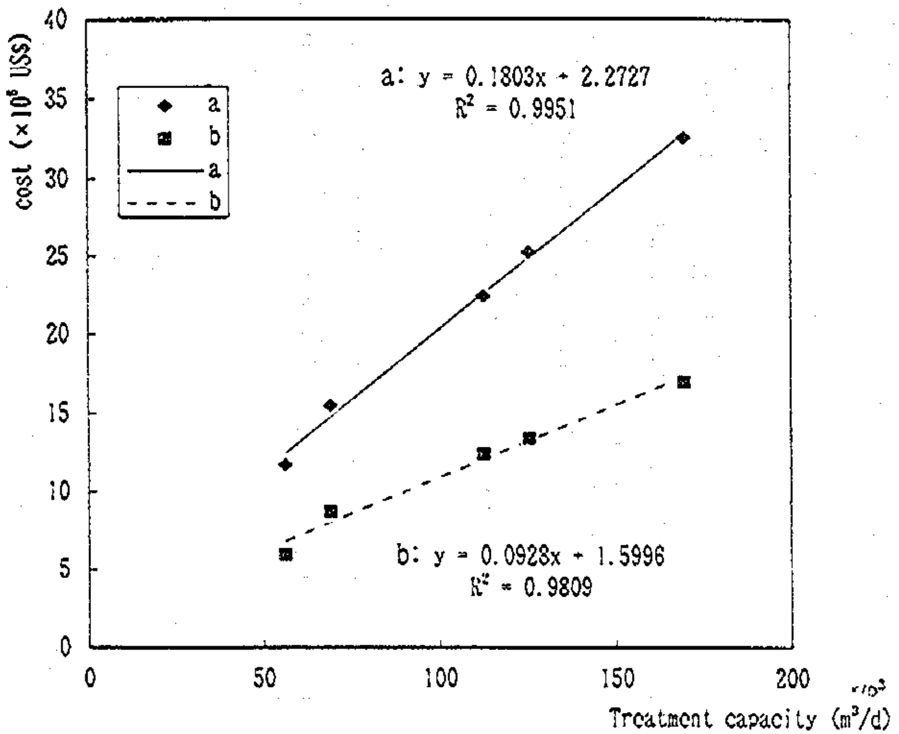
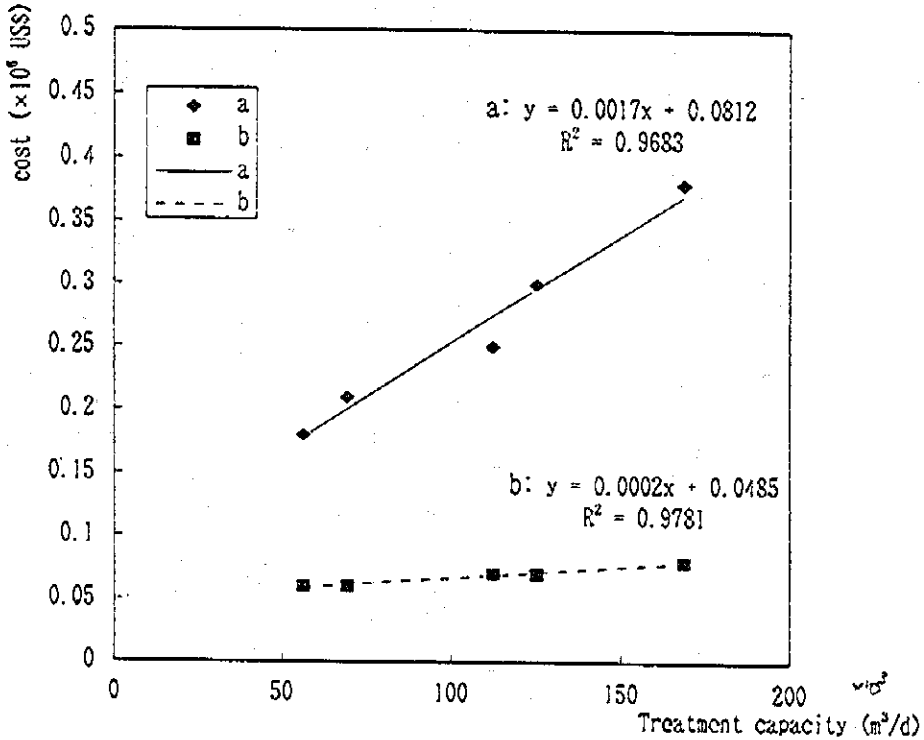


Figure-1.8 Project Cost of Sewerage Treatment Plant



a: Standard Activated Sludge Process
b: Anaerobic Digestion + Aerobic Treatment

Figure-1.9 O/M Cost of Sewerage Treatment Plant

1.10 Cost Estimate for Flood Control Projects

Project costs for structural measures in flood control in União da Vitoria and São Mateus do Sul are estimated as shown in Table-1.27 and 1.28, respectively. Conditions assumed in the estimation are as follows:

(1) Conditions for Dike Construction

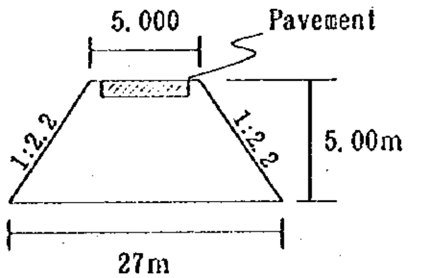
1) Preparatory Works (Access Road Construction and Clearing Quarry Sites)

- access road with a width of 5m: flat region; US$ 100/m
  flat region; US$ 180/m

- clearing quarry sites: considered for dike construction with a volume of more than 1,400,000 m^3

2) Main Construction

a) Dike: $80.0\ m^2 \times 17,000\ m = 1,360,000\ m^3 \fallingdotseq 1,400,000\ m^3$
US$ 25 / m^3 including compacting



a width of more than 5m is necessary for compacting

a width of more than 4m of pavement is necessary for the use as a road

$1/2 \times (5.00+27.00) \times 5.00 = 75.0\ m^2$

Figure-1.10 Cross Section of a Dike

b) Pavement: $4.00\ m \times 17,000\ m = 68,000\ m^2$
US$ 50 / m^2

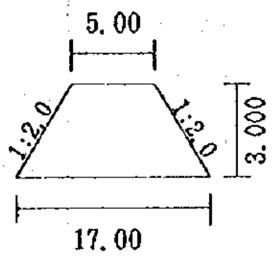
c) Sluice Way: concrete, 1,000 m^3/site, US$ 800 / m^3
appurtenant works (abutting waterway, gate, etc.); 60% of the cost for sluice construction

(2) Excavation

1) Preparatory Works (Access Road Construction and Clearing Quarry Sites)

- access road with a width of 5m: in flat region; US$ 180/m, 30 Km

- cofferdam:



extension; 4.0 x 2 = 8.0 Km
A = 33 m²

33.0 m² x US$ 8 / m³ = US$ 270/m

Figure-1.11 Cross Section of a Cofferdam

2) Main Work

excavation of 2,000,000 m³ of river bed excavation

Table-1.27 Flood Control Project of União da Vitoria

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^6US$)	Remarks
1.Preparatory work					
- access road (1)	m	20,000	100	2.0	about 20 km flat region
- access road (2)	m	30,000	180	5.4	about 30 km wave region
- other facilities	set	1	900,000	0.9	large scale
2.Main construction					
- dike	m³	1,400,0 00	25	35.0	include transport of soil
- pavement	m³	68,000	50	3.4	unit cost 50 US$/m²
- sluice	pc	8	800,000	6.4	
- appurtenant works	pc	8	500,000	4.0	
					Total US$ 57.1 x 10^6
3.Equipment	pc				
- worming system				---	
- spare parts				---	
- parks				---	
4.Land Acquisition	ha	80	2,500	0.2	36.00 x 17,000 x 1.3 ≠ 80.0 ha
5.Contingency				8.6	15 %
6.E/S & Administration				20.0	30 % (COPEL)
Total project cost				85.9	US$ 85.9 x 10^6

Table-1.28 Flood Control Project of São Mateus do Sul

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^6US$)	Remarks
1.Preparatory work					
- access road (1)	m	20,000	100	2.0	about 20 km flat reign
- clearing	pc	1	70,000	0.7	up to 300,000 m^3
2.Main construction					
- dike	m^3	110,000	25	2.8	include transport of soil
- pavement	m^3	10,000	50	0.5	unit cost 50 US$/$m^2$
- sluice	pc	1	800,000	0.8	
- appurtenant works	pc	1	500,000	0.5	
					Total US$ 7.3 x 10^6
3.Equipment	pc				worming system spare parts accessories
4.Land Acquisition	ha	12	2,500	0.1	36.00 x 25,000 x 1.3 ≠ 12 ha
5.Contingency				1.1	15 %
6.E/S & Administration				2.6	30 % (COPEL)
Total project cost				11.1	US$ 11.1 x 10^6

Table-1.29 Flood Control Project of União Vitoria Alternative 1 (Riverbed Excavation)

Items	Unit	Quantity	Unit Cost (US$)	Construction Cost (10^6US$)	Remarks
1.Preparatory work					
- access road (1)	m	30,000	180	5.4	about 30 km wave region
- cross dike	m	8,000	270	2.2	about 8 km
2.Main construction					
- Excavation	m^3	2,000,0 00	40	80.0	include transport of soil
					Total US$ 87.6 x 10^6
3.Equipment	pc				
4.Land Acquisition		0		0.0	
5.Contingency	pc	1		13.1	(15 %)
6.E/S & Administration	pc			30.2	(30 %)
Total project cost				130.9	US$ 130.9 x 10^6

APPENDIX - 1

The Storage Capacity Curve of Planned Dam Sites

No	Planned Dam Site
1	Irai
2	Piraquara II
3	Pequeno
4	Alto Miringuava
5	Cotia Despique
6	Alto Mauricio
7	Das Onças (Mandirituba)
8	Faxinal
9	Das Onças (Contenda)
10	Piunduva

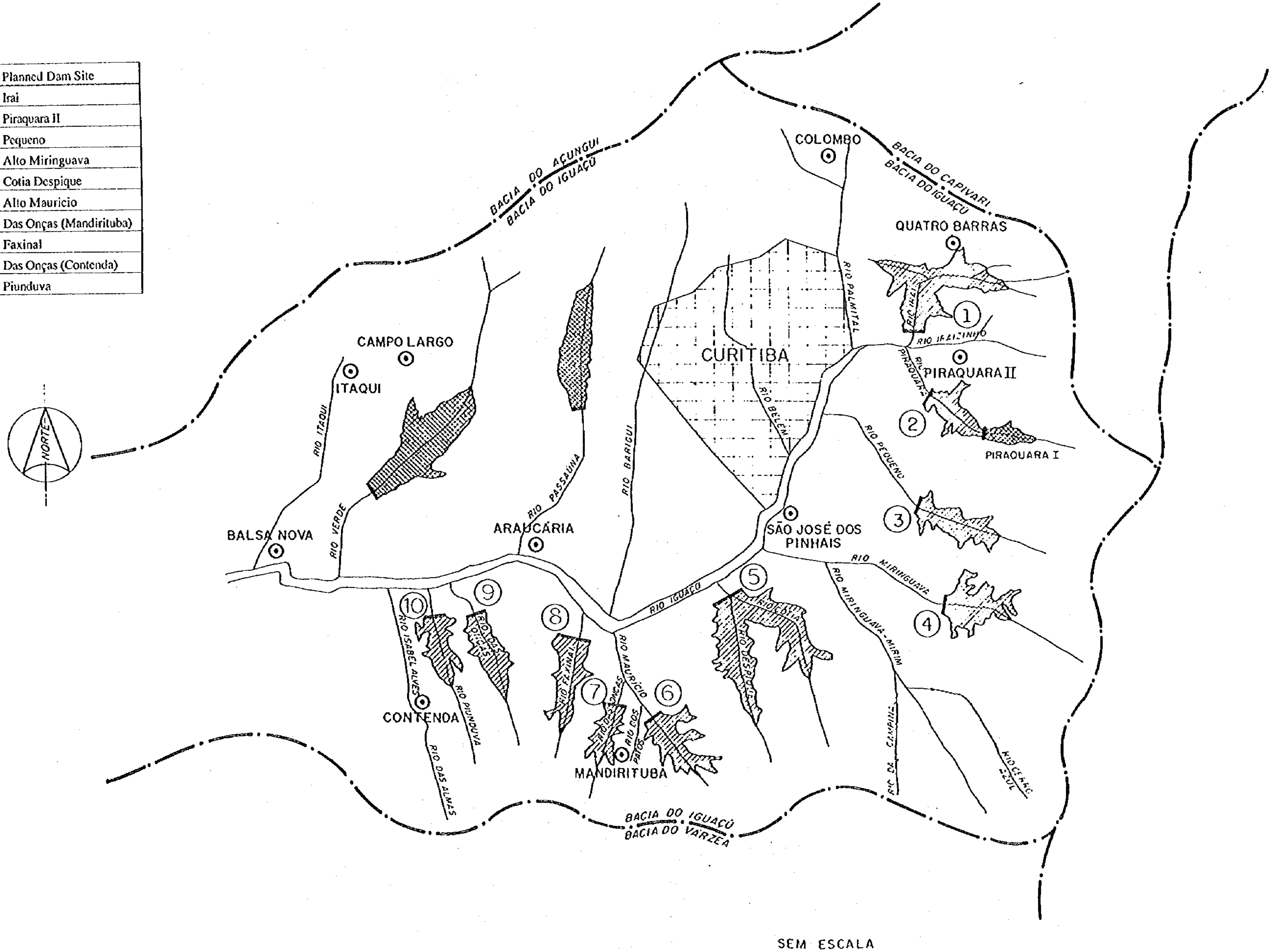
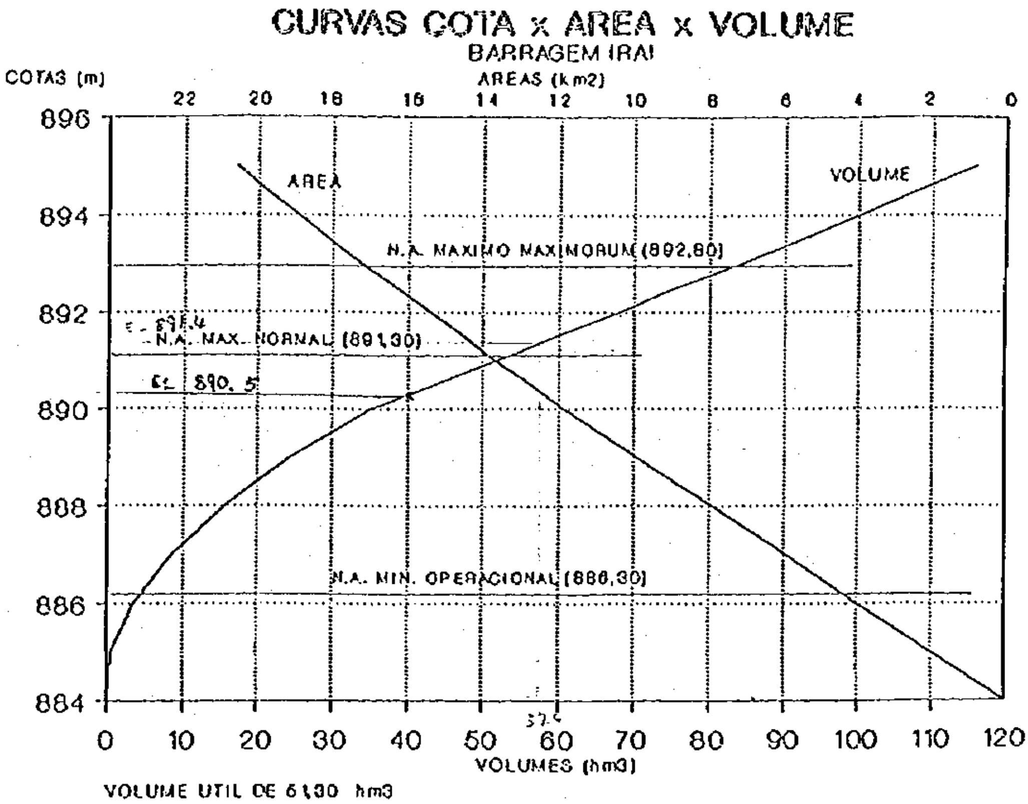
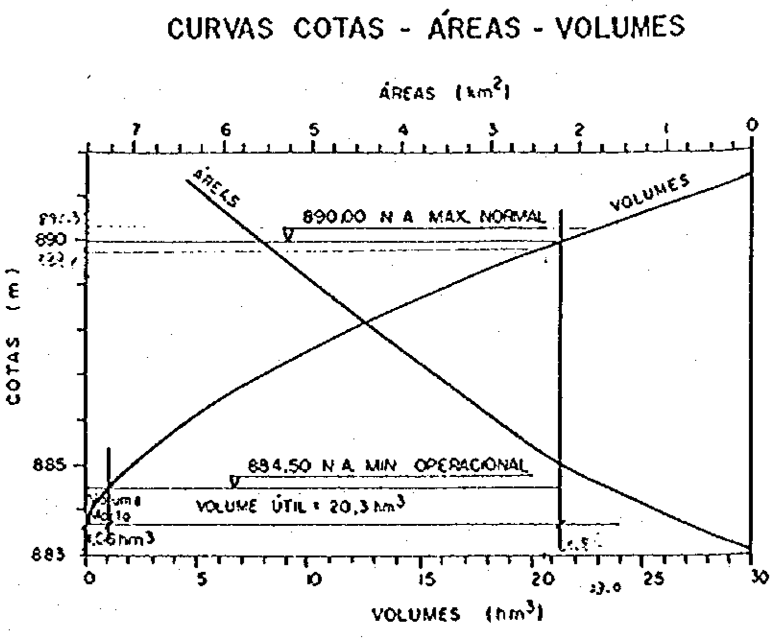


Figure-A1.1 Location of Planned Dam Sites

1. Iraí

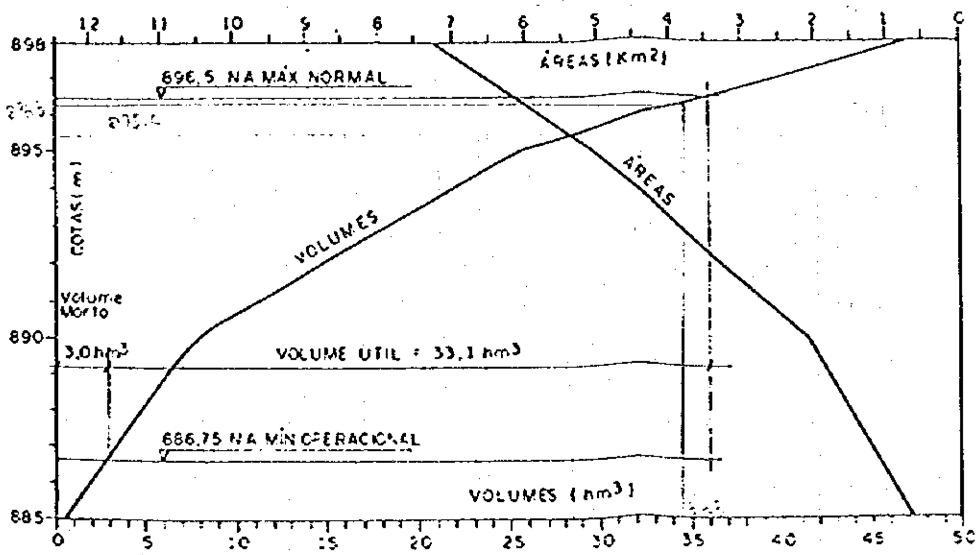


2. Piraquara II



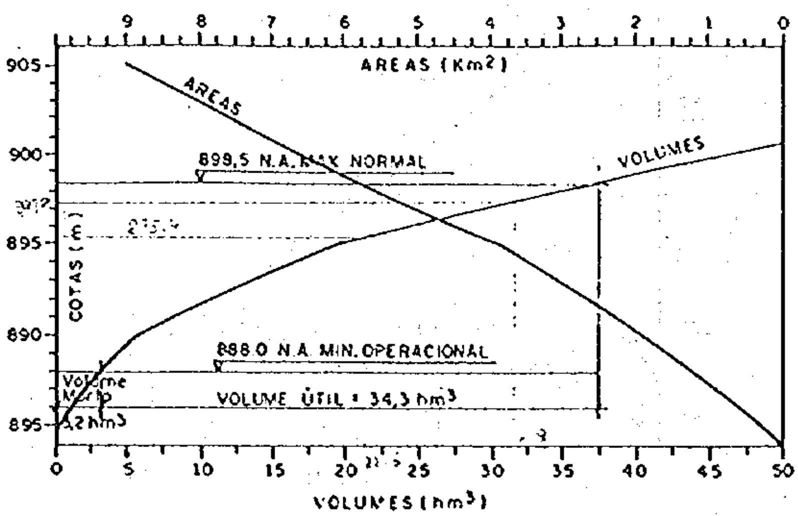
3. Pequeno

CURVAS COTAS - ÁREAS - VOLUMES

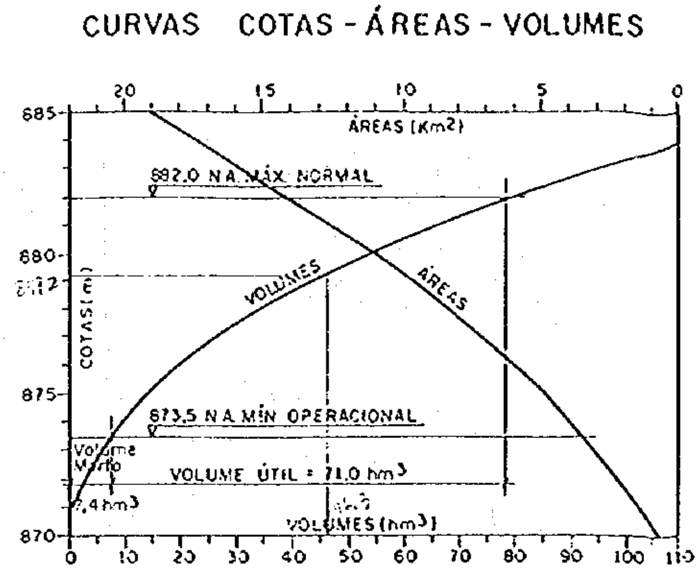


4. Alto Miringuava

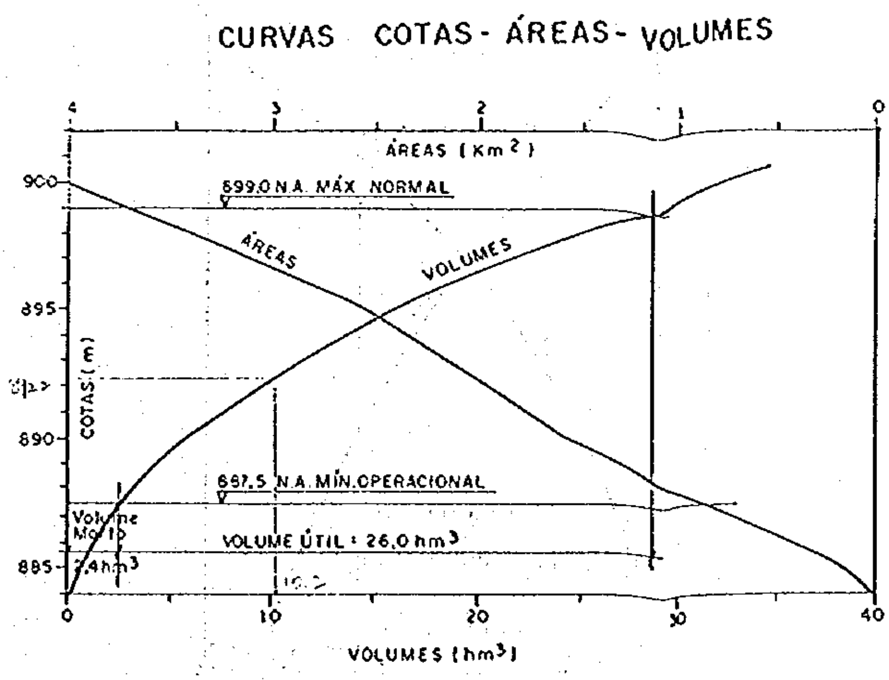
CURVAS COTAS - ÁREAS - VOLUMES



5. Cotia Despique

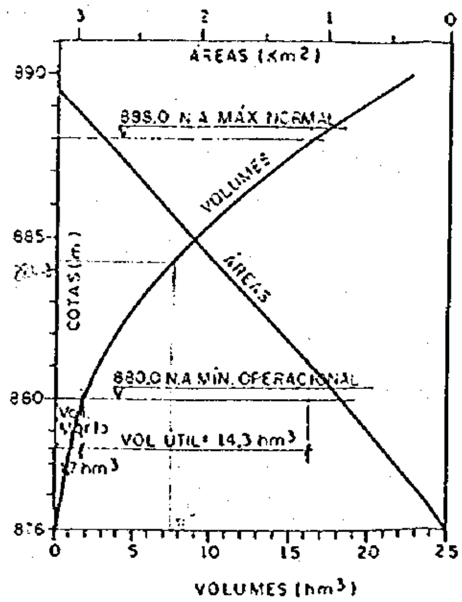


6. Alto Mauricio



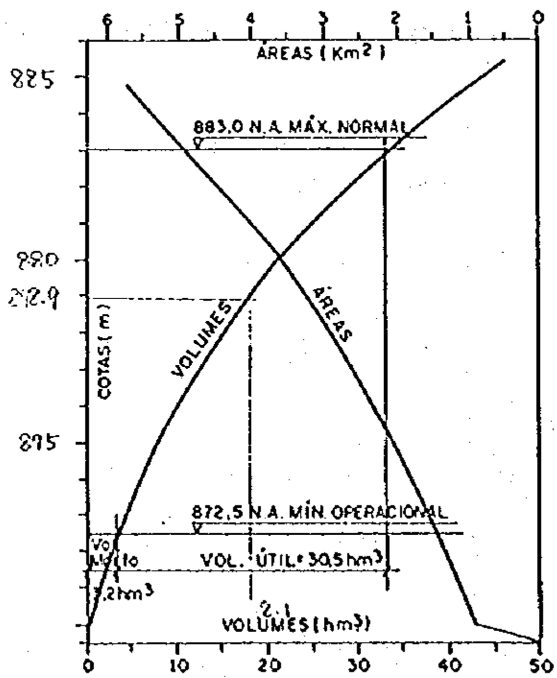
7. Das Oncas (Mandirituba)

CURVAS COTAS - ÁREAS - VOLUMES



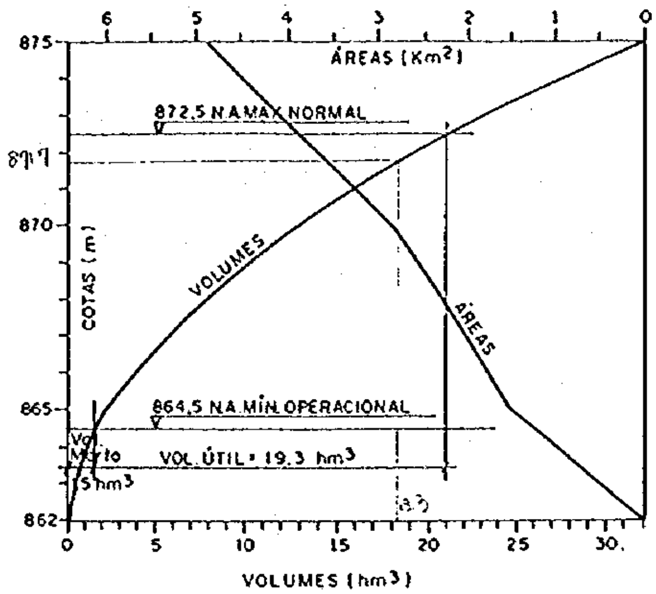
8. Faxinal

CURVAS COTAS - ÁREAS - VOLUMES



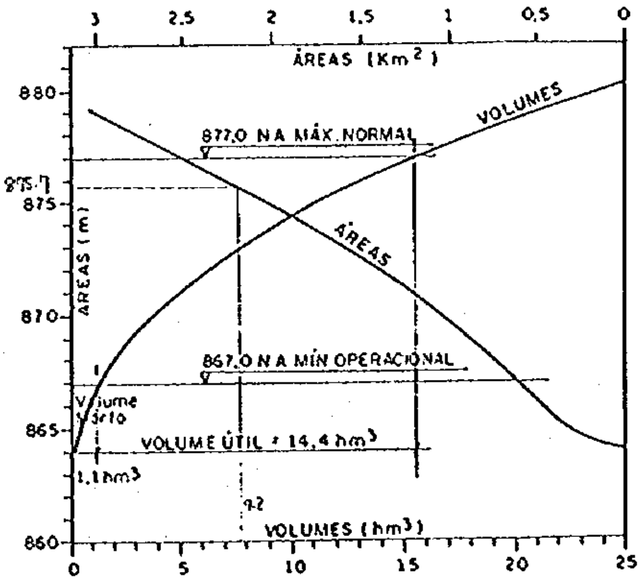
9. Das Onças (Contenda)

CURVAS COTAS - ÁREAS - VOLUMES



10. Piunduva

CURVAS COTAS - ÁREAS - VOLUMES



APPENDIX - 2

Project Cost for Groundwater Development

Table-A1.1 Calculation for Design of Pipeline for Surface Water Development in Large and Medium Urban Area (Iguacu River Basin)

NO.	Basin	River	Municipality	Water Developed (m^3/s)	Diameter (mm)	Cross Section of Pipeline (m^2)	Distance (m)	Velocity (m/s)	friction coefficient	Friction Loss H2(m)	Head H1(m)	Total Head (H1+H2)*1.2	Pump (kw)	Pump (ps)	Yield	Remark
	Iguacu	Irai, Piraquara II	CM.A	2.150	1200	1.131	15,000	1.90	210.6	39	80	150	3,040	4,140		
	ditto	Pequeno	ditto	0.800	800	0.503	8,000	1.59	192.8	25	70	120	990	1,350		
	ditto	Alto Miringuava	ditto	0.600	700	0.385	23,500	1.56	676.8	84	60	180	640	870		
	ditto	Cotia Despique	ditto	1.200	900	0.636	17,000	1.89	350.2	64	60	150	1,280	1,740		
			ditto	0.450	600	0.283	18,000	1.59	636.7	82	60	180	480	650		
	ditto	Alto Mauricio	ditto	0.250	400	0.126	14,000	1.99	850.3	172	70	300	310	430		
		Das Oncas(Mandirituba)	ditto	0.200	400	0.126	8,500	1.59	516.2	67	60	160	220	290		
	ditto	Faxinal	ditto	0.500	600	0.283	13,000	1.77	459.8	73	60	160	530	730		
	ditto	Das Oncas(Contenda)	ditto	0.600	700	0.385	13,000	1.56	374.4	46	70	140	750	1,010		
	ditto	Piunduva	ditto	0.200	400	0.126	5,000	1.59	303.7	39	70	140	250	340		
S-FI1	ditto	Itaipu Reservoir	Foz do Iguacu	0.347	500	0.196	1,900	1.77	85.7	14	20	50	130	170	1.043	3
S-C1(c.R.S.i)	ditto	Rio Sao Jose	Cascavel	0.150	300	0.071	13,000	2.12	1158.7	266	70	410	190	260	0.542	2
S-G1	ditto	Rio Bananas	Guarapuava	0.146	300	0.071	4,800	2.07	427.8	94	200	360	600	710	0.292	2
S-M1	ditto	Rio Represa Grande	Medianeira	0.013	200	0.031	5,900	0.41	903.0	8	82	110	20	30	0.066	
S-M2	ditto	Corrego Sango Funda	ditto	0.017	200	0.031	4,700	0.54	719.3	11	167	220	60	70		
S-M3	ditto	Corrego Sol de Ouro	ditto	0.010	200	0.031	6,900	0.32	1056.0	6	90	120	20	30		
S-D3	ditto	Rio Chopim	Dois Vizinhos	0.134	300	0.071	7,500	1.90	668.5	123	180	370	430	580	0.134	
S-F1	ditto	Rio Marrecas	Francisco Beltrao	0.119	300	0.071	700	1.68	62.4	9	10	30	30	30	0.231	2
S-PB2	ditto	Rio Chopim	Pato Branco	0.112	300	0.071	12,500	1.58	1114.1	142	170	380	340	460	0.112	
S-PA1	ditto	Rio das Caldeiras	Palmas	0.065	200	0.031	3,400	2.07	520.3	114	70	230	90	110	0.065	
S-UV1	ditto	Iguacu	Uniao da Vitoria	0.035	200	0.031	200	1.11	30.6	2	10	20	10	10	0.035	
D-C3	ditto	Baneiro(II)	Cascavel	0.690	700	0.385	21,000	1.79	604.8	99	270	450	3,300	4,500		
D-C5	ditto	Antos	ditto	0.690	700	0.385	8,000	1.79	230.4	38	200	290	2,500	3,400		

c.R.S.i : combine with Rio do Salto intake

Table-A1.2 Calculation for Design of Pipeline for Surface Water Development in Large and Medium Urban Area (Tibagi River Basin)

NO.	Basin	River	Municipality	Water Developed (m^3/s)	Diameter (mm)	Cross Section of Pipeline (m^2)	Distance (m)	Velocity (m/s)	friction coefficient	Friction Loss H2(m)	Head H1(m)	Total Head (H1+H2)*1.2	Pump (kw)	Pump (ps)	Yield	Remark
S-P1	Tibagi	Rio Tibagi	Ponta Grossa	0.217	400	0.126	6,000	1.72	364.4	55	134	230	600	700	0.433	2
S-L1	ditto	ditto	Londrina and Cambe	0.408	500	0.196	13,400	2.08	604.4	133	177	380	1,300	1,800	1.223	3
S-A1	ditto	Riveirao do Cerne	Apucarana	0.041	200	0.031	20,000	1.31	3060.9	268	320	710	240	320	0.232	
S-A2	ditto	Rio Xaxim	ditto	0.009	200	0.031	13,500	0.29	2066.1	9	310	390	50	70		
S-CA1	ditto	Rio Iapo	Castro	0.125	300	0.071	1,200	1.77	107.0	17	58	90	130	180	0.250	2
S-T1	ditto	Rio Tibagi	Telemaco Borba	0.108	300	0.071	2,700	1.52	240.7	28	100	160	190	260	0.215	2
S-IR1	ditto	Rio Imbituvinha	Irati	0.075	300	0.071	13,200	1.06	1176.5	67	40	130	60	80	0.075	
S-CP1	ditto	Congonhas	Corneiro Precopio	0.069	300	0.071	8,500	0.98	757.6	37	290	400	360	490	0.069	
S-AR1	ditto	Rio Pirapo	Arapongas	0.101	300	0.071	11,100	1.43	989.3	103	230	400	410	560	0.142	
S-CB	ditto	Rio Tibagi	Ibipora	0.105	300	0.071		1.49	0.0	0	0	0	0	0	0.105	

Table-A1.3 Calculation for Design of Pipeline for Groundwater Development (Iguacu Basin)

Iguacu Basin

Municipalities		Water Developed (m^3/s)	Diameter (mm)	Cross Section of Pipeline (m^2)	Distance (m)	Velocity (m/s)	friction coefficient	Friction Loss H2(m)	Head H1(m)	Total Head (H1+H2)*1.2	Pump (kw)	Pump (ps)
Curitiba	stage I	1.000	900	0.636		1.57	0.0	0		0	0	0
	stage II	1.000	900	0.636		1.57	0.0	0		0	0	0
	stage III	1.000	900	0.636		1.57	0.0	0		0	0	0
	stage IV	1.000	900	0.636		1.57	0.0	0		0	0	0
Cascavel	stage I	0.220	400	0.126	11,000	1.75	668.1	104	200	370	780	1,060
	stage II	0.080	300	0.071	8,000	1.13	713.0	46	150	240	220	290
	stage III	0.220	400	0.126	13,000	1.75	789.6	123	200	390	780	1,060
	stage IV	0.080	300	0.071	15,000	1.13	1337.0	87	230	390	330	450
Guarapuava	stage I	0.041	200	0.031	5,000	1.31	765.2	67	100	210	80	100
	stage II	0.124	300	0.071	20,000	1.75	1782.6	279	150	520	330	450
	stage III			0.000								
	stage IV			0.000								
Francisco Beltrao	stage I	0.011	200	0.031	5,000	0.35	765.2	5	100	130	20	30
	stage II	0.124	300	0.071	4,000	1.75	356.5	56	100	190	220	300
	stage III											
	stage IV											
Medianeira	stage I	0.124	300	0.071	4,000	1.75	356.5	56	100	190	220	300
	stage II	0.020	200	0.031	2,000	0.64	306.1	6	100	130	40	50
	stage III											
	stage IV											
Dois Vizinhos	stage I	0.018	200	0.031	700	0.57	107.1	2	100	130	40	50
	stage II	0.138	300	0.071	6,000	1.95	534.8	104	150	310	370	500
	stage III											
	stage IV											
Palmas	stage I	0.033	200	0.031	5,000	1.05	765.2	43	100	180	60	80
	stage II	0.033	200	0.031	11,000	1.05	1683.5	95	100	240	60	80
	stage III											
	stage IV											
Pato Branco	stage I	0.124	300	0.071	6,000	1.75	534.8	84	100	230	220	300
	stage II	0.149	400	0.126	3,000	1.19	182.2	13	100	140	270	360
	stage III											
	stage IV											

Tibagi Basin

Table-A1.4 Calculation for Design of Pipeline for Groundwater Development (Tibagi Basin)

Municipalities		Water Developed (m^3/s)	Diameter (mm)	Cross Section of Pipeline (m^2)	Distance (m)	Velocity (m/s)	friction coefficient	Friction Loss H2(m)	Head H1(m)	Total Head (H1+H2)*1.2	Pump (kw)	Pump (ps)
Londrina	stage I	0.223	400	0.126	5,000	1.77	303.7	49	100	180	400	540
	stage II	0.223	400	0.126	7,500	1.77	455.5	73	150	270	600	810
	stage III	0.223	400	0.126	8,000	1.77	485.9	78	200	340	790	1,080
	stage IV	0.223	400	0.126	11,000	1.77	668.1	107	250	430	990	1,350
Apucarana	stage I	0.132	300	0.071	9,000	1.87	802.2	143	150	360	350	480
	stage II	0.132	300	0.071	8,000	1.87	713.0	127	150	340	350	480
	stage III											
	stage IV											
Correlio Procopio	stage I	0.029	200	0.031	6,500	0.92	994.8	43	150	240	80	110
	stage II	0.129	300	0.071	14,000	1.82	1247.8	211	200	500	460	630
	stage III											
	stage IV											
Arapongas	stage I	0.190	400	0.126	9,000	1.51	546.6	64	200	320	680	920
	stage II											
	stage III											
	stage IV											
Ibipora	stage I	0.050	200	0.031	3,500	1.59	535.6	69	100	210	90	130
	stage II	0.050	200	0.031	6,000	1.59	918.3	118	100	270	90	130
	stage III											
	stage IV											
Cambe	stage I	0.224	400	0.126	5,000	1.78	303.7	49	100	180	400	540
	stage II	0.050	200	0.031	2,500	1.59	382.6	49	100	180	90	130
	stage III											
	stage IV											

Table-A1.5 Calculation for Design of Pipeline for Surface Water Development in other Urban Area

Type	Zone	Water Developed (m^3/s)	Diameter (mm)	Cross Section of Pipeline (m^2)	Distance (m)	Velocity (m/s)	friction coefficient	Friction Loss H2(m)	Head H1(m)	Total Head (H1+H2)*1.2	Pump (kw)	Pump (ps)	Remark
C	a	0.010	100	0.008	2,000	1.27	771.3	63	20	100	10	10	
		0.050	200	0.031	2,000	1.59	306.1	39	20	80	20	30	
		0.100	300	0.071	2,000	1.41	178.3	18	20	50	40	50	
C	b	0.010	100	0.008	10,000	1.27	3856.4	317	100	510	20	30	
		0.050	200	0.031	10,000	1.59	1530.4	197	100	360	90	130	
		0.100	300	0.071	10,000	1.41	891.3	90	100	230	180	250	
C	c	0.010	100	0.008	15,000	1.27	5784.7	476	200	820	40	50	
		0.030	150	0.018	15,000	1.70	3368.9	497	200	840	110	150	
		0.050	200	0.031	15,000	1.59	2295.6	296	200	600	180	250	

Table-A1.6 Cost Estimation for Surface Water Development in other Urban Area

Type	Zone	Water Developed (1)(m^3/s)	Diameter (mm)	Distance (m)	Unit Cost US$/m	Cost 10^6 US$	Pump (2) (ps)	(1)*(2) 10^6	Cost 10^6 US$	Total Cost 10^6 US$	Project Cost 10^6 US$
C	a	0.010	100	2,000	60	0.12	10	0.0001	0.02	0.14	0.41
		0.050	200	2,000	100	0.20	30	0.0015	0.06	0.26	0.76
		0.100	300	2,000	130	0.26	50	0.0050	0.10	0.36	1.06
C	b	0.010	100	10,000	60	0.60	30	0.0003	0.03	0.63	1.85
		0.050	200	10,000	100	1.00	130	0.0065	0.12	1.12	3.30
		0.100	300	10,000	130	1.30	250	0.0250	0.20	1.50	4.41
C	c	0.010	100	15,000	60	0.90	50	0.0005	0.04	0.94	2.77
		0.030	150	15,000	80	1.20	150	0.0045	0.10	1.30	3.82
		0.050	200	15,000	100	1.50	250	0.0125	0.15	1.65	4.85

1.265times / 43% = 2.942

Table-A1.7 Project Cost for Groundwater Development with one borehole in other Urban Area

Yield 0.0111m³/s 1pc

Item	Unit	Quantity	US\$ Unit Cost	US\$ Total (×10³)	Remarks
1 Preparatory work					
-access road	m	200	170	34	
-other facilities	set	1	5,000	5	electric facility
2 Main Construction work					
-drilling	m	180	150	27	1pc×180=180m
-well pipeline(100mm)	m	3,000	60	180	
-sub pipeline(500mm)	m	—	260	—	
-main pipeline(1,000mm)	m	—	750	—	
-sub pumping station	set	1	50,000	50	concrete 120m³
-main pumping station or water treatment station	set	—	1,200,000	—	concrete 3,000m³
3 Equipment					
-well pump(100kw)	pc	2	30,000	60	
-sub pump(700kw)	pc	—	350×10³	—	
-main pump(2,400kw)	pc	—	1,000×10³	—	Sub total US\$356×10³
4 Land Acquisition	ha	1	2,500	3	
5 Contingency	pc			54	(1~3)×15%
6 E/S & Administration	ps			42	(1~5)×10%
Total project cost				455	1.058×10⁶ US\$

Table-A1.8 Project Cost for Groundwater Development with two boreholes in other Urban Area

Yield 0.0111m³/s 2pc

Item	Unit	Quantity	US $ Unit Cost	US $ Total (×10³)	Remarks
1 Preparatory work					
-access road	m	400	170	68	200×2=400m
-other facilities	set	2	5,000	10	electric facility
2 Main Construction work					
-drilling	m	360	150	54	2pc×180=360m
-well pipeline(100mm)	m	400	60	24	200(m)×2=400m
-sub pipeline(150mm)	m	3,000	80	240	3,000×5 =15,000
-main pipeline(1,000mm)	m	—	750	—	
-sub pumping station	set	2	50,000	100	concrete 120m³
-main pumping station or water treatment station	set	—	1,200,000	—	concrete 3,000m³
3 Equipment					
-well pump(100kw)	pc	3	30,000	90	
-sub pump(700kw)	pc	2	50,000	100	
-main pump(2,400kw)	pc	—	1,000×10³	—	Sub total US$686×10³
4 Land Acquisition	ha	2	2,500	5	
5 Contingency	pc			103	(1~3)×15%
6 E/S & Administration	ps			80	(1~5)×10%
Total project cost				874	2.033×10⁶ US$

Table-A1.8 Project Cost for Groundwater Development with three boreholes in other Urban Area

Yield 0.0111m³/s 3pc

Item	Unit	Quantity	US$ Unit Cost	US$ Total (×10³)	Remarks
1 Preparatory work					
-access road	m	600	170	102	200×3=600m
-other facilities	set	3	5,000	15	electric facility
2 Main Construction work					
-drilling	m	540	150	81	3pc×180=540m
-well pipeline(100mm)	m	600	60	36	200(m)×3=600m
-sub pipeline(150mm)	m	3,000	80	240	3,000×5 =15,000
-main pipeline(1,000mm)	m	—	750	—	
-sub pumping station	set	3	50,000	150	concrete 120m³
-main pumping station or water treatment station	set	—	1,200,000	—	concrete 3,000m³
3 Equipment					
-well pump(100kw)	pc	4	30,000	120	
-sub pump(700kw)	pc	2	70,000	140	
-main pump(2,400kw)	pc	—	1,000×10³	—	Sub total US$884×10³
4 Land Acquisition	ha	3	2,500	8	
5 Contingency	pc			133	(1~3)×15%
6 E/S & Administration	ps			103	(1~5)×10%
Total project cost				1,128	2,623×10⁴ US$

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ECONOMIC AND FINANCIAL ANALYSES

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CHAPTER 1 ECONOMIC AND FINANCIAL ANALYSES FOR THE STRATEGY

1.1 Evaluation of Investment Magnitude

The financial requirement for the Strategy is reviewed in the light of the past investment achievement of related organizations. The data of SANEPAR and COPEL are collected. Their past investments account for the most part of water-related investment in Praná in the past.

The data on SANEPAR's past investment achievement were collected for 1992 to 1994 period as shown below. A detail is presented in Appendix -1

1992 : US$ 78,290 thousand

1993 : US$ 51,050 thousand

1994 : US$ 79,531 thousand

Total : US$ 208,871 thousand

The proportions of the water supply and sewerage components are 75% and 25% on average. Regarding the source of investment fund, the SANEAR's own fund accounted for 42%. Other major sources include the national bank(22%), state governemnt fund (20%) and the state government (11%). No foreign fund was recorded during this period.

The investment record of COPEL was collected between 1975 and 1995 as shown in Appendix-2. During this period, three major hydropower projects were implemented or committed : Areia Project, Segredo Project and Salto Caxias Project. In the present analysis, the data between 1980 and 1994 were used since the price adjustment index is available only for this period. The total investment amount during this period was US$ 912 million as shown in Appendix-2. The data on the source of fund were available only for the Segredo Hydropower Project as follows.

- World Bank :	8.3 %
- FINAME :	11.6 %
- ELETROBRAS :	17.9 %
- State government :	8.6 %
- COPEL :	49.4 %
- Previous selling to private large consumers :	4.2 %

The records collected as above were converted to 1994 price level using an index prepared by COPEL to correct for deviation between the change in exchange rate and inflation rate as shwon in Appendix-2 . Based on the adjusted figures, annual average investment figures were derived to be compared with the investment cost proposed by the Strategy. The following are the results.

(Unit : million US$ in 1994 prices)

Sector	Proposed Investment (total*)	(annual**)	Past Investment (annual)
Water Supply			
Domestic	1,309	65	-
Industrial	502	25	-
Sub-total	1,811	90	57
Sewerage	704	35	19
Total	2,279	114	76
Hydropower	3,381	169	94

* The proposed investment amount between 1996 and 2015.
** These figures are annual average figures for 20 years between 1996 and 2015.

The proposed investment for the water supply sector is by about 58% higher than the past investment on an annual basis (US$ 90 miilion vs. US$ 57 million.) A reservation should be made, however, regarding the industrial water supply. In reality, there is a number of possible choices for industrial water supply such as direct abstraction of surface water and groundwater, development of independent industrial water supply system separate from domestic water supply and a system both for domestic and industrial water supply such as assumed in the present study. A realistic comparison might be that between the planned investment for domestic water supply system (US$ 65 million) and SANEPAR's past investment on water supply (US$ 57 million) on the ground that most of SANEPAR's investment on water supply systems until now has been for domestic water since a large part of industrial water demand has been met by direct abstraction. Based on this concpet, these two figures are judged to stay within almost the same range.

The proposed investment for sewerage at US$ 35 million annually is about 85 % higher than the past record at US$ 19 million. This deviation can be explained by the following two factors.

a) Until now, the focus of SANEPAR's investment has been placed on water supply rather than on sewerage, having resulted in degradation of water quality.

b) In the proposed Strategy, the emphasis on water quality improvement is reflected in the target that planned water quality fully complies with the CONAMA resolution. This target results in the planned investment cost higher than the past achievement.

The following directions are recommended to be pursued for fund raising for the future investment need.

- possibility of charging on direct water abstraction and direct discharge
- review of the present tariff system
- participation of the private sector

The hydropower sector shows a deviation of 80%: US$169 million per year vs. US$94 million per year in the past. A unique characteristics of the Paraná's hydropower sector is that nearly a half of the electricity produced is transmitted out of Paraná to neighboring states. Reflecting this fact, external investment fund was made available for past hydropower development in Paraná. In the case of the Segredo Hydropower project, the COPEL's fund accounted only for 49 % of the total fund with the remaining fund financed by other sources such as the World Bank (8 %), FINAME (12 %), ELETROBRAS (18 %), the state government (9%) and other sources (4 %). It would, therefore, be appropriate to judge that the deviation such as above at 80 % is within a reasonable range taking into consideration both COPEL's financial capability and the availability of external sources.

1.2 Economic and Financial Measures for the Strategy

1.2.1 Objectives

This section presents a number of economic and financial measures recommended for the Strategy. Non-structural measures such as economic and financial measures are as important as structural measures in improving the water environment in Parana. Success in improving the water environment through non-structural measures would lead to easing the burden on the public sector for investment on structural measures. The investment requirement can be minimized by controlling the demand side behavior through various incentives and disincentives. It should be recognized that the future planning for water environment improvement should incorporate both non-structural and structural measures. In this sense, the present study has paid attention to a number of economic and financial measures such as follows to indicate general directions for further detailed analysis.

- charging on direct water abstraction
- charging on direct discharge of wastewater
- review of the existing tariff level
- cleaner production
- economic efficiency in sewerage planning
- ecological ICMS

1.2.2 Charging on Direct Abstraction of Water

(1) Need for Charging on Direct Abstraction

The possibility of charging on direct abstraction of surface water and groundwater was reviewed. The objective would be to achieve an efficient use of water through demand side measures. Through charging on direct abstraction, an incentive will work on the part of direct water abstractors to save water use through various measures such as reduction in the amount of water used and increased recycling of used water.

This idea would be suited to areas like the Curitiba Metropolitan Area where water supply and demand balance has been becoming increasingly tight. Until present, direct abstraction of both river water and groundwater has been common among industries. Usually they put up their own facilities abstracting either surface water or groundwater. The costs they bear are application fee (US$24.3) and registration fee (either US$81.0 or 24.3) for water right acquisition and the cost of their own facilities. A simple analysis revealed that the unit cost of private water abstracting facilities is nearly one-fortieth (or 2.5 %) of the tariff currently imposed by SANEPAR on industrial and commercial use. (0.028 US$/$m^3$ for surface water and groundwater as opposed to 1.10 US$ /m^3. A calculation process is shown in Appendix-3.) Direct abstraction of water is significantly inexpensive compared with buying water from public water supply system. Once industries acquire water right, they are free to abstract as much water they need within the amount permitted under the water right authorization or permission.

In this situation there is no incentive to save water use. In Parana this situation generally has not caused a serious problem until now since water resources have been abundant compared with demand. In the near future, however, in certain areas like the Curitiba Metropolitan Area, a rapid increase in water demand is forecast and urgent measures are needed. Supply side measures such as water source facilities development are required on one hand. Demand side measures, on the other hand, are also needed to minimize financial burden for supply side measures. With tariff imposed on direct abstraction, direct abstractors would make an effort to rationalize their water use.

An assumption in water demand projection in the present study is the achievement of industrial water recycling rate at 37.5 %, about half the present level in Japan, in the year 2005. This kind of target will be attained by demand side measures such as charging on direct abstraction of water.

(2) Example of Other Countries

The following part presents a number of examples in other countries where direct abstraction of water is charged. Examples are taken from Japan, UK, France, USA and Thailand.

Japan

The Yodo basin in the Kansai area (Osaka is the major city) has been adopting the system to charge on direct abstraction of surface water. Direct abstraction of groundwater is not charged. Direct abstractors are charged according to a tariff matrix which sets out various charges on a per liter per second basis. Variation in charges are determined by the following factors :

a) type of activity (e.g., industrial and mining, supplies of water to towns, other uses);

b) location of abstractors on the river (four zones)

c) In one of the zones, the size of abstraction (greater or less than 100 liters per second)

The objectives of the system are equity of burden and to raise funds to pay for maintenance of resources.

United Kingdom

In England and Wales, all direct abstractions, either surface water or groundwater, are charged except those for domestic purposes and non-spray-irrigation use in agriculture. A noteworthy concept in the system of the Yorkshire Water Authority is the distinction between abstraction and consumption. The higher the proportion of the consumption of abstracted water, which means the lower rate of abstracted water returns to the river, the higher the charge. The variations are illustrated as follows with relative charge factors.

a) by use of abstraction, divided up into:

complete loss (including evaporative cooling)	150
high loss (spray irrigation)	135
general (industrial use, public water supply)	50

low loss (circulated cooling, sand gravel washing, fish farming)	4.5
zero loss (return unchanged in temperature, quality and quantity)	1

b) by source, divided up into :

inland water (1st class) :	10
inland water (2nd class, groundwater)	7
inland water (tidal)	3

c) by season, divided into :

summer use (April - September) :	3
all-year-round use :	2
winter use (October - March)	1

France

The charges of the Seine-Normandie Agence system are determined based on the following factors :

a) zone (14 in all, reflecting quality variation)

b) surface or groundwater

c) season (summer 5 months and winter 7 months)

d) quantity of water abstracted or quantity of water consumed

Restitution coefficients as follows are applied to derive the amount of consumption relative to abstraction.

- 0.93 for industrial uses
- 0.80 for public supplies of potable water
- 0.60-0.70 for run-off irrigation
- 0.30 for spray irrigation

Charge for groundwaters is about 2 to 3.5 times higher than that for surface water.

The imposition of charges by the Picardy Agence de Bassin in 1970 led to industrial water consumption falling by 50 per cent ten years later, a good example of incentive effect of the charging system.

United States

In the Delaware River Basin, a much simpler system was in operation. The abstraction/consumption distinction operated but with much larger differential. Water consumed is charged at 100 times water simply abstracted.

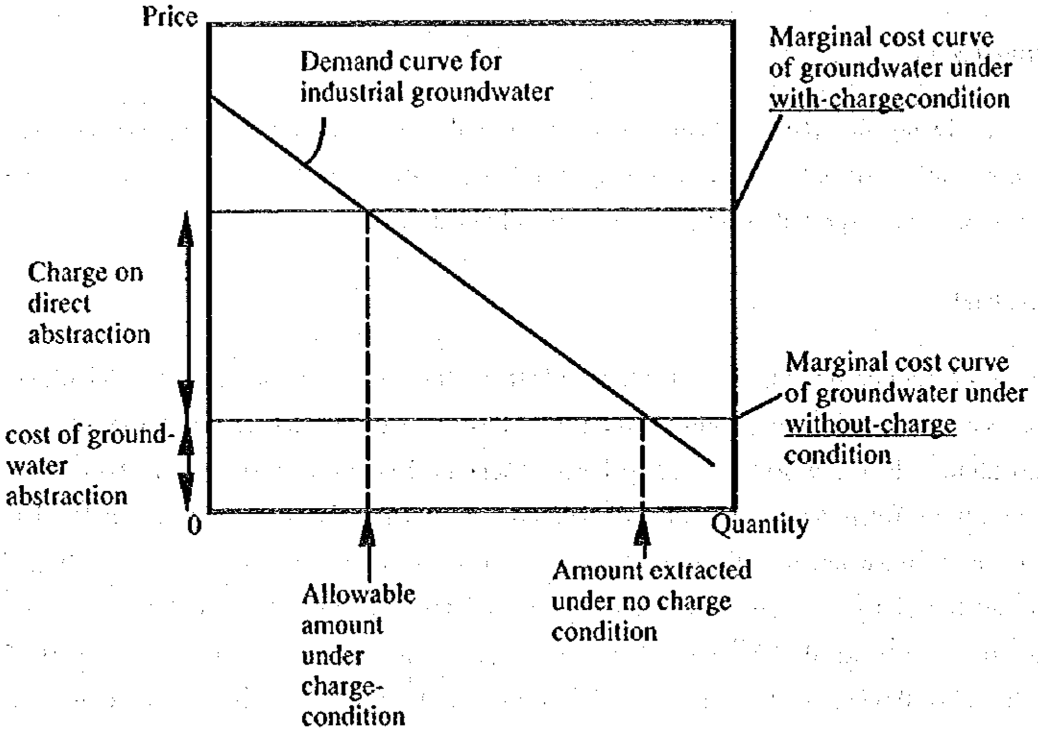
Thailand

Land subsidence has been a serious problem in Bangkok, the capital city of Thailand. Excessive extraction of groundwater for industrial use was the major cause of land subsidence. In the worst year subsidence reached 12 centimeters per year. To prevent the problem from worsening, the government enacted the Groundwater Act in 1979 to control groundwater use. By this act the permitted groundwater abstractors are obliged to pay for charge depending on the amount of groundwater abstracted : 1 Baht/m^3 (0.04US$/$m^3$) in the Metropolitan Waterworks Authority service area and 0.75 Baht/m^3 (0.03US$/$m^3$) in other areas. A report by JICA suggests that the imposition of groundwater charge had led to a significant rise in the rate of industrial water recycling, 70-80 % for surveyed industries, a good example of incentive effect of the charging system.

(3) Method of Setting Tariff on Direct Abstraction

In the case of surface water, direct abstraction charge can be set based on the concept of sharing the cost of water resources development that would ensure stable flow of surface water. Under the water scarcity condition, direct surface water abstractors will benefit from water resources development. The cost for water resources development, thus, should be shared by direct abstractors as a beneficiary.

Excessive extraction of groundwater is beginning to cause various damages such as decrease in groundwater availability and quality degradation. In terms of the amount, there is an upper limit within which groundwater extraction should be sustained. A sustainable use of groundwater could be achieved under an appropriate management of groundwater use. Theoretically charge level of groundwater use can be set at a price level where demand for groundwater meets the allowable maximum quantity of groundwater. This concept can be expressed in the following figure.



The present study has revealed that the Curitiba Metropolitan Area is forecast to suffer from severe water shortage. The new charging system should be incorporated into an overall water environment management system for the metropolitan area as an effective tool to control industrial water demand. A detailed analysis of the following factors will be required to work out a new charging system for direct water abstraction.

- level of tightness in water supply-demand balance
- level of direct abstraction in the future or the level of coverage by public water supply system
- detailed cost estimate for water resources development and cost allocation
- demand function of industrial water demand
- cost of groundwater extraction facilities
- clarification of the maximum allowable abstraction volume of groundwater

Regarding the second point, the present study assumes that all the industrial water demand be met by the planned public water supply system. For specific areas like the Curitiba Metropolitan Area where the highest concentration of industries is observed, however, it is likely that certain portion of industries remain self-reliant in acquiring industrial water continuing direct abstraction. In the planning for specific areas, therefore, it would be necessary to determine the levels of coverage by the public system and direct abstraction taking into consideration local conditions. Charging on direct abstraction should be planned in the overall planning context.

Appendix-4 presents an overview of Japan's experience in industrial water supply management. In Japan ground subsidence grew to be serious problem as a result of excessive extraction of groundwater for industrial use. The measure the government took was the prohibition and limitation of groundwater development in stead of charging on groundwater abstraction. In parallel the government promoted development of the industrial water supply system separate from domestic water supply system. As a result, water source for industrial source shifted significantly from groundwater to surface water. Efficiency in water use was greatly improved : water recycling rate grew from 36% in 1965 to 66% in 1975 and further up to 76% in 1991.

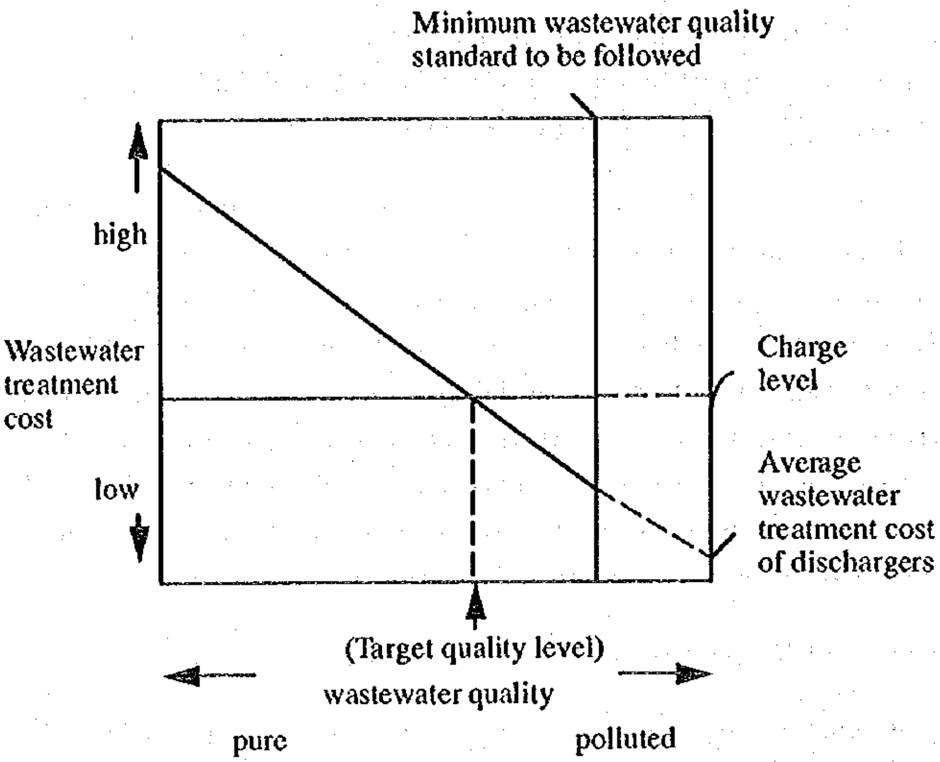
1.2.3 Charging on Direct Discharge of Wastewater

Charging on direct discharge of wastewater into public water is another possibility to be sought. The objectives of this charging system are :

a) to manage the level of water quality through partial introduction of market mechanism for the part of direct discharge, and

b) to raise funds for water quality management.

Under the present system, water quality is managed by the implementation of wastewater quality standard as explained in the water quality section. The system proposed here is the one combining the existing regulation system and a charging mechanism below certain level of pollution. Under this system, there is a minimum level of wastewater quality that all the direct dischargers are obliged to conform with. For a discharger following the standard, he has a choice of either paying the charge or further purifying the wastewater to minimize the charge payment. A simplified mechanism can be explained by the following chart.



The following procedures are needed to implement this system.

a) determination of the minimum wastewater quality standard to be followed by every discharger

b) determination of target water quality level

c) determination of charge level that would achieve the target quality level. The charge level can be set through clarifying the costs of wastewater treatment for direct dischargers corresponding to different levels of wastewater.

Worldwide, a number of countries have adopted systems such as above. They include Australia, Belgium, Canada, France, Germany, Netherlands, Portugal, Spain and USA. Experiences in these countries would be relevant for planning the introduction of the new charging system in Parana. For further analysis in the future, problems and limitations of the existing regulation system should be clarified and an addition of the charging element be evaluated.

1.2.4 Review of the Existing Tariff Level

A simple analysis was made to evaluate the present tariff levels of SANEPAR in view of the development cost of the proposed master plan and the Strategy. The objective is to clarify the present status of the existing tariff levels in comparison with the future need for investment. A detailed analysis on the tariff system should be made separate from the present study. The conclusion of the analysis is that there would be a necessity for upward adjustment for water tariff, whereas the present sewerage tariff level would be appropriate to cover the development cost.

The following table summarizes the derived cost of water.

(Unit US$/m3)

Area	Average Incremental Cost	OM Cost		Total
		Direct	Indirect	
Iguacu	0.291	0.247	0.250	0.788
Tibagi	0.137	0.116	0.250	0.503
Curitiba MA	0.353	0.300	0.250	0.903
Parana	0.318	0.247	0.250	0.815

Average incremental costs were derived by first annualizing the investment costs with a discount rate of 10%, the opportunity cost of capital, and a discount period of 30 years, average life of facilities, then dividing annualized investment costs by the corresponding annual water volume. Direct OM costs include actual expenses needed to operate the systems, while indirect OM cost comprises administrative costs etc. In all the cases, direct OM cost is assumed to be 9.0% annually of the investment cost before annualized. Indirect OM costs are set at US$ 0.25 /m^3 based on the SANEPAR's past performance.

The average domestic water tariff actually collected by SANEPAR is US$ 0.62/m^3. The cost of water for Parana is estimated to be US$ 0.82/m^3, about 32% higher than the present level. The following two points are concluded.

a) Overall water tariff level needs to be raised from the view points of economic efficiency as well as cost recovery on the ground that every cost minimizing effort has been made.

b) Regional variation in the tariff level should be allowed such that the tariff level reflect the cost of water of each region.

c) As a prerequisite, utmost effort should be made on the part of SANEPAR to minimize various costs before adjusting the tariff level. The decision on tariff adjustment can be made by incorporating social and political consideration.

d) A detailed analysis on the tariff structure should be made covering all the relevant aspects such as engineering, financial and institutional factors.

The following table summarizes the cost of sewage treatment for the four cities.

(Unit US$/m3)

Area	Average Incremental Cost	OM Cost Direct	OM Cost Indirect	Total
Curitiba	0.200	0.020	0.250	0.470
Cascavel	0.320	0.040	0.250	0.610
Ponta Grossa	0.280	0.030	0.250	0.560
Londrina	0.250	0.040	0.250	0.540

The present domestic sewage treatment charge is set at 80% of water tariff, US$ 0.50/m^3. The average tariff level of domestic and industrial sewage treatment actually collected by SANEPAR is US$ 0.58/m^3. These levels are almost within a similar range as the costs derived above. Based on this result, it is judged that no adjustment is needed for sewage treatment charge.

1.2.5 Cleaner Production

" Cleaner production " is an essential concept in formulating a strategy for water environment improvement. Cleaner production in manufacturing production process aims at minimizing generation of wastes and effluent by the application of new manufacturing technologies. The application of environmentally more sound " in-process technology " is contrasted with the conventional approach to waste and wastewater management by the "end-of pipe" technology. In-process technology tries to change the production process itself to minimize wastes, while the end-of pipe technology aims to treat wastes and wastewater generated in the production process to meet the effluent standard without changing the production process. This concept of " Cleaner Production " has been emphasized and encouraged by the United Nations Environment Program (UNEP) and the United Nations Industrial Development Organization (UNIDO) recently. The Agenda 21 in 1992 spared a chapter for cleaner production.

From the economic view point, the application of cleaner technology plays an important part in water environment management. Many cases have been reported in which the adoption of new in-process technologies are more economical than the conventional end-of-pipe technology. A promising alternative to investing on wastewater treatment facilities might be for the state government to provide subsidy to private companies for investment on cleaner production facilities. In total, it might turn out to be more cost saving for the government to provide subsidy to private companies to encourage the adoption of cleaner production technology than investing on wastewater treatment facilities. Appendix-5 presents 14 cases of factories worldwide applying cleaner production technologies and succeeded in saving cost as well as minimizing wastewater generation. In most cases, additional investment cost for adopting the new in-process technology is set off by saved operation cost soon, a few years at most. This means beyond the payback period saved cost can be counted as net benefit generated by the new in-process technology. A number of benefits in addition to economic benefit include : improvement of the quality of final product, safer work environment for workers, generation of sellable by-products, reduced requirement for inputs such as raw materials, water and energy. While it should be reminded that there are still cases in which in-process technology costs more than the conventional end-of-pipe approach, the possibility of applying environmentally more friendly technologies will expand in the future as a result of technological innovation and profit maximization mechanism.

In Parana, Klabin company, a paper company, is reported to have recently adopted a new whitening technology using nitrogen peroxide in the production of cellulose with the advice of the state government. A detail in economic efficiency is not known. In the case of Parana, the opportunity for applying cleaner production technologies will keep expanding in the future as industrialization will be one of the key strategies for economic growth of the state. While in developed countries industries may be more hesitant to replace the existing facilities with more environmentally sound facilities because of additional financial burden, this obstacle would be smaller in places like Parana where industrial growth is the challenge for the present and future. New industries will have a wider option in selecting technologies.

An important approach for the state government would be to take " the carrot and the stick" approach by promoting " Polluter-Pay" principle in combination with the encouragement of "Cleaner Production". Government effort in wastewater quality management will bear fruits more effectively when stringent water control measures based on the polluter-pay principle are associated with cleaner production promotion which will show the industries realistic alternatives to end-of-pipe wastewater technologies. In the event that only stringent effluent quality control and charging measures are taken, many industries would seek to find loopholes of the system, thus resulting in low achievement of the target. The government resource would be insufficient to prevent this situation from taking place. On the contrary, if industrial investors who are faced with stricter wastewater quality control policy are presented with an option which is technically feasible, economically attractive and environmentally sound, they would positively consider the proposed option, thus leading to higher level of cooperation from the private sector for wastewater quality control.

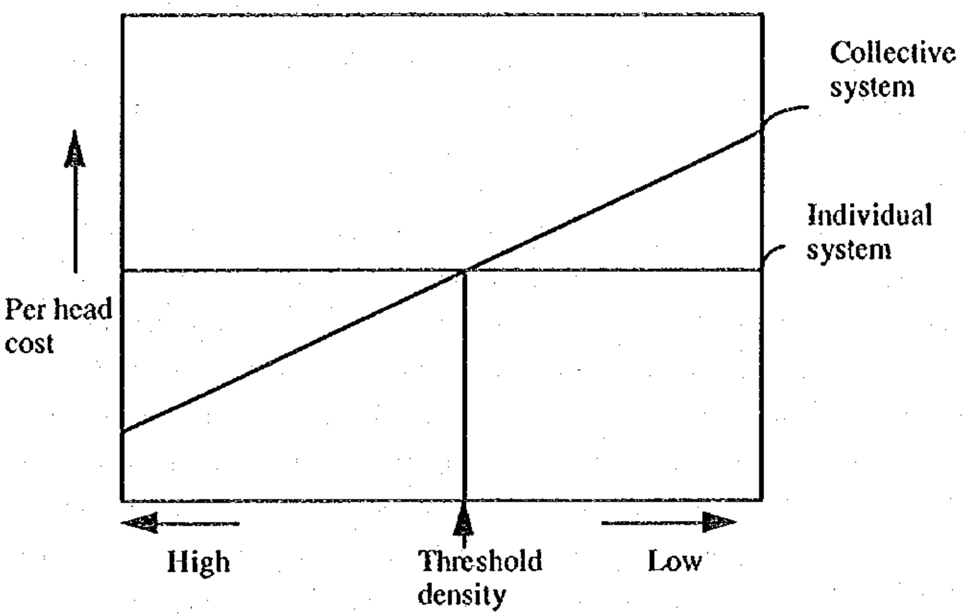
For the Parana government to be able to play a leading role in the promotion of cleaner production technologies, the following actions will be required.

- to collect and stock information on cleaner production technologies with the cooperation of international aid agencies such as UNEP and UNIDO and developed countries (e.g. through the existing data base service by UNEP such as the International Cleaner Production Information Clearinghouse or ICPIC)
- to develop human resources in the government in the field of cleaner production
- to take measures for information dissemination to the private sector in various forms (publications, seminars, counseling etc.)
- to take legislative measures for financial support to the private sector, once it is found effective.
- to prepare an optimum wastewater quality management plan integrating both in-process technology and end-of-pipe technologies
- to coordinate wastewater management plan and industrial development plan

1.2.6 Economic Efficiency in Sewerage Planning

The master plan of the present study proposes to develop sewerage systems in four cities in the Iguacu and Tibagi River basins : Curitiba, Cascavel, Ponta Grossa and Londrina. In the future, the coverage of the sewerage system is expected to expand along with further urbanization in Parana. An important issue in sewerage planing in the future would be the cost efficiency of the sewerage system. In formulating an optimum sewerage system for an area, an important issue would be the choice of an appropriate combination of collective sewerage system and individual sewerage system. An important factor in this decision is the economic efficiency of the system which can be measured by costs per head for investment and operation and maintenance. In the case of the individual system such as septic tank, per head cost for treatment facility is constant and no cost is incurred for pipes. In the case of the collective system such as basin-wise system, local government system or village system, per head costs of both treatment facility and pipes rise as population density lowers due to the economy of scale of the treatment cost and longer length of pipes needed per head. Consequently, there is a point where per head costs of the two categories equilibrate. This concept can be visualized as below.

Per Head Cost Relation of Alternative Sewerage Systems



According to this graph, it is more cost efficient to apply the collective system where the density is higher than the threshold point, whereas the individual system is more cost efficient for the areas with the densities lower than this point. A study in Japan revealed that the threshold population density is 40 inhabitants per hectar (4,000 per square km). This indicates that the collective system is more economical for areas with a population density of more than 40 per hectar, whereas the individual system is better for areas where the density is lower than 40 per hectar.

While the threshold density would vary in each country and region, the concept could be applied to everywhere. Relative cost efficiency would be determined by the technologies actually available and their costs for treatment facilities and pipes. In the planning of sewerage development for smaller cities such as type B and C cities in the future, the following aspects should be duly considered and an appropriate system be selected.

- technology actually available
- costs of pipes, treatment facilities and individual system
- threshold point of density (e.g. population, household)

1.2.7 Ecological ICMS

The Ecological ICMS in Parana is an innovative form of allocating part of tax revenue for environmental preservation. The following part presents an overview of the system and directions for the future improvement of the system.

ICMS is short for Imposto Circulacao Mercadorias. It is one of the 54 taxes in Brazil imposed for distribution of commodities. In the Parana state, a legislation was passed in 1991 which designates that part of ICMS revenue be allocated for environment preservation purpose. Revenue from ICMS is allocated between the federal government and the state government at 25% and 75%. This 75% for the state is further divided into education sector, state budget and municipalities budget. Out of the total amount for municipalities, 5% is reserved for allocating to municipalities with environmentally important areas. Those municipalities which have either green area or water recharging area which, they judge, is to be preserved make application to the IAP for receiving the money. The IAP evaluates the applications and when judged appropriate makes a decision to provide the fund.

The basic idea of this new system is to compensate for the economic loss caused by prohibition of development in a certain area. Municipalities like Piaquara had a limit in developing their area because much of their area was water recharging area for Curitiba. Local voice raise requiring for compensation for the lost opportunity for economic development. Responding to the request of this kind, the system was legislated and started in 1991. Parana was the first state in Brazil introducing the system. Following Parana, four states have adopted similar systems. They are Santa Catarina, Sao Paulo, Mato Grosso and Rio de Janeiro. In 1996, a total of 30 million US$ is to be reserved for ecological ICMS which will be provided for 15 municipalities with green areas and 16 municipalities with water source areas.

A number of problematic cases such as follows have been pointed out.

- A municipality which received ecological ICMS fund for preserving green area started constructing a paved road passing through the middle of the preservation area.

- There was an attempt to acquire the ecological ICMS fund for private reforestation program for commercial purpose.

These problematic cases have occurred largely due to a young history of the system and the lack of understanding on the part of potential beneficiaries of the system. These problems will be overcome by continued effort in information dissemination by the state government.

More fundamentally, it is recommended that an integrated environmental and economic framework for the Parana State be established to achieve a fair and effective operation of the system. The following factors need to be clarified for operating the system.

a) to judge the degree of the need for preservation

- to evaluate the environmental asset
- to evaluate the level of importance of water source areas

b) to estimate the economic loss caused by preservation

Regarding the first aspect, an integrated statewise strategy for land use will be needed. Underlying criteria for the integrated land use strategy will serve as a basis for evaluating the need for preservation and prioritization of applications by municipalities.

Regarding the second aspect, an evaluation should be made from an overall economic viewpoint rather than a short-sighted view such as looking only at lost tax revenue and commercial loss. Quantification of economic benefits accrued to environmental preservation should be attempted in this sense.

CHAPTER 2 ECONOMIC AND FINANCIAL ANALYSES FOR THE MASTER PLANS OF THE THE IGUAÇU AND TIBAGI RIVER BASINS

2.1 Economic Analysis

2.1.1 Objectives and target areas

This section presents an outline of an economic analysis carried out for the proposed master plans for the Iguacu and Tibagi River Basins. The objective of the analysis is to assess the magnitude of economic return to the proposed master plans by sector from the perspective of overall economy.

The result of the economic analysis would serve as the basis for making a judgement in promoting each component to the feasibility study stage and making a comparison among each of the master plan components. A cost-benefit analysis derived economic internal rates of return (EIRRs), benefit - cost ratios and net present values for each component.

The target areas of the economic analysis are the following. The selected target areas are those for which economic benefit could be quantified.

Sector	Iguacu	Tibagi
water supply	O	O
sewerage	O	O
flood mitigation	O	X
soil erosion	O	O
ecological preservation	O	X
hydropower	O	O

Note : O; conducted, X ; not conducted

2.1.2 Results of the Analysis

(1) Common Assumptions

The following are the assumptions underlying all the sectors.

a) An evaluation period of each sector is determined based on such factors as the life of the facilities and present practice of the related organizations.

b) A construction period of each sector is determined based on the average length needed for constructing the facilities of each sector.

c) A conversion factor of 0.85 is applied to adjust the investment and operation and maintenance costs in order to correct for price distortion. A number of information collected suggests that a conversion factor in Brazil and Parana ranges between 0.85 and 0.90. The figure 0.85 was used for the economic evaluation for the Segredo Hydropower Project as presented in the Project Information Report prepared in March 1990 by the Inter-American Development Bank committee. The total cost was adjusted using the conversion factor based on the judgement that the proportion of foreign currency in the investment cost of the past projects in Parana was marginal.

d) The exchange rate applied is R$0.89 = US$1.0.

(2) Water Supply

Assumptions

A cost-benefit analysis for water supply sector was conducted based on the following assumptions.

a) An economic analysis was conducted for the urban water supply component. The rural water supply component was not included in the analysis since the magnitude of investment is marginal.

b) A construction period of 4 years and an evaluation period of 30 years are assumed.

c) The volume of water to be supplied by the proposed system is divided into domestic and industrial uses based on the proportions derived in the water demand projection for each city.

d) Economic benefit was estimated to be 0.93 US$/$m^3$ for domestic water composed of 0.62 US$/$m^3$ as the present average tariff level collected by SANEPAR and 0.31 US$/$m^3$ as the assumed consumer surplus. It is assumed that the total willingness-to-pay of water consumers can be derived by adding a 50% to the tariff they actually pay. The assumption of 50% as representing the consumer surplus portion is worked out based on the following considerations.

- Since water is the basic necessity for life, the willingness-to-pay of consumers must be high.

- A study made in Espirito Santo State indicates that consumer surplus portion is equivalent to 200% to 300% of the present tariff level. A detail of this study is presented in Appendix - 6.

The rule-of-thumb approach such as above is considered appropriate for master plans such as the present study. In the feasibility analysis, however, a more detailed analysis should be made on consumers' demand for water.

e) Industrial water supply benefit is estimated to be 0.56 US$/$m^3$, the average of SANEPAR's tariff on industrial water and unit water cost of direct abstraction:

$$(US\$0.028/m^3 + US\$\ 1.10/m^3)/2 = US\$0.56/m^3$$

A detail of estimating direct abstraction cost is presented in Appendix-3.

f) Water losses are assumed to be 25% for domestic water and 10 % for industrial water. Benefit, therefore, is estimated for the volume measured at the point of consumers.

Results

The EIRRs, B-C ratios and net present values (NPV) derived for the water supply sector are presented in Table-1. A discount rate of 10 % is applied for B/C and NPVs. Appendix - 7 contains the cost and benefit flows of each of the water supply components.

Various information in Parana and Brazil indicates that the opportunity cost of capital (OCC), which is a criterion against which an EIRR can be compared, is somewhere between 10% and 12%. In the Iguacu River basin, the derived EIRRs of the type A and B cities range between the highest in Foz do Iguacu at 77.81% and lowest in Unio da Vitoria at 10.27%. Overall the EIRRs for all the type A and B cities in the Iguacu River Basin are calculated at 40.79% and 25.92% respectively implying sufficient economic return to the investment. The EIRR of the type C cities is 8.20% on average indicating lower return, which would be a reflection of more dispersed settlement pattern in smaller cities.

For the Curitiba Metropolitan Area, which accounts for 67% and 79% of the total water supply volume and the investment cost of all the type A and B cities in the Iguacu River Basin respectively, an EIRR was derived at 10.29%, almost equal to the OCC. The relatively low EIRR for the Curitiba MA compared with other cities would be due to severe water balance condition in the Curitiba MA and resultant higher investment cost per unit water volume. The needs for constructing dams and conveying water from more distant sources lead to lower investment efficiency.

In the Tibagi River basin, the derived EIRRs of the type A and B cities range between the highest in Apucarana at 40.88% and lowest in Irati at 7.09 %. Overall the EIRRs for all the type A and B cities in the Tibagi River Basin are calculated at 35.98% and 22.82%. The EIRR of the type C cities is 12.90%, reflecting lower investment efficiency for smaller cities with more rural characteristics.

Conclusion

It is concluded that the urban water supply component of the Iguacu River Basin and the Tibagi River Basin, in general, shows sufficient economic return to the proposed investment. It is judged that all the projects are worth promoting to the feasibility study stage for further detailed analysis. In order to be able to make a more rigid judgement on investment justification, the following aspects should be refined and incorporated into an economic analysis in the feasibility analysis stage.

a) a detailed estimate of investment cost and operation and maintenance cost

b) an estimate of benefit reflecting economically optimum tariff level and consumer surplus

Special consideration should be given to water supply planning in the Curitiba Metropolitan Area such as follows.

a) Demand side measures such as charging on direct abstraction as proposed for the Strategy should be taken into consideration. Total demand would fall as a result reducing the burden for supply side measures.

b) A new tariff system would be worth considering. Regional variation in the tariff level is inevitable based on the marginal cost pricing or from the cost recovery perspective. In the Curitiba Metropolitan Area where water is more expensive and the economic level is higher than other areas, a higher level of tariff would be acceptable.

c) The present study assumes that both domestic and industrial water demand are to be met by facilities of the same standard. In reality, separation of domestic water supply system and industrial water supply system would be necessary. For the part of industrial water demand to be met by public water supply system, facilities of lower cost would be suitable since the quality of water demanded by industries would be lower. An EIRR soly for domestic water supply would be higher than derived as above due to the higher economic benefit of domestic water than that for industrial use.

(2) Sewerage

Assumptions

A cost-benefit analysis for the sewerage component was carried out based on the following assumptions.

a) A construction period of 4 years and an evaluation period of 30 years are assumed.

b) Present average tariff level of SANEPAR at US$0.58 /m^3 is used as the economic benefit as a proxy of the willingness-to-pay of customers.

Results and Conclusion

The EIRRs derived for Curitiba, Cascavel, Ponta Grossa and Londrina are as follows. Appendix - 8 presents cost and benefit flows of the four sewerage projects.

- Curitiba : 24.27 %
- Cascavel : 16.57 %
- Ponta Grossa : 18.56%
- Londrina : 20.56%

All the four cities show high economic return to the investment largely surpassing the OCC at 10 %. Real EIRRs would be higher than the above figures since the benefit applied captures only part of actual willingness-to-pay of customers and do not reflect improved water quality affecting non-customers. The different level of EIRRs between the four cities would be due to different proportions of costs for pipe works. Curitiba shows higher investment efficiency reflecting a more dense settlement pattern.

In the feasibility analysis stage, a more detailed analysis should be made including the following items.

a) a detailed estimate of investment cost and operation and maintenance cost

b) an estimate of benefit reflecting :

- economically optimum tariff level and consumer surplus, and
- quantification of external effect (economic impact of water quality improvement for non-customers).

(3) Ecology

Objective and methodology

In general, a number of approaches have been introduced to quantify economic benefit of ecological preservation such as focusing on genetic resources as a pharmaceutical resource and a contingent valuation method to clarify peoples' willingness-to-pay for preservation. Regarding the first concept, an indicator for economic value would be the cost that pharmaceutical firms would be ready to pay for preserving an important area. The second view looks at preservation as important for the society to maintain psychological stability or give comfort for the people. People might want to preserve an area for visiting the nature or they might judge that preserving the area itself is important regardless of him or her actually visiting the area. Or they might think that the area should be preserved for future generations. A contingent valuation method is often applied to quantify environmental benefits based on this concept.

In the present analysis, a simplified approach was taken to quantify ecological benefit. The case of Serra da Baitaca Preservation Area in the Iguacu River Basin is taken as an example. The objective is to show a methodology for quantification of ecological project benefit. The present analysis is, therefore, conducted based on a number of assumptions, each of which should be further surveyed in the feasibility study stage.

The methodology adopted for benefit quantification is based on the travel cost approach, which is often applied to measuring economic benefit of recreational resources. The idea is that the costs people pay for spending a certain time for recreational activities reflect the value of the recreational resource. Theoretically, the costs are broken down into travel cost to reach the place and time cost, which is the income lost due to spending the time for recreation. Consumer surplus can be measured once a demand function for the recreational asset is derived.

Assumptions

In the present analysis, a simplified method is adopted. Two basic assumptions are set : the aspects of the travel cost and the opportunity cost of preserving the area. The latter means the economic growth lost due to prohibiting the commercial use of the area other than recreational activities.

The following assumptions are set for the analysis.

a) Investment cost is assumed to be 1,170,000 US$, of which US$585,000 is for various program costs as estimated in the ecology section and another US$585,000 is assumed as costs for constructing various facilities. Operation and maintenance cost is assumed to be 5% of the investment cost annually.

b) Travel cost is estimated based on the following assumed factors :

   - population in Curitiba : 1,315,000,
   - 10 % of the population visit the place (131,500 people),
   - frequency of the visit is once a year on average, and
   - travel cost between Curitiba and the place is US$10/round trip.

   Annual travel cost is, thus, derived at 1,315,000 US$. This value can be regarded as the minimum level of economic benefit. Actual benefit would be higher by the portion of consumer surplus.

c) Opportunity cost of preservation is estimated based on an information on the ecological ICMS. The total amount to be used for preservation under the ecological ICMS system in 1996 would be around US$ 30 million for 31 preservation areas or about 1 million US$ per one preservation area on average. The opportunity cost is, therefore, assumed to be US$ 1 million per year. This value is added to the cost side on an annual basis.

Results and Conclusion

An economic internal rate of return for the Serra da Baitaca Preservation Area Project is derived at 12.4% based on the above assumptions. A cost - benefit flow is presented in Appendix - 9. It should be emphasized, however, that this calculation is preliminary based on assumptions. The following aspects should be surveyed in the feasibility study stage as the basic factors for benefit estimation.

- number of visitors to the area and frequency of visits
- willingness-to-pay of potential visitors
- a detailed estimate of opportunity cost of preservation
- an estimate of benefit from a wide perspective (preservation of genetic resources, peoples' valuation of preservation etc.)

(4) Flood Protection

An economic analysis was carried out for the Unio da Vitoria Flood Protection Project in the Iguacu River Basin.

Assumptions

a) An evaluation period is set at 50 years.

b) A construction period of 5 years is assumed.

c) Annual operation and maintenance cost is assumed to be 0.5% of the investment cost.

d) Probable flood damage is estimated to be US$ 9,779 thousand annually, which would be avoided by the implementation of the flood mitigation project. The process of deriving this flood damage value is presented in the section on flood mitigation. This economic benefit is assumed to grow by 5% per year in accordance with economic growth of the affected area. The idea is that under no-flood condition, economic activities will expand in the area. The growth rate is set at 5% per year conforming with the assumed GDP growth rate applied to water demand projection.

Result and Conclusion

An EIRR is calculated to be 14.65 % indicating economic viability of the Unio da Vitoria Flood Control Project. The project is judged to be worthwhile to be promoted to the feasibility study stage. A cost - benefit flow is shown in Appendix - 10.

(5) Soil Erosion Prevention

The master plans propose soil erosion prevention measures for an area of 1.3 million ha in the Iguacu River Basin and of 534 thousand ha in the Tibagi River Basin. There are altogether 19 locations in the two river basins planned under the master plans. An economic analysis was conducted for the total of all the soil erosion projects in each river basin.

Assumptions

a) An evaluation period of 30 years is assumed.

b) A construction period of 1 year is assumed.

c) The cost of fertilizers to be saved by the project is employed as the economic benefit. A detail is presented in Sector Report J "Soil Erosion and Forest".

Result and Conclusion

The following EIRRs are derived. The cost - benefit flows are shown in Appendix - 11.

- Iguacu : 8.63 %

- Tibagi : 8.36 %

These EIRRs are the minimum level of EIRR expected. Actual EIRRs would be much higher than these levels since a number of expected benefits were not included in the present analysis due to the limited availability of data needed for quantification. They would include the rise in agriculture productivity, reduction in the water treatment cost due to the fall in sedimentation volume and reduction in fertilizer use leading to improved water quality. A higher EIRR would be expected once a more detailed economic analysis in the feasibility study stage succeeds in quantifying these benefits.

(6) Hydropower

Project to be Analyzed

There are in total 8 hydropower projects planned to start operation by the year 2015 in the Iguacu and Tibagi River Basins as follows. Out of these, construction of Jordao diversion and the Salto Caxias project have already started. The present analysis, therefore, focuses on the remaining 1 hydropower project in the Iguacu River Basin as well as all the 5 hydropower projects planned in the Tibagi River Basin.

- Jordão diversion (Iguacu)
- Salto Caxias (Iguacu)
- Cebolão (Tibagi)
- Jataizinho (Tibagi)
- Saõ Jerônimo (Tibagi)

- Mauná (Tibagi)
- Telêmaco Borba (Tibagi)
- Fundão (Iguacu)

Assumptions

The following assumptions are set.

a) An evaluation period of 50 years is set.

b) A construction period of 5 years is assumed.

c) The operation and maintenance cost is assumed to be 0.5% annually of the investment cost based on the information regarding the past performance of ELETROBRAS.

c) Economic benefit from consumption is set at 72US$/MWh, including tariff and consumer surplus. This figure was used in the economic analysis for the Segredo Hydropower Project in 1990. Benefit from demand, that is mainly from high tension consumers, in the peak and out-of-peak time is assumed to be 17% of the consumption benefit based on the COPEL's data in 1994.

Result and Conclusion

The EIRRs, B/C ratios and NPVs for the hydropower projects are calculated as shown in Table-2. All the hydropower projects in the two river basins except the Tagua project show high economic return. The cost - benefit flows are shown in Appendix - 12.

2.2 Financial Analysis

2.2.1 Objective

A financial analysis was conducted for the water supply component and sewerage component. The objective of the financial analysis is to evaluate the return to investment from the perspective of implementing agency.

2.2.2 Water Supply

Methodology and Assumptions

Financial internal rates of return (FIRR) were derived for each component of the water supply sector. The following are the assumptions.

a) The investment cost and operation and maintenance costs presented in Sectoral Report N-I " Cost Estimate" are used.

b) Revenue is estimated based on the present average revenue per cubic meter collected by SANEPAR : US$ 0.62/m^3 for domestic use and US$ 1.10/m^3 for industrial use.

c) The volume of water to be supplied by the proposed system is divided into domestic and industrial uses based on the proportions derived in the water demand projection for each town.

d) Water losses are assumed to be 25% for domestic water and 10 % for industrial water. Revenue, therefore, is estimated based on the amount measured at the point of consumers.

Result and Conclusion

Financial internal rates of return (FIRRs) are derived for two cases : the first case of industrial use and domestic use combined and the second case of domestic use only. The first case assumes that all the industries would pay the industrial water tariff at US$1.10/$m^3$. The second case focuses only on domestic water supply. The derived FIRRs are presented in Table - 3. Cash flows of each project are shown in Appendix - 13.

Since data on real interest rates in Parana was not available, it is difficult to make a straight judgement on these FIRRs. In general, however, it can be judged that most of the components will generate sufficient return to operate the system in a sound manner. The derived FIRRs would also serve as a criterion for the following objectives.

- loan procurement for implementing organizations such as SANEPAR
- adjustment of tariff level reflecting different level of cost efficiency among different regions
- decision on investment in water supply project by the private sector

2.2.3 Sewerage

Methodology and Assumptions

Financial internal rates of return (FIRR) were derived for the sewerage components in Curitiba, Cascavel, Ponta Grossa and Londrina. The following are the assumptions.

a) The investment cost and operation and maintenance costs presented in the sectoral report N-I "Cost Estimate" are used.

b) Revenue is estimated based on the present average revenue per cubic meter collected by SANEPAR : US$ 0.58/m^3.

Results and Conclusion

The following FIRRs are derived. The cash flows are shown in Appendix -14.

- Curitiba : 21.34 %
- Cascavel : 14.27 %
- Ponta Grossa : 15.95 %
- Londrina : 17.73 %

It is judged that these levels will be sufficient for a sound financial management of the sewerage system. These FIRRs can be referred to in making various judgements in the same manner as for the water supply component.

Table-1 EIRR, B/C and B-C of Water Supply Projects

Area	Type	EIRR (%)	B/C	B-C (Million US$)
(Iguacu River Basin)				
Curitiba MA	A	10.29	1.02	14.90
Cascavel	A	21.49	1.81	36.70
Foz do Iguacu	A	77.81	10.98	129.10
Guarapuava	A	38.16	3.52	26.80
Medianeira	B	37.54	3.45	12.30
Dois Vizinhos	B	18.42	1.56	6.00
Francisco Beltrao	B	51.19	5.38	24.00
Pato Branco	B	17.02	1.46	4.90
Palmas	B	18.76	1.59	3.40
Unio da Vitoria	B	10.27	1.02	0.07
Type A Cities *	-	40.79	3.86	197.10
Type B Cities	-	25.92	2.20	50.10
Type C Cities	-	8.20	0.90	-11.70
(Tibagi River Basin)				
Ponta Grossa	A	37.58	3.45	38.60
Londrina-Cambe	A	34.12	3.05	110.90
Apucarana	A	40.88	3.87	49.90
Castro	B	46.69	4.68	23.60
Telemaco Borba	B	35.57	3.21	17.50
Irati	B	7.09	0.85	-1.60
Corneiro Procopio	B	10.79	1.05	0.40
Arapongas	B	17.55	1.50	9.80
Ibipora	B	19.08	1.61	5.30
Type A Cities	-	35.98	3.26	197.50
Type B Cities	-	22.82	1.92	55.90
Type C Cities	-	12.90	1.18	6.70

Note : (1) Cities with a population of more than 100,000 are type A cities, whereas
Type B cities are those with a poulation of between 50,000 and 100,000.
Type C cities are other cities.
(2) * excluding Curitiba MA

Table - 2 EIRRs, B/C Ratios and NPVs of Hydropower Projects

Project	EIRR (%)	B/C	B-C (million US$)
(Iguacu River Basin)			
Fundao	19.7	2.31	188.4
(Tibagi River Basin)			
Cebolao	25.6	3.35	275.4
Jataizinho	25.3	3.30	274.1
Sao Jeronimo	27.8	3.81	530.0
Maua	25.0	3.24	580.0
Telemaco Borba	25.2	3.27	194.8
Tibagi Total	25.9	3.41	1,853.8

Table-3 Summary of FIRRs for Water Supply Projects

(Unit : %)

Area	Industry + domestic	Domestic only
(Iguacu River Basin)		
Curitiba MA	9.51	3.99
Cascavel	13.50	11.55
Foz do Iguacu	62.16	58.31
Guarapuava	33.30	27.22
Medianeira	27.57	24.77
Dois Vizinhos	20.38	12.80
Francisco Beltrao	47.21	39.02
Pato Branco	11.15	8.33
Palmas	14.37	10.49
Unio da Vitoria	8.73	3.63
Type A cities(*)	28.85	26.89
Type B cities	22.71	17.23
Type C cities	4.75	-
(Tibagi River Basin)		
Ponta Grossa	34.55	27.43
Londrina-Cambe	25.53	22.30
Apucarana	35.91	29.56
Castro	51.06	38.54
Telemaco Borba	36.10	27.13
Irati	4.66	-
Corneiro Procopio	7.34	3.29
Arapongas	16.45	11.29
Ibipora	12.97	10.11
Type A cities	29.50	24.79
Type B cities	22.01	15.50
Type C cities	9.41	5.41

Note : (a)" - " means negative.
(b) Industrial water tariff is assumed at US$1.10/m3, the present average level.
(c) (*) excluding Curitiba MA

Appendices

ppendix -1

Past Investment by SANEPAR between 1992 and 1994 by Source and Use of Fund

(Unit :US$1,000)

Application	Source of Fund								
	SANE-PAR	State	Munici-pality	National Bank	BID	State Gov Fund	Unpaid expense	Others	Total
(1994)									
Water Supply, design	224	0	0	0	0	0	0	0	224
Sewerage ,design	104	0	0	134	0	0	0	0	238
Water supply, implementation	20,054	16,202	0	3,268	0	0	0	2,430	41,954
Sewerage, implementation	11,176	1,331	0	0	0	0	0	0	12,507
PEDU	0	0	0	0	0	24,608	0	0	24,608
Debt unused	0	0	0	0	0	0	0	0	0
Total	31,558	17,533	0	3,402	0	24,608	0	2,430	79,531
(1993)									
Water Supply, design	184	0	0	80	0	0	0	0	264
Sewerage ,design	447	0	0	1,187	0	0	0	0	1,634
Water supply, implementation	18,354	0	0	10,337	0	0	0	2,055	30,746
Sewerage, implementation	2,348	0	0	0	0	0	0	0	2,348
PEDU	0	0	0	0	0	16,058	0	0	16,058
Debt unused	0	0	0	0	0	0	0	0	0
Total	21,333	0	0	11,604	0	16,058	0	2,055	51,050
(1992)									
Water Supply, design	1,059	0	0	890	0	0	0	0	1,949
Sewerage ,design	472	0	0	686	0	0	0	0	1,158
Water supply, implementation	26,846	0	0	18,261	0	0	0	4,514	49,621
Sewerage, implementation	3,818	0	0	0	0	0	0	0	3,818
PEDU	2,628	5,899	1,760	0	0	0	0	0	10,287
Debt unused	0	0	0	10,698	0	0	677	82	11,457
Total	34,823	5,899	1,760	30,535	0	0	677	4,596	78,290
(1992-1994)									
Water Supply, design	1,467	0	0	970	0	0	0	0	2,437
Sewerage ,design	1,023	0	0	2,007	0	0	0	0	3,030
Water supply, implementation	65,254	16,202	0	31,866	0	0	0	8,999	122,321
Sewerage, implementation	17,342	1,331	0	0	0	0	0	0	18,673
PEDU	2,628	5,899	1,760	0	0	40,666	0	0	50,953
Debt unused	0	0	0	10,698	0	0	677	82	11,457
Total	87,714	23,432	1,760	45,541	0	40,666	677	9,081	208,871
(% distribution, 1992-1994)					(in %)				
Water Supply, design	0.7	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.2
Sewerage ,design	0.5	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.5
Water supply, implementation	31.2	7.8	0.0	15.3	0.0	0.0	0.0	4.3	58.6
Sewerage, implementation	8.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	8.9
PEDU	1.3	2.8	0.8	0.0	0.0	19.5	0.0	0.0	24.4
Debt unused	0.0	0.0	0.0	5.1	0.0	0.0	0.3	0.0	5.5
Total	42.0	11.2	0.8	21.8	0.0	19.5	0.3	4.3	100.0

Source : SANEPAR

Appendix 2 (1/2)
Investment Made by COPEL between 1975 and 1995

Year	(in thousand US$)				(in %)			
	Areia	Segredo	Caxias	Total	Areia	Segredo	Caxias	Total
1975	20,593	0	0	20,593	3.3	0.0	0.0	1.4
1976	78,692	0	0	78,692	12.6	0.0	0.0	5.5
1977	105,050	0	0	105,050	16.9	0.0	0.0	7.4
1978	118,138	0	0	118,138	19.0	0.0	0.0	8.3
1979	139,439	0	0	139,439	22.4	0.0	0.0	9.8
1980	115,471	1,968	0	117,438	18.5	0.3	0.0	8.2
1981	25,289	6,073	0	31,362	4.1	0.8	0.0	2.2
1982	13,599	18,128	0	31,727	2.2	2.4	0.0	2.2
1983	2,598	10,688	0	13,286	0.4	1.4	0.0	0.9
1984	2,332	4,435	0	6,767	0.4	0.6	0.0	0.5
1985	142	5,633	0	5,775	0.0	0.8	0.0	0.4
1986	125	6,750	0	6,875	0.0	0.9	0.0	0.5
1987	908	26,472	0	27,380	0.1	3.6	0.0	1.9
1988	160	63,563	0	63,723	0.0	8.6	0.0	4.5
1989	7	74,632	0	74,639	0.0	10.0	0.0	5.2
1990	24	136,067	0	136,091	0.0	18.3	0.0	9.5
1991	17	172,920	0	172,937	0.0	23.3	0.0	12.1
1992	0	139,568	6,576	146,144	0.0	18.8	10.9	10.2
1993	0	55,061	3,121	58,182	0.0	7.4	5.2	4.1
1994	0	15,373	5,268	20,641	0.0	2.1	8.8	1.4
1995	0	5,731	45,207	50,938	0.0	0.8	75.1	3.6
Total	622,582	743,062	60,172	1,425,816	100.0	100.0	100.0	100.0
Annual Average	36,622 (1975-91)	46,441 (1980-91)	15,043	89,114 (1975-91)	-	-		-

Source : COPEL

Appendix - 2 (2/2)

Past Investment Record of COPEL Adjusted by Price-Exchange Rate Index

Year	Investment Amount in Current Prices (000US$)	Price-Exchange Rate Index			Adjusted Investment	
		1986=1.00	1993=1.00	1994 1.00	(1993 base) (000US$)	(1994 base) (000US$)
1980	117,438	0.87	0.47	0.43	249,725	272,673
1981	31,362	1.14	0.62	0.56	50,895	55,572
1982	31,727	1.14	0.62	0.56	51,487	56,219
1983	13,286	1.16	0.63	0.57	21,188	23,135
1984	6,767	0.95	0.51	0.47	13,178	14,389
1985	5,775	0.95	0.51	0.47	11,246	12,280
1986	6,875	1.00	0.54	0.50	12,718	13,887
1987	27,380	1.09	0.59	0.54	46,471	50,741
1988	63,723	1.21	0.65	0.60	97,427	106,380
1989	74,639	1.39	0.75	0.69	99,340	108,469
1990	136,091	1.98	1.07	0.98	127,156	138,840
1991	172,937	1.75	0.95	0.87	182,819	199,619
1992	146,144	1.67	0.90	0.83	161,896	176,773
1993	58,182	1.85	1.00	0.92	58,182	63,528
1994	20,641	2.02	1.09	1.00	18,904	20,641
Total	912,968	-	-	-	1,202,633	1,313,146

Source : COPEL

Annual Average :

1994 base 93,796 thousand US$

1993 base 85,902 thousand US$

Appendix - 3
Facility Cost of Direct Water Abstraction

Item	Groundwater		Surface Water
	Curitiba	Other Areas	
Volume of water	760 m3/day	760 m3/day	760 m3/day
	500 /minute	500 /minute	
Facility Cost			US$6 million/m3/second
Drilling	3,000,000 yen/2 holes	2,000,000 yen/hole	-
Pump	1,000,000 yen/2pumps	500,000 yen/pump	-
Tank	500,000 yen/2 tanks	500,000 yen/tank	-
Pipes	450,000 yen	300,000 yen	-
Total	4,950,000 yen	3,300,000 yen	-
	55,000 US$	36,667 US$	-
Life	15 years	15 years	20 years
Discount rate	10 %/year	10 %/year	10 %/year
OM cost	10 %(of drilling and pump costs)	10 %(of drilling an	10 %
Abstraction cost	7,231 US$	4,821 US$	7,048 US$/year
OM cost	584 US$/year	365 US$/year	705 US$/year
Unit cost	0.028 US$/m3	0.019 US$/m3	0.028 US$/m3

Appendix - 4
Japan's Experience in Industrial Water Management

Japan's experience in industrial water management is briefly presented hereunder. In the post war Japan, the supply of industrial water was a big issue to ensure a rapid growth of the industrial sector. Groundwater developed by each industry was initially the main source of industrial water. After seveal years, however, the problem of ground subsidence emerged as a result of excessive extraction of groundwater. Measures taken by the government comprised the development of independent industrial water supply systems and the promotion of rational use of industrial water such as increased recycling of water. As a result of investment on industrial water supply systems, the ratio of the amount of industr* ial water supplied by the industrial water supply system rose from 14% in 1965 to 30 % in 1975, whereas that of groundwater declined from 41% in 1965 to 34% in 1975. These ratios were projected to reach 44% for industrial water supply system and 23 % for groundwater in 1985. Transfer of water source from groundwater to the industrial water supply system amounted to 1,704 million m^3 and 3,838 million m^3 by 1965 and 1975 respectively.

Water recycling rate rose from 36% in 1965 to 66% in 1975, further to 76% in 1991. The following is a comparison of growth of total water demand and the amount of water recycled and supplied.

	Recycling Rate (%)	Total water demand (m^3/day)	Amount of recycled water (m^3/day)	Amount of supplied water (m^3/day)
1965	36	134,043	87,978	46,065
1975	66	237,746	169,733	68,013
Change	+33%	+77%	+93%	+48%

The above figures show that while the growth of total water demand was 77%, that of the amount of water supplied was supressed to 48% as a result of higher growth of the amount of recycled water at 93%.

Attachment-1 presents the rates of water recycling and amount of water consumed per factory in Japan in 1991. It is observed that factories with highest recycling rates are those consuming the largest amount of water such as chemical, petroleum and steel industries. This indicates that water consuming industries have been making the most effort in increasing the recycling rate with cost saving motive.

The challenge for Japan now is to achieve a higher level of rational water use by such means as follows. The target for this direction has been shfiting from large sacle water consuming industries to medium to small scale industries with less water consumption.

- strict management of water use
- improvement of manufacturing equipment and water-related facilities
- cyclical use of cooling and temperature adjustment water
- cyclical use of industrial effluent

Appendix - 4
Attachment -1
Rates of Industrial Water Recycling in Japan in 1991

Type of Industry	Recycling Rate	Amount of Water Consumed per Factory	
	(%)	(m3/day)	(%)
Food	37.7	572	0.4
Beverage, feed, tobacco	32.3	1,599	1.2
Textile	21.2	980	0.8
Aparrel	0.6	15	0.0
Wood & related	16.5	63	0.0
Furniture & related	10.8	47	0.0
Pulp, paper & related	42.8	8,459	6.5
Printing, publishing & related	53.4	70	0.1
Chemical & related	81.8	21,702	16.7
Petroleum, coal & related	88.4	57,738	44.3
Plastic	65.5	943	0.7
Rubber & related	76.4	1,393	1.1
Leather , tanning & related	5.3	62	0.0
Furnace & related	66.9	1,145	0.9
Steel	89.9	26,095	20.0
Non-ferous metal	72.3	3,888	3.0
Metal products	50.0	242	0.2
General machinery	63.8	268	0.2
Electric machinery	71.3	556	0.4
Transport machinery	32.3	3,382	2.6
Fine machinery	53.2	236	0.2
Armament	45.8	722	0.6
Other	51.7	127	0.1
All	76.0	130,304	100.0

Source : Survey on Unit Rates of Industrial Location
(Japan Industrial Location Center)

Appendix - 5 (1/4)
Instances of Cleaner Production with Cost Saving (1/4)

Advantages	Economic Bebefit (Cost Saving in US$ per year)
Gas phase heat treatment of metals (Singapore)	
a) reduction in effluents b) improved work atmosphere c) safety improved d) improved quality of products	energy : 36,000 salt & maintenance : 51,000 Total : 87,000 Capital investment : 180,000 Payback : 2 years
Chrome recovery and recycling in the leather industry (Greece)	
a) very little change to production process b) more consistent product quality c) easier to monitor amounts of water and process chemicals used d) much reduced chromium content of effluent waters	savings : 73,750 operational cost : 30,200 Total net saving : 43,550 Capital investment : US$ 40,000 Payback : 11 months
Minimized environmental effects in cotton production (Denmark)	
a) Organic methods produce plants, without polluting the soil and the surrounding environment. b) Improved environment for workers at all stages. c) The environmental impact of each stage of production has been minimized. d) Reduction in water consumption.	(not quantified)
Pollution and waste reduction by improved process control in cement production (Indonesia)	
a) The waste of coal at high temperature is avoided. b) Higher quality clinker is produced. c) The lining of the kiln has a longer life. d) Some reduction in NOx and SOx emissions.	Power & fuel saving : 350,000 Capital investment : 375,000 Payback : less than one year
Recovery of protein from potato starch effluent The nehterlands)	
a) Major reduction in the volume of process water consumed through the recycling of wastewater b) The reduction in the quantity of waste handled enables the heat coagulation and evaporation plant to be half the size, so giving capital and energy cost saving c) Production of two by-products from the effluent	(not quantified) a) Wastewater disposal cost is avoided. b) Water cost is reduced. c) Two by-products generate revenue.

Appendix - 5 (2/4)
Instances of Cleaner Production with Cost Saving (2/4)

Advantages	Economic Bebefit (Cost Saving in US$ per year)
New technology : galvanizing of steel (France)	
a) Total supression of conventional plating waste b) Smaller inventory of zinc c) Better control of the quality and thickness of the zinc coating d) Reduced labor requirements. e) Reduced maintenance. f) Safer working conditions	a) Capital cost reduced by 2/3 b) Cost reduction in coating process from 60 % of operating cost to 18%. Payback period : 3 years
De-inking process for waste paper (UK)	
a) The process allows the use of a wider range of printed waste paper. b) The amount of dirt in the finished paper is reduced thereby improving quality and reducing the amount of reject paper. c) The brightness of the finished paper is improved without the use of chlorine bleaching. d) The energy requirements are low. e) The demands on effluent and waste disposal are minimal. f) The plant is safe to operate giving minimum risk to personnel and the environment.	(not quanified)
Reduction of sulphide in effluent from sulphur black dyeing (India)	
a) Reduction of sulphide in the effluent. b) Improved settlimg characteristics in the secondary settling tank of the activated sludge unit. c) Less corrosion in the treatment plant due to reduced sulphide levels in the effluent. d) The foul smell of sulphide in the work place was eliminated.	(not quanified)
Waste reduction in electroplating (Poland)	
a) A decrease in both water and raw materials consumption b) The reduction in both waste stream quantities are as follows: chromic acid 80% copper 95% cyanide 80% nickel 98% zinc 96% waste water 93%	Cost saving ; 193,000 Capital investment : 36,000 Payback period : 2 months

Advantages	Economic Bebefit (Cost Saving in US$ per year)
(continued) c) The wastewater is purified to the following levels : chromium 0.1mg/liter copper 0.1mg/liter nickel 1.0mg/liter cyanide 2.0mg/liter zind 0.9mg/liter	
Waste reduction in steelwork painting (Poland)	
a) Reduction of high disposal cost. b) Reduced running cost c) Decreased financial liability by generating a smaller quantity of hazadrous waste. d) Also indicated were potential reductions in the effluent concentrations of about 45% for sludge and 75 % for organic solvents.	airless spray / Pressure atomized electrostaic spray Saving: 38,500 / 39,400 capital: 4,800 / 13,000 Payback: 1.5months / 4months
New Product : water-based adhesives (UK)	
a) Product is non-toxic. b) Requires only 1/3 to 1/5 drying enrgy thereby needing no special solvent recovery system or explosion-proof equipment. c) Ensures higher level of adhesion and allows more time for the precise positioning of adherents d) Particulary suitable for food packaging.	(not quantified) savings in equipment, raw materials, safety precautions and overheads.
Cleaner production in a city-based project (Australia) (Case of printing shops) Reductions in : solvent emissions : 90% metal hydroxide sludge : 40% wash water : 90% use of chemicals : 70% waste of small containers : 50% (Case of car repair shop) Reductions in : halogenated materials : 100% oil-containing materials: 100% solvents : >50% waste : 30%	Based on 10 car respray jobs per day : 50,000 Capital cost : 13,000 Payback period : 3 months Material and emission reduction : hardener : 30% sanding : 15% solvents : 1,400kg dried-up paints/hazadrous waste : 350 kg

Appendix - 5 (4/4)
Instances of Cleaner Production with Cost Saving (4/4)

<table>
<tr><th>Advantages</th><th>Economic Bebefit
(Cost Saving in US$ per year)</th></tr>
<tr><td colspan="2">Minimization of organic solvents in degreasing and painting (Sweden)</td></tr>
<tr><td>(Changed degreasing techniques)
<table>
<tr><th>Environmental charge per annum</th><th>Previous trichloro-ethylene degrease</th><th>present alkaline degrease</th></tr>
<tr><td>air emission</td><td>11 ton trichloroethylene</td><td>0</td></tr>
<tr><td>water emission</td><td>0</td><td>water pulification plant</td></tr>
<tr><td>Hazadrous waste</td><td>5 ton of trichloroethylene sludge</td><td><2 ton sludge</td></tr>
</table>
(Changed painting techniques)
<table>
<tr><th>Environmental charge per annum</th><th>Previous liquid lacquering</th><th>present powder painting</th></tr>
<tr><td>Air emission</td><td>65ton</td><td>7ton</td></tr>
<tr><td>Hazadrous waste</td><td></td><td></td></tr>
<tr><td>solvent</td><td>10 cubic meter</td><td>2 cubic meter</td></tr>
<tr><td>color residues</td><td>47ton</td><td>0.2ton</td></tr>
<tr><td>powder residues</td><td><0.5ton</td><td>3ton</td></tr>
</table>
</td><td>Paint : 206,000
Cleaning : 62,000
Disposal: 47,000
Pumping : 33,000
Labor : 112,000
Total : 460,000
Capital investment :430,000
Payback period :11 months</td></tr>
<tr><td colspan="2">Recovery of copper from printed circuit board etchment (USA)</td></tr>
<tr><td>a) The quality of the circuit boards is improved.
b) The disposal cost is virtually eliminated.
c) The etching solution is maintained at its optimum composition.
d) The copper is recovered in high value form.
e) There are no hazadrous chemicals to be handled.</td><td>(Based on 50 tonnes of copper recovered per year)
copper : 50,000
materials : 80,000
disposal : 25,000
Total : 155,000

Capital investment : 220,000
Payback period : 18 months</td></tr>
</table>

Source : " Cleaner Production Worldwide " United Nations Environment Program Industry and Environment Program Activity Center