Appendix 3 Proposed Rules of VINACOAL Environmental Fund

1) VINACOAL Environmental Fund

(a) In order to pay for its commitment to this agreement, VINACOAL will set up a mandatory "Environmental Fund". The fund will be set up in accordance with the terms in Article 4.3 of this Agreement.

(b) VINACOAL will establish an Environmental Fund in accordance with the Prime Minister's Decision No.98/TTG. The Fund's assets will be used to implement the activities of the VINACOAL Environmental Improvement Program.

(c) Beginning on January 1, 1999, each VINACOAL mining company will contribute money or commit an equivalent value of labor, materials and equipment usage to the Fund. Each company's contribution will be one percent (1 %) of its total revenue of the previous year. The "equivalent value" of in-kind contributions will be calculated by the same method as is used to develop the annual operating budgets for each VINACOAL mining company.

(d) If the total contribution from all VINACOAL mining companies is less than VND 10 billion during any year, the required contribution for the next year will include the balance from the previous year. If the total contribution during any year exceeds 10 billion, then the balance will be applied to the next year's contribution.

2) Distribution of Fund assets

(a) Money and in-kind commitments of labor, materials and equipment will be distributed from the Environmental Funds as follows :

i) Fifty percent (50 %) of the value distributed to the various VINACOAL company's mines, coal preparation plants, and coal transport facilities for use in installing pollution control measures and land restoration activities located within the various company's site boundaries ;

ii) Forty percent (40 %) of the value distributed to VINACOAL for use in environmental restoration projects located outside of the mine

company's boundaries ; and

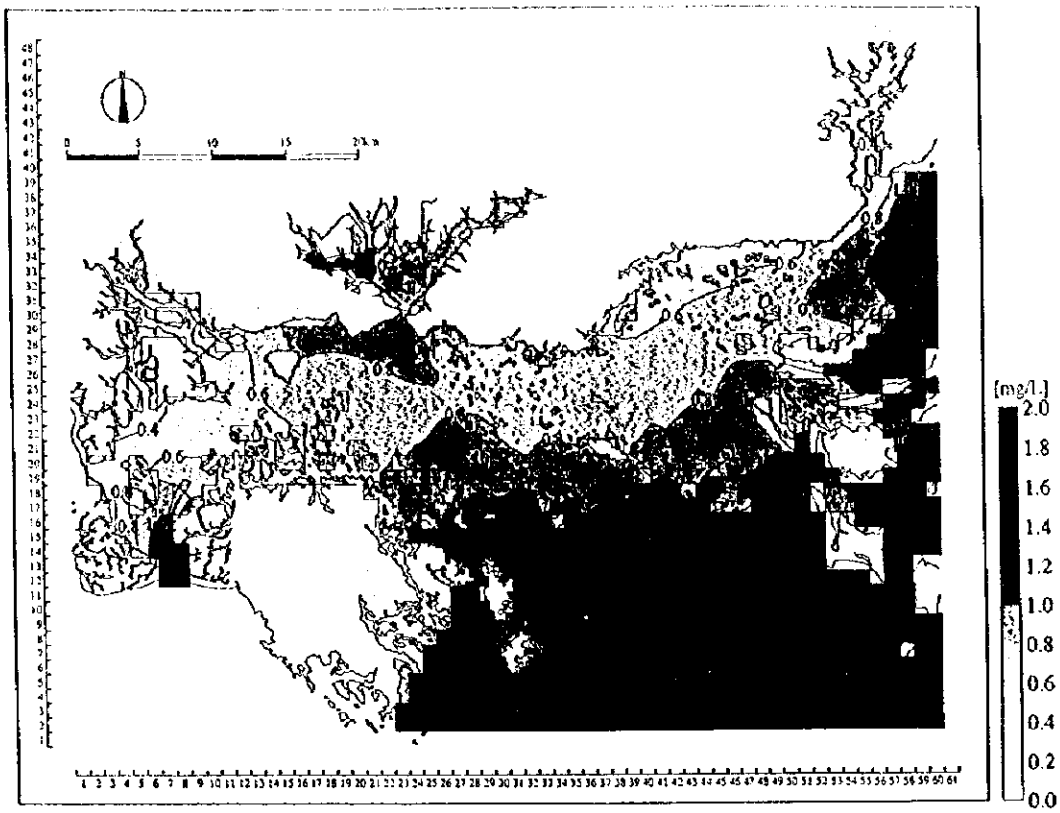
iii) Ten percent (10 %) of the value distributed to PCQNP for use in general environmental management activities in Quang Ninh Province, including civic awareness campaigns and the administration of environmental inspection and enforcement activities.

(b) To the extent practicable, disbursements of Fund assets for the VINACOAL Environmental Improvement Program will be made on a regular, uniform basis throughout the period of this Agreement. At a minimum, at least thirty five percent (VND 17.5 billion) of VINACOAL's total obligation must be disbursed by December 31st, 2001, and one hundred percent (VND 50 billion) must be disbursed by July 1, 2004.

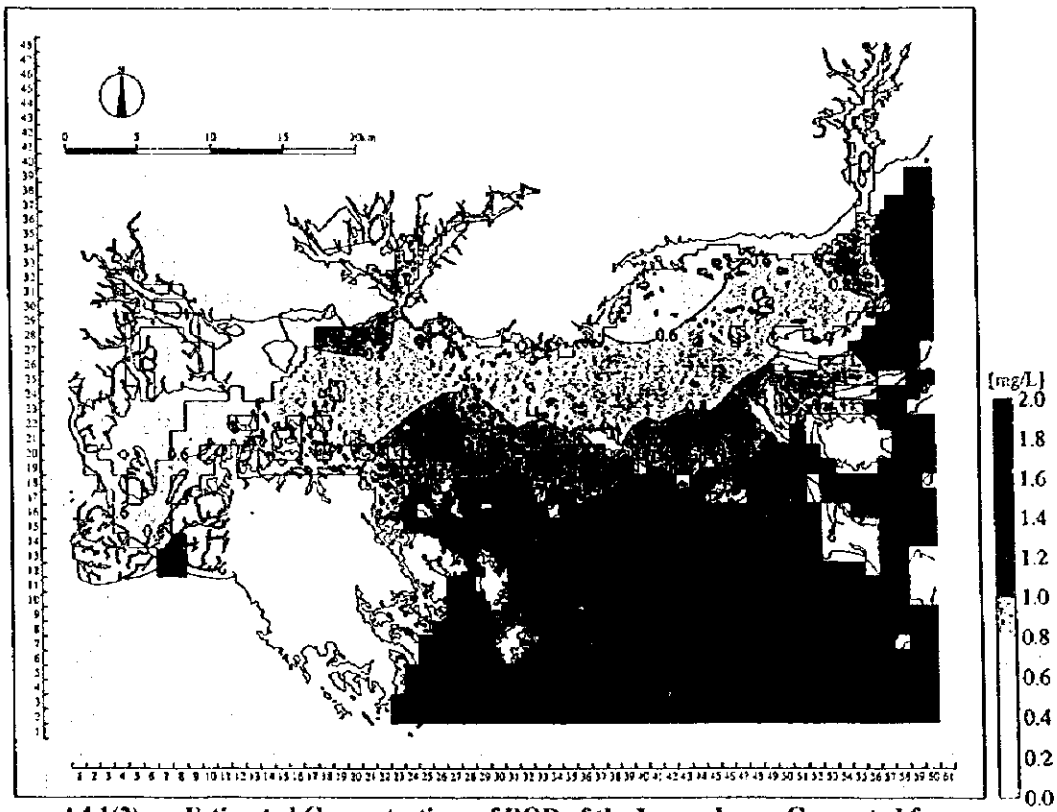
Source : Provincial Environmental Protection Standards for the Open Cast Coal Mining Industry in Quang Ninh Province (UNDP, 1998)

Appendix 4 Water Quality Prediction by Scenarios

Page



A4.1(1) Estimated Concentrations of BOD of the Upper Layer Converted from the Predicted COD by Scenario II



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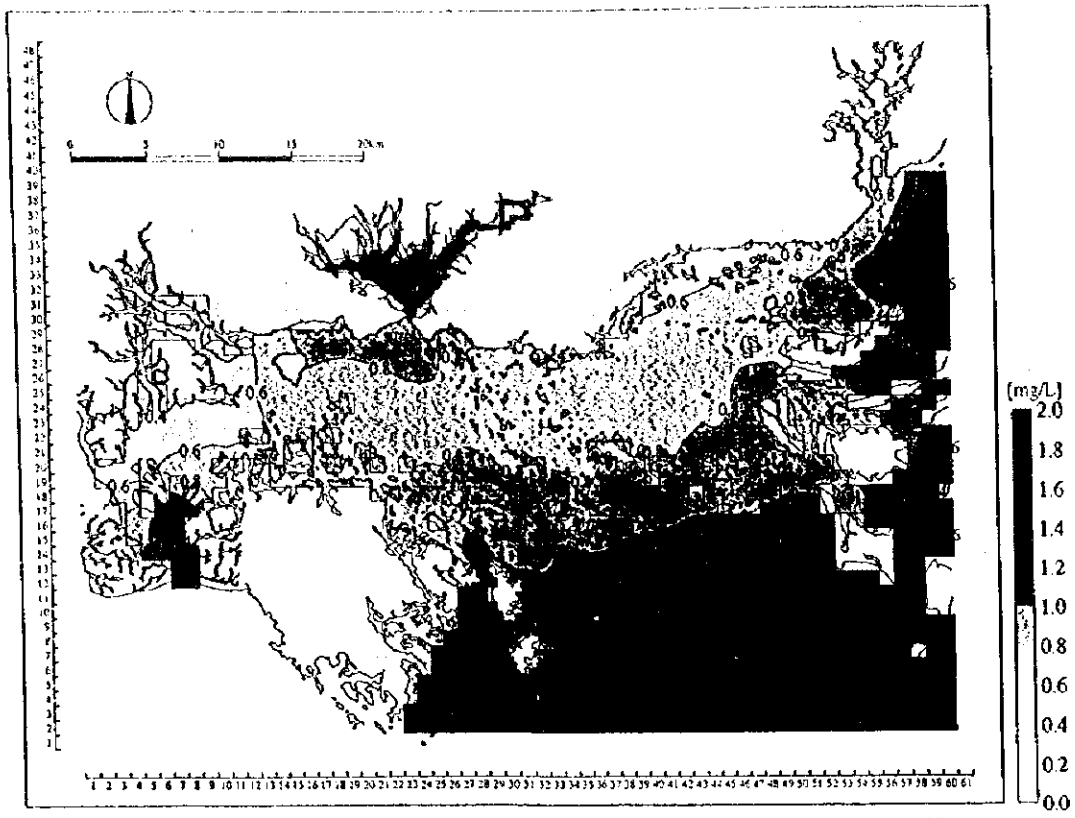
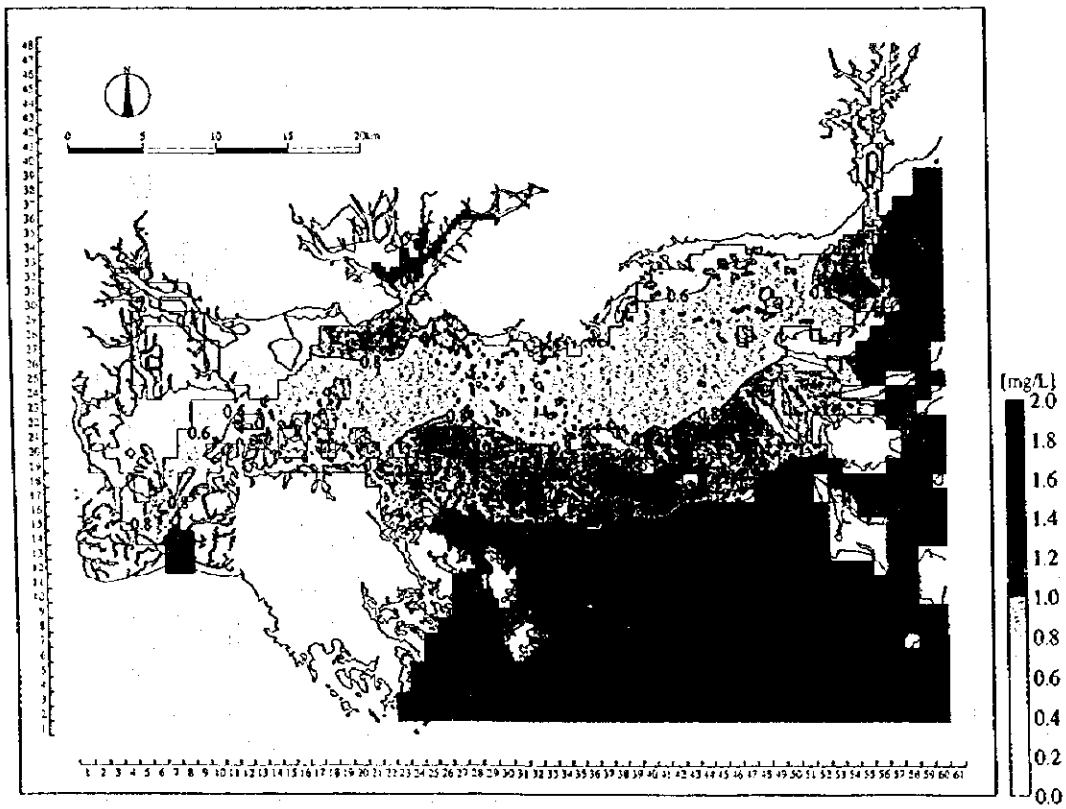
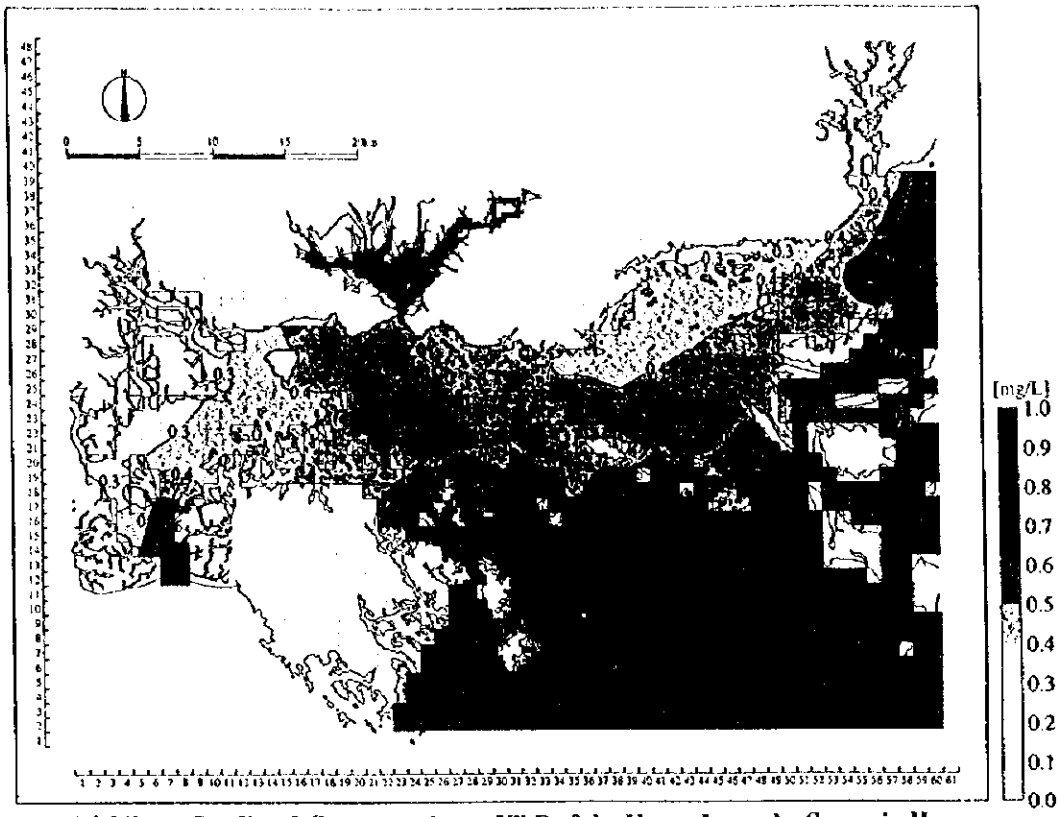


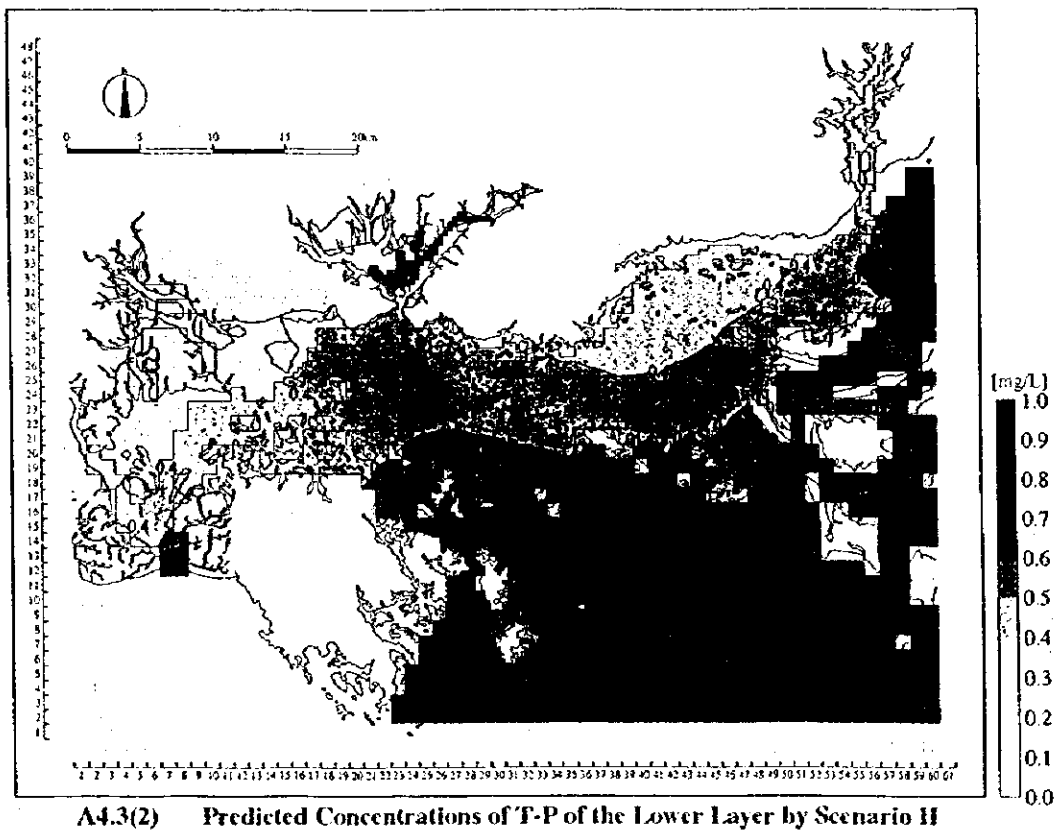
A4.2(1) Predicted Concentrations of T-N of the Upper Layer by Scenario II



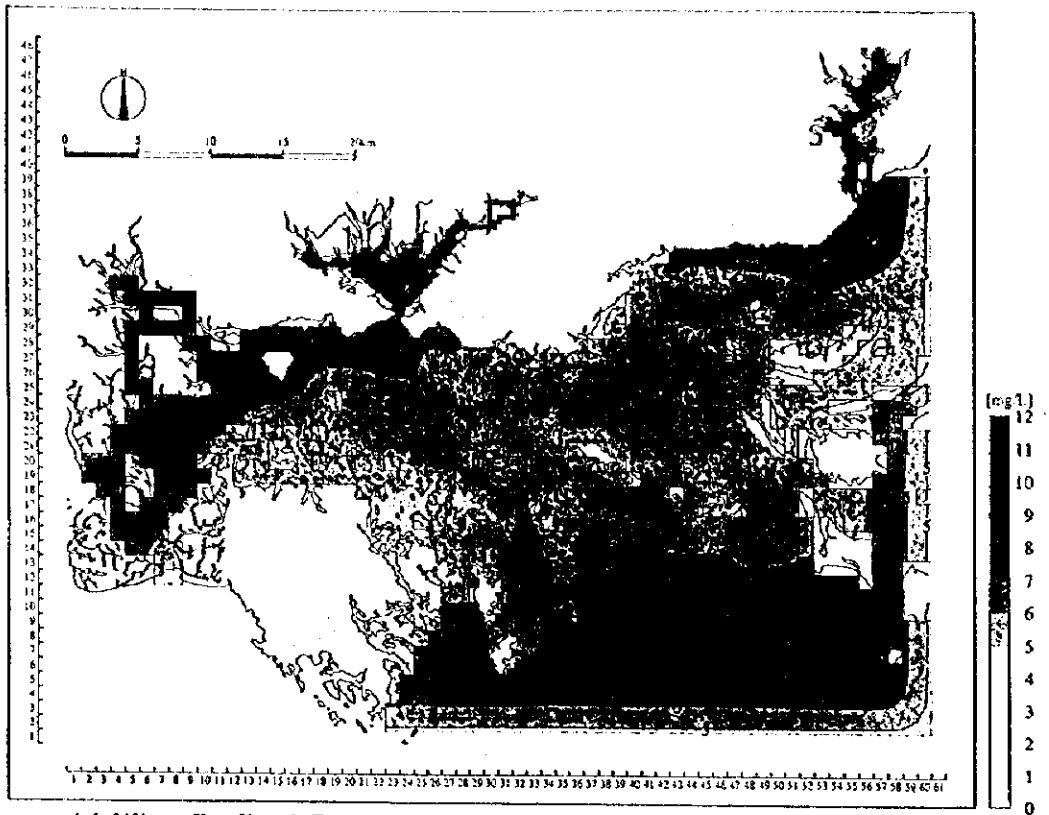
A4.2(2) Predicted Concentrations of T-N of the Lower Layer by Scenario II



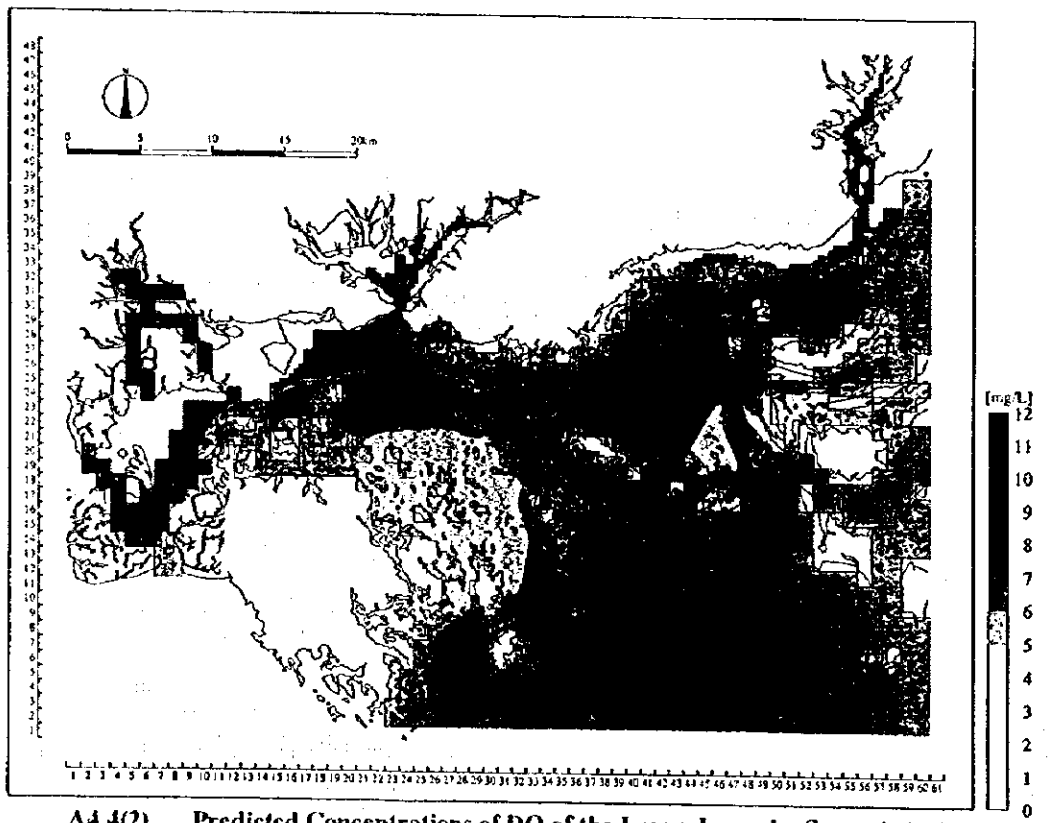
A4.3(1) Predicted Concentrations of T-P of the Upper Layer by Scenario II



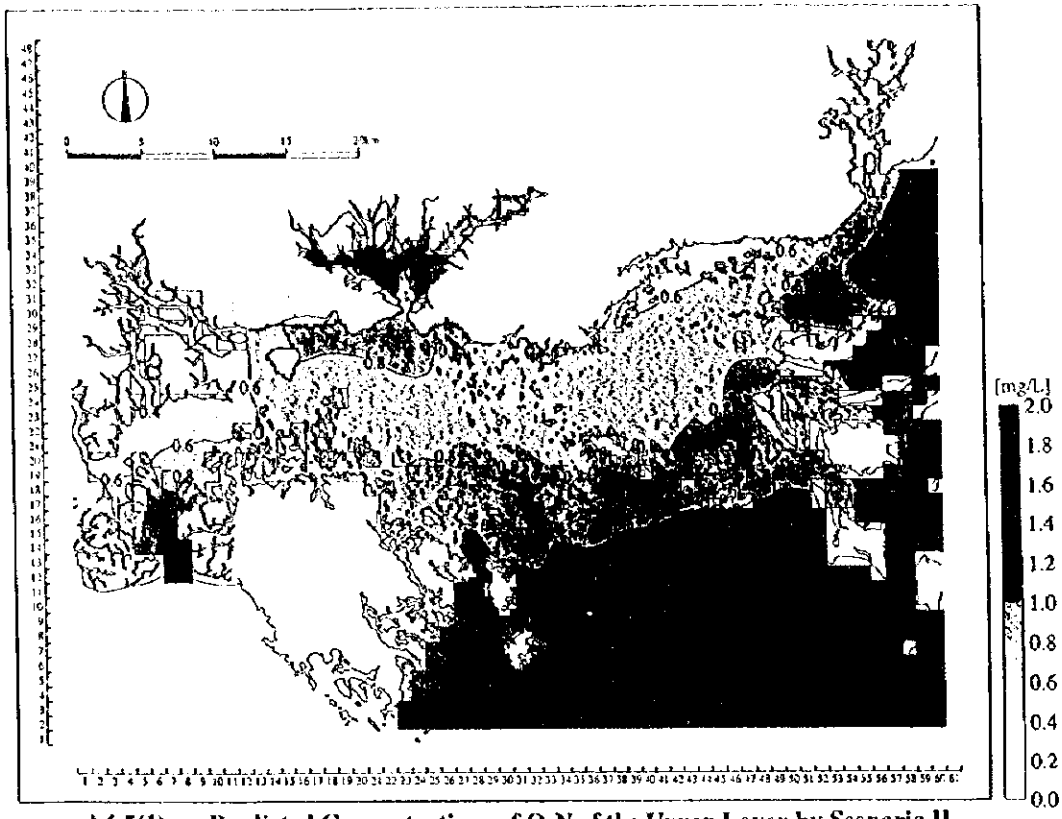
A4.3(2) Predicted Concentrations of T-P of the Lower Layer by Scenario II



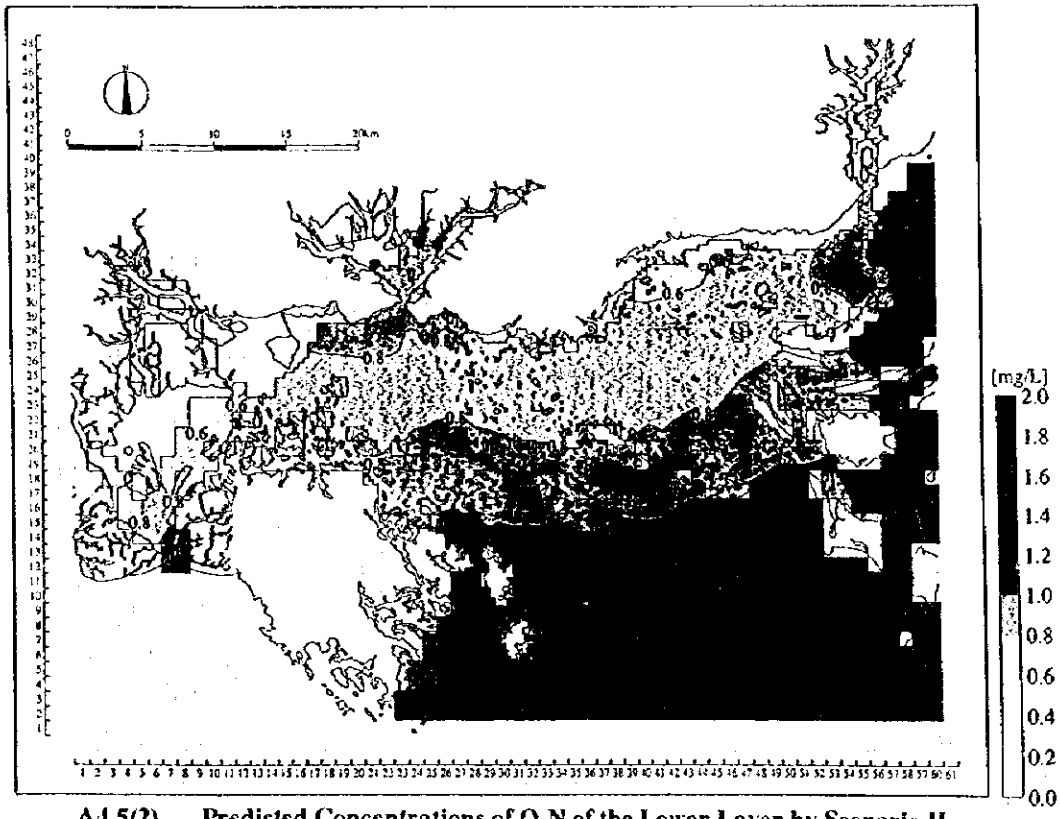
A4.4(1) Predicted Concentrations of DO of the Upper Layer by Scenario II



A4.4(2) Predicted Concentrations of DO of the Lower Layer by Scenario II



A4.5(1) Predicted Concentrations of O-N of the Upper Layer by Scenario II



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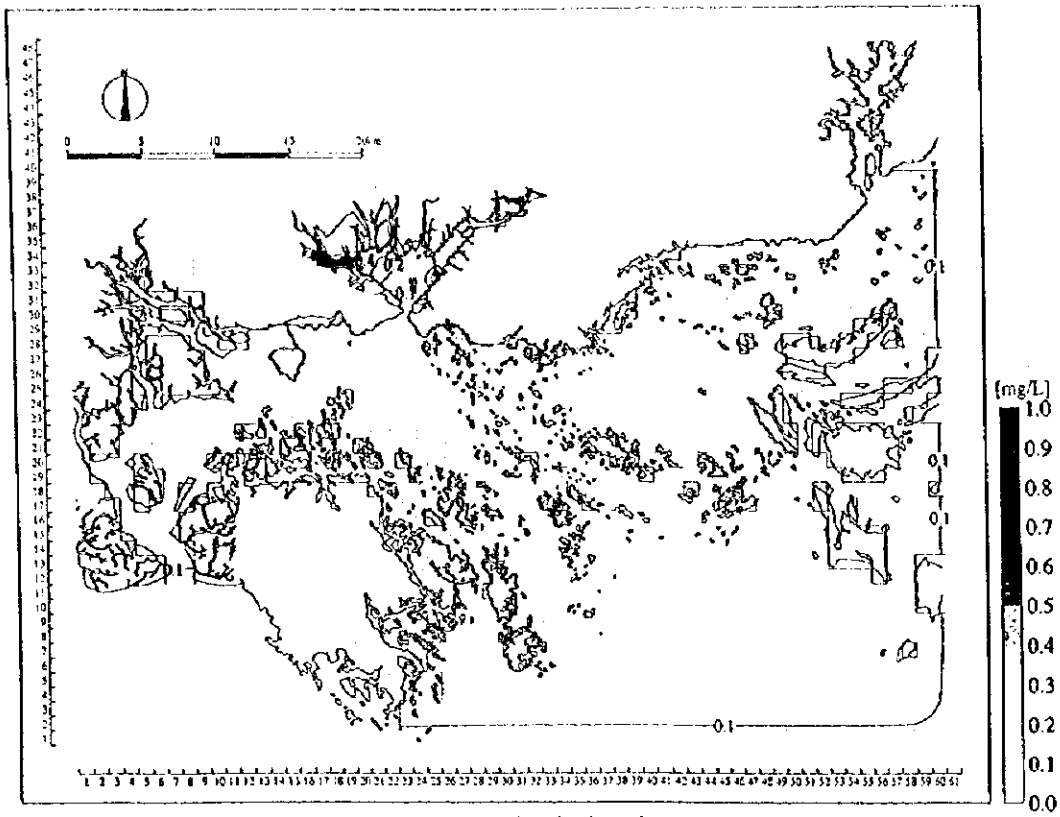
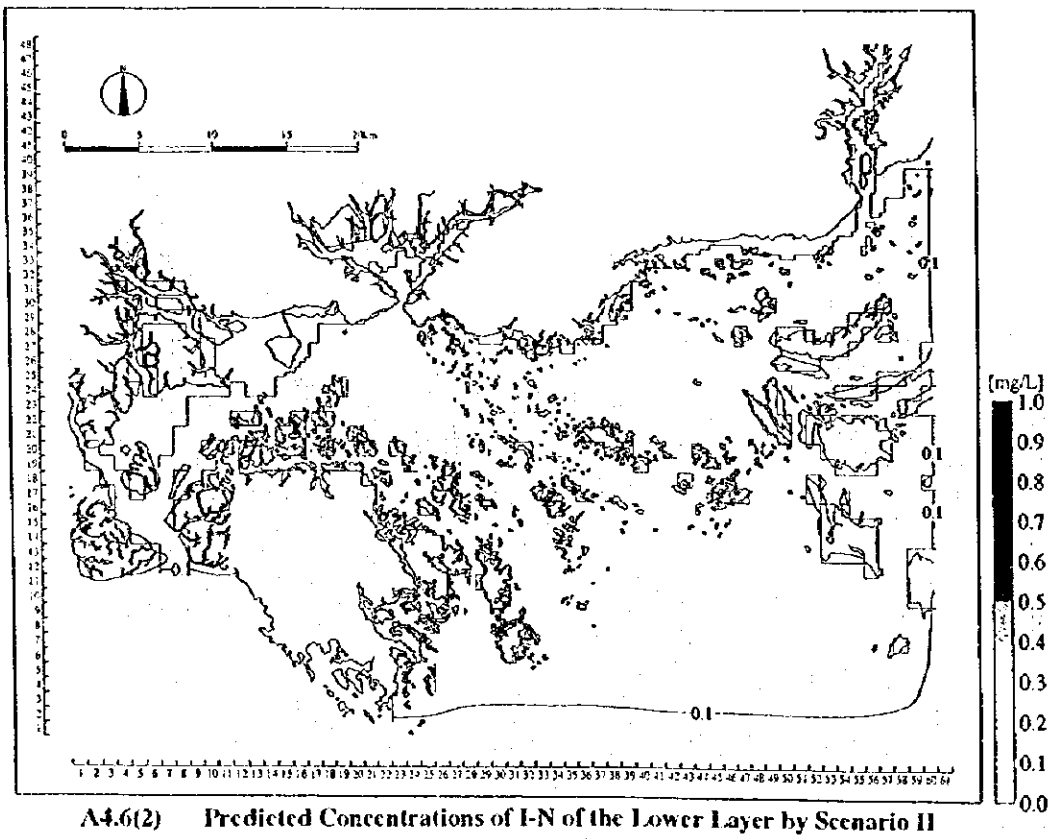
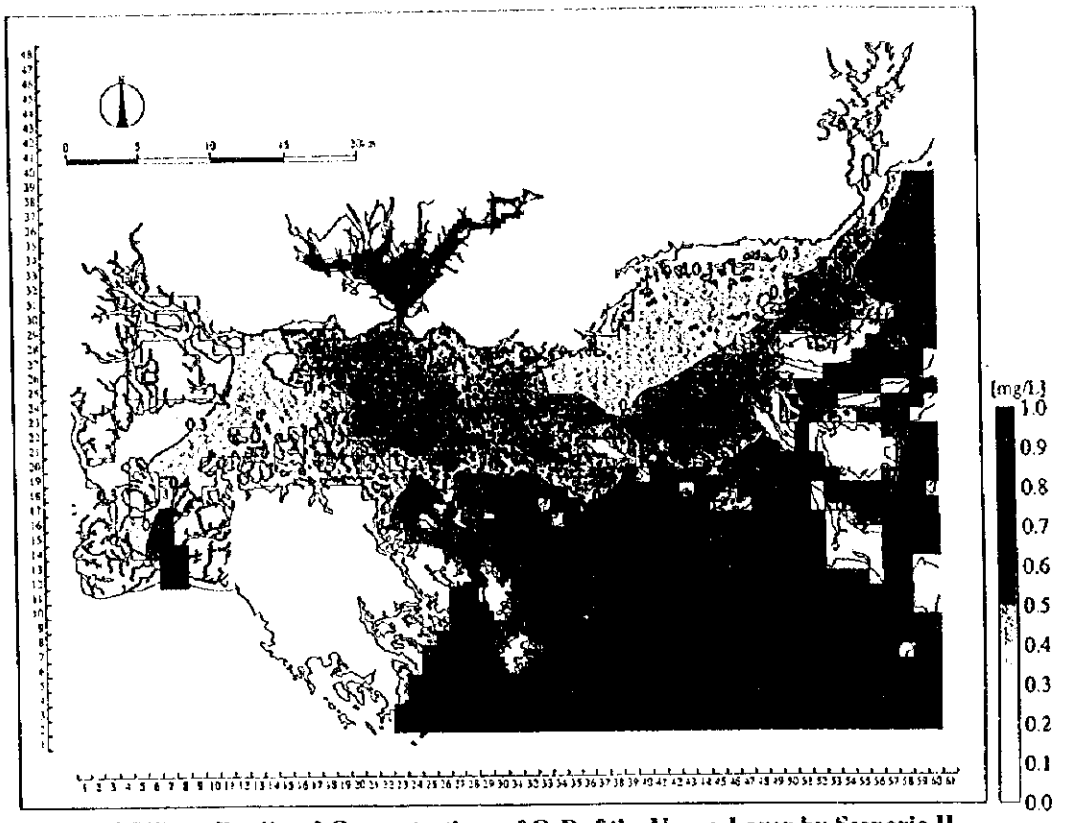


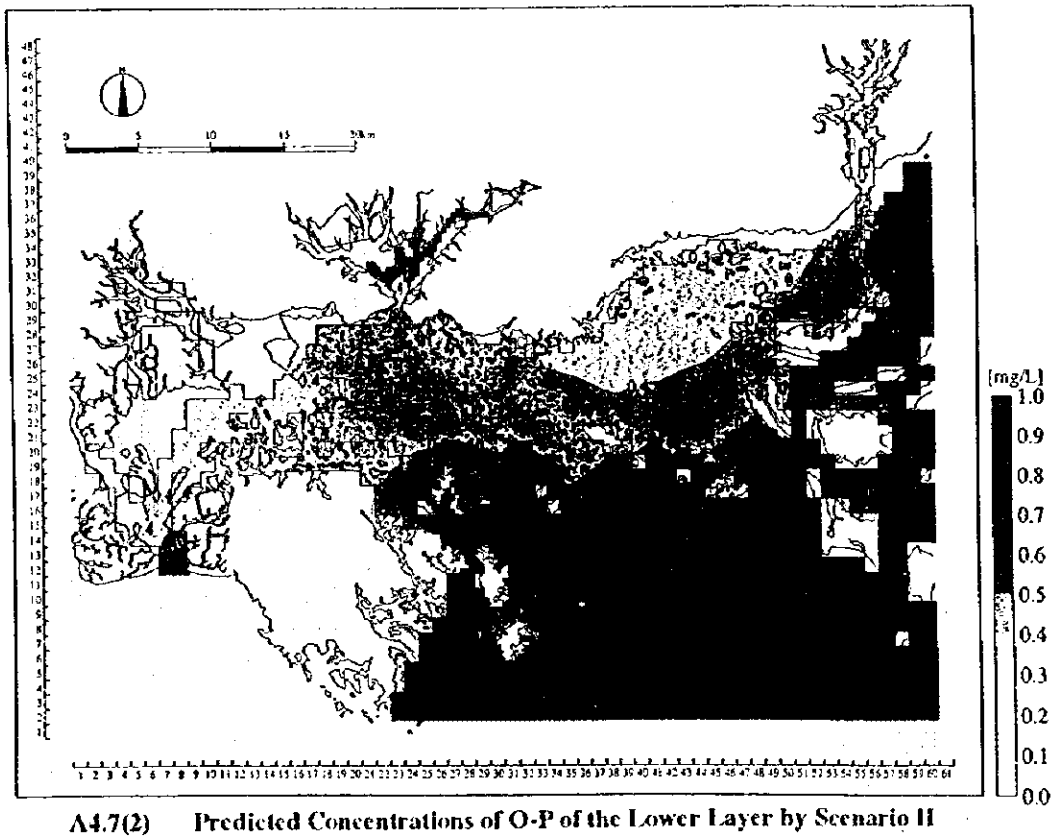
A4.6(1) Predicted Concentrations of I-N of the Upper Layer by Scenario II



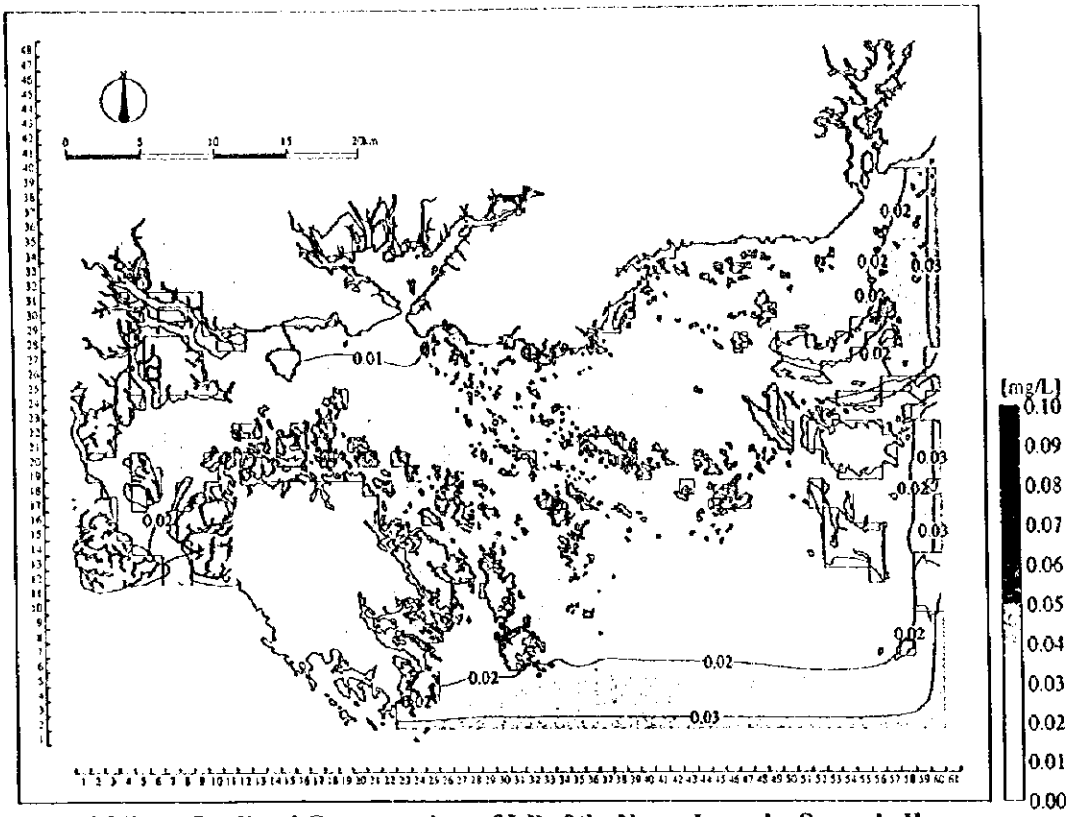
A4.6(2) Predicted Concentrations of I-N of the Lower Layer by Scenario II



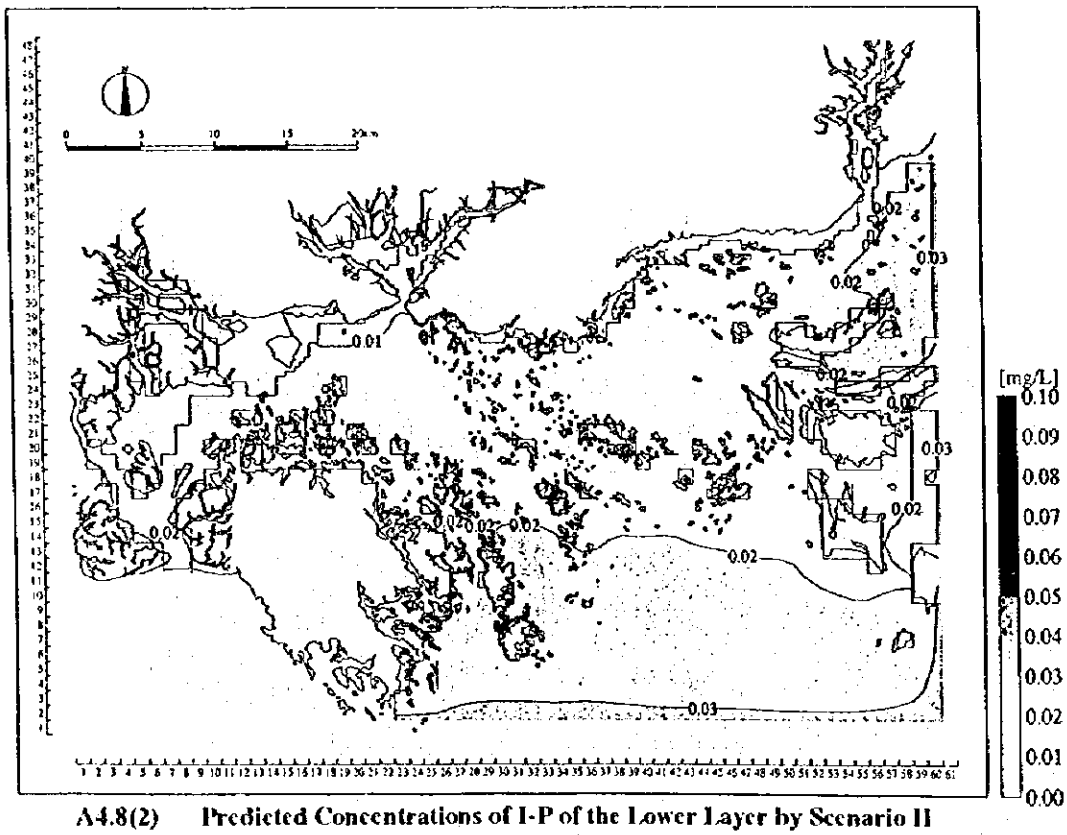
A4.7(1) Predicted Concentrations of O-P of the Upper Layer by Scenario II



A4.7(2) Predicted Concentrations of O-P of the Lower Layer by Scenario II



A4.8(1) Predicted Concentrations of I-P of the Upper Layer by Scenario II



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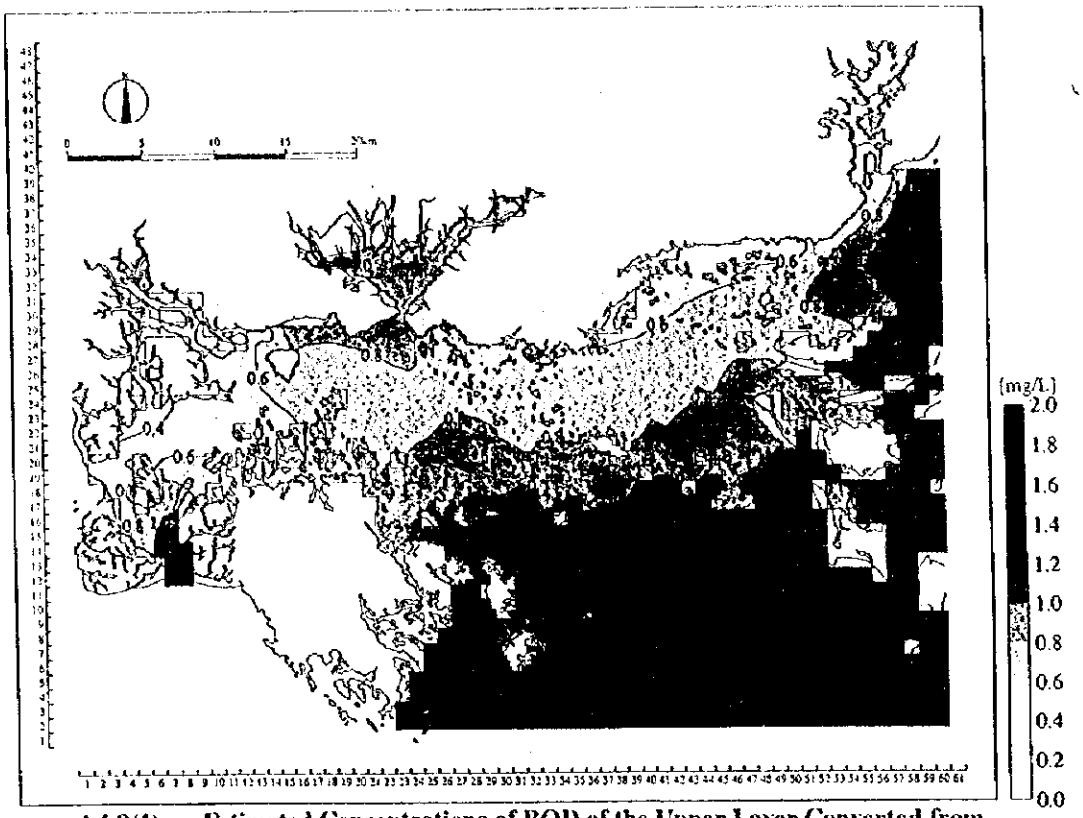
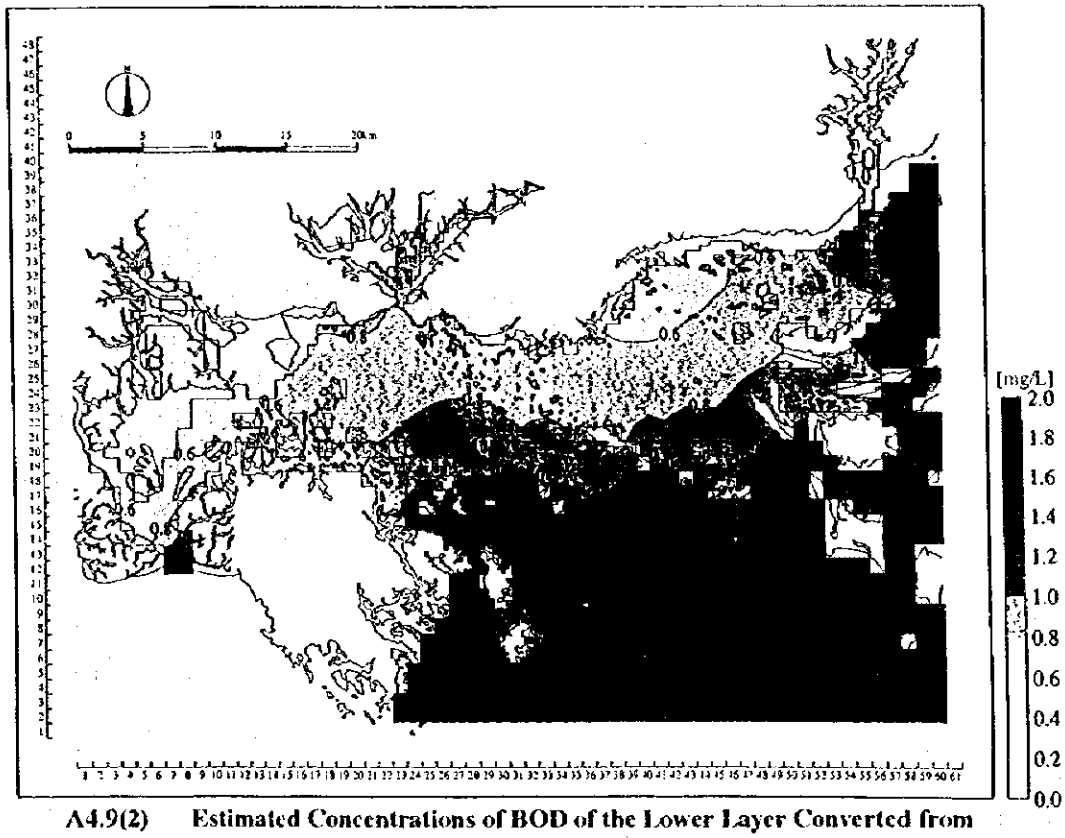
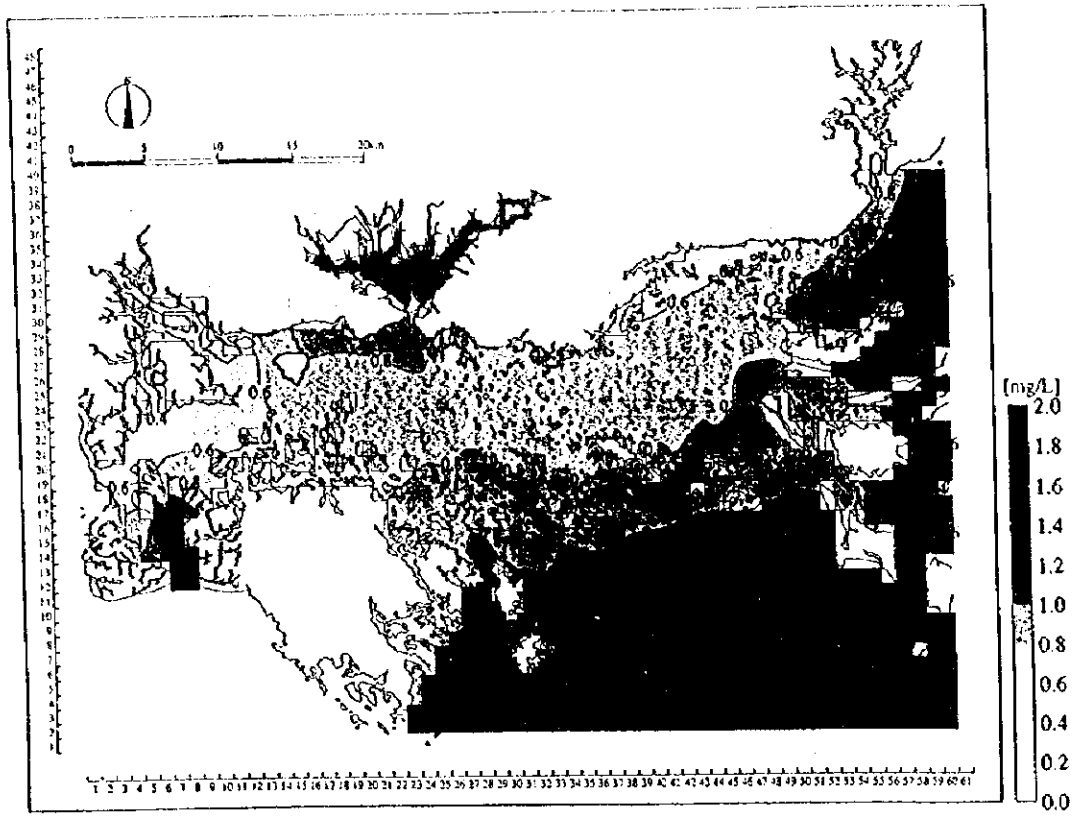


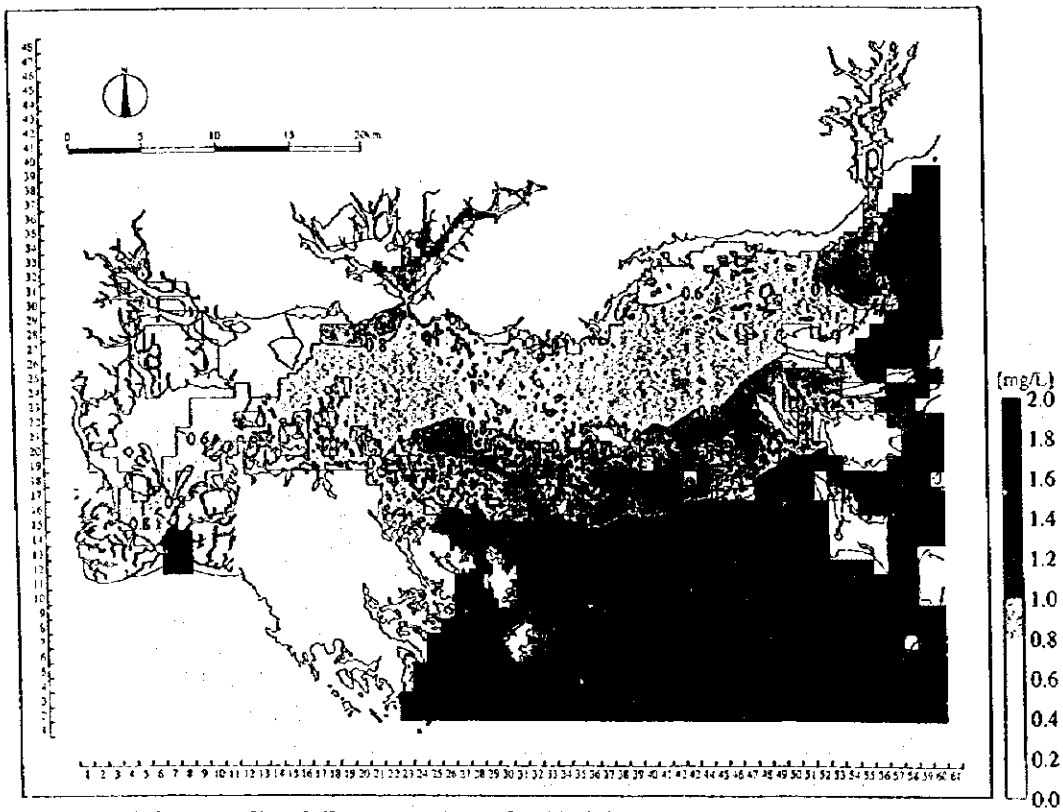
A4.9(1) **Estimated Concentrations of BOD of the Upper Layer Converted from the Predicted COD by Scenario III**



A4.9(2) **Estimated Concentrations of BOD of the Lower Layer Converted from the Predicted COD by Scenario III**



A4.10(1) Predicted Concentrations of T-N of the Upper Layer by Scenario III



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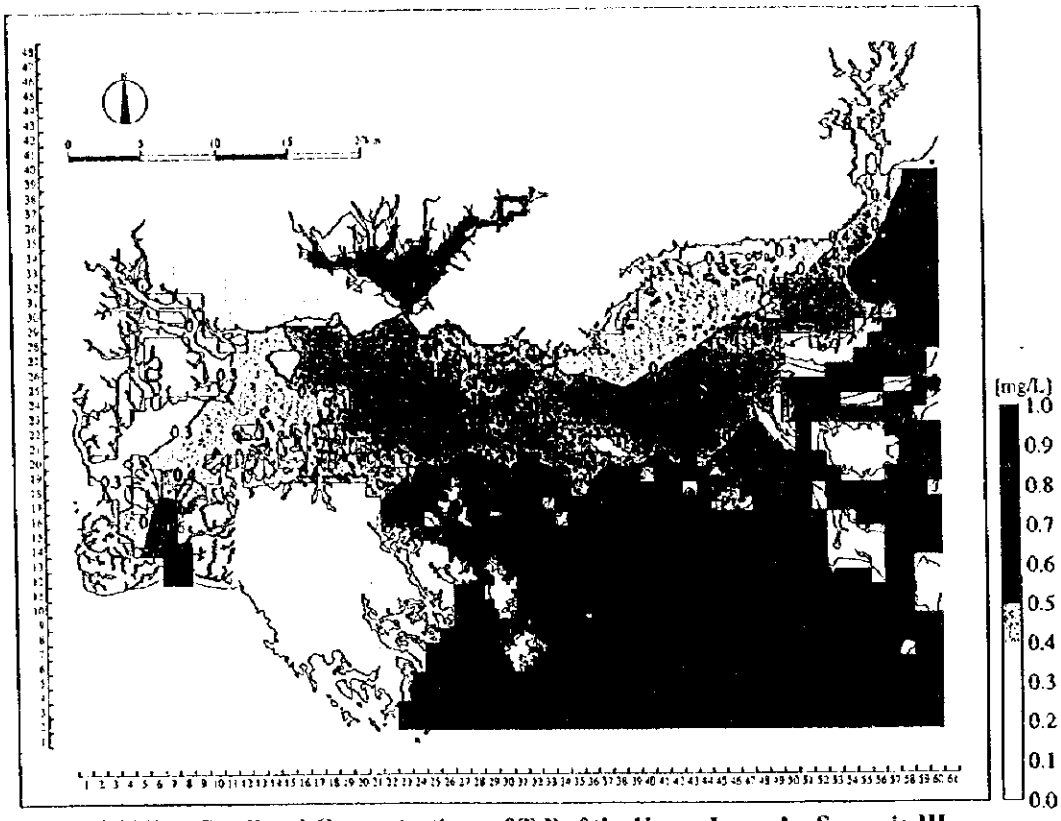
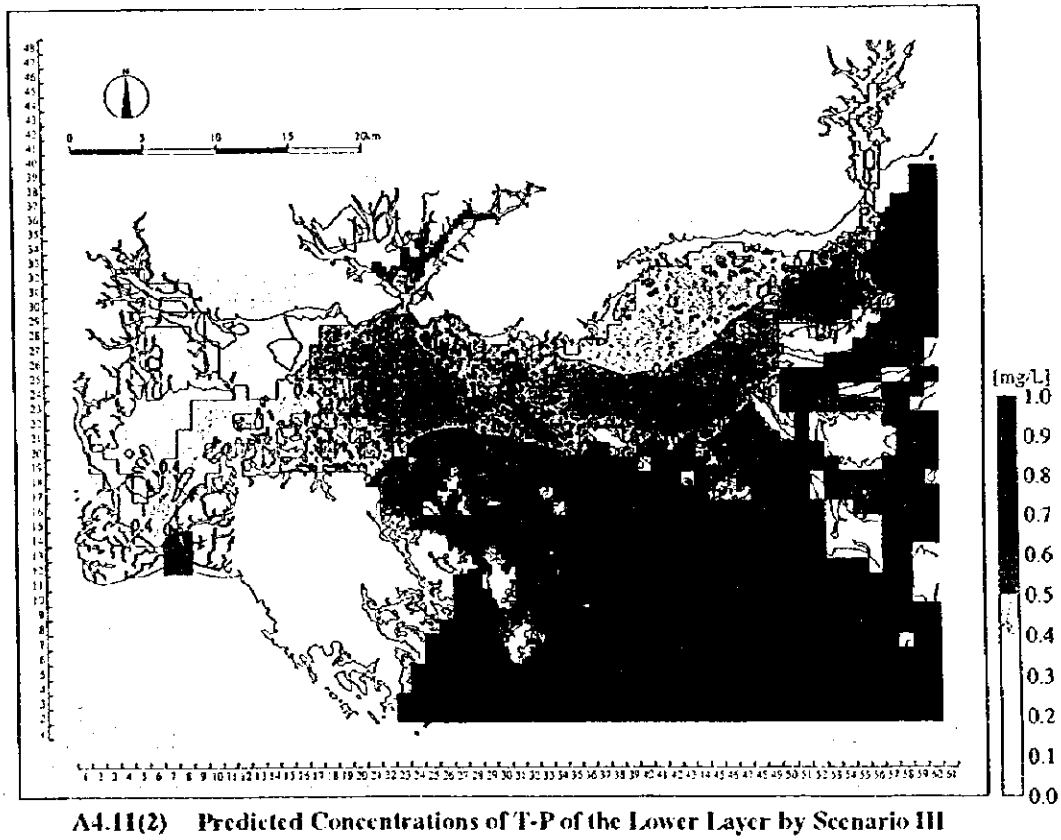


A4.11(1) Predicted Concentrations of T-P of the Upper Layer by Scenario III



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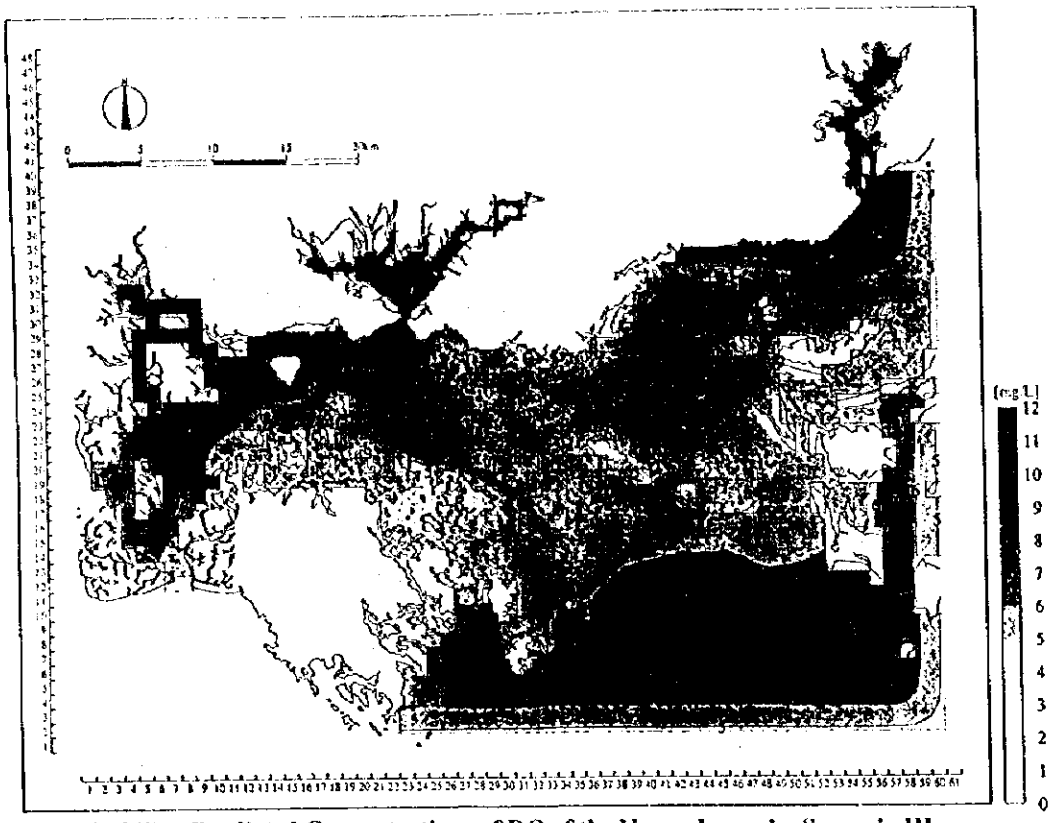

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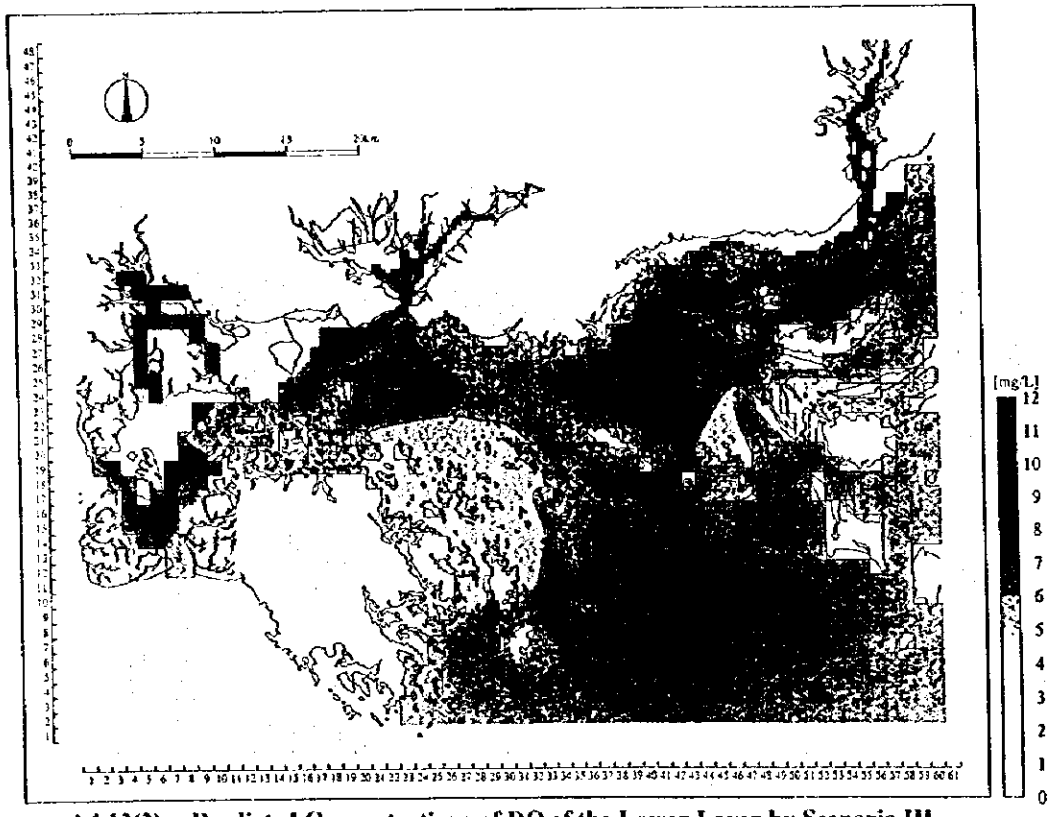

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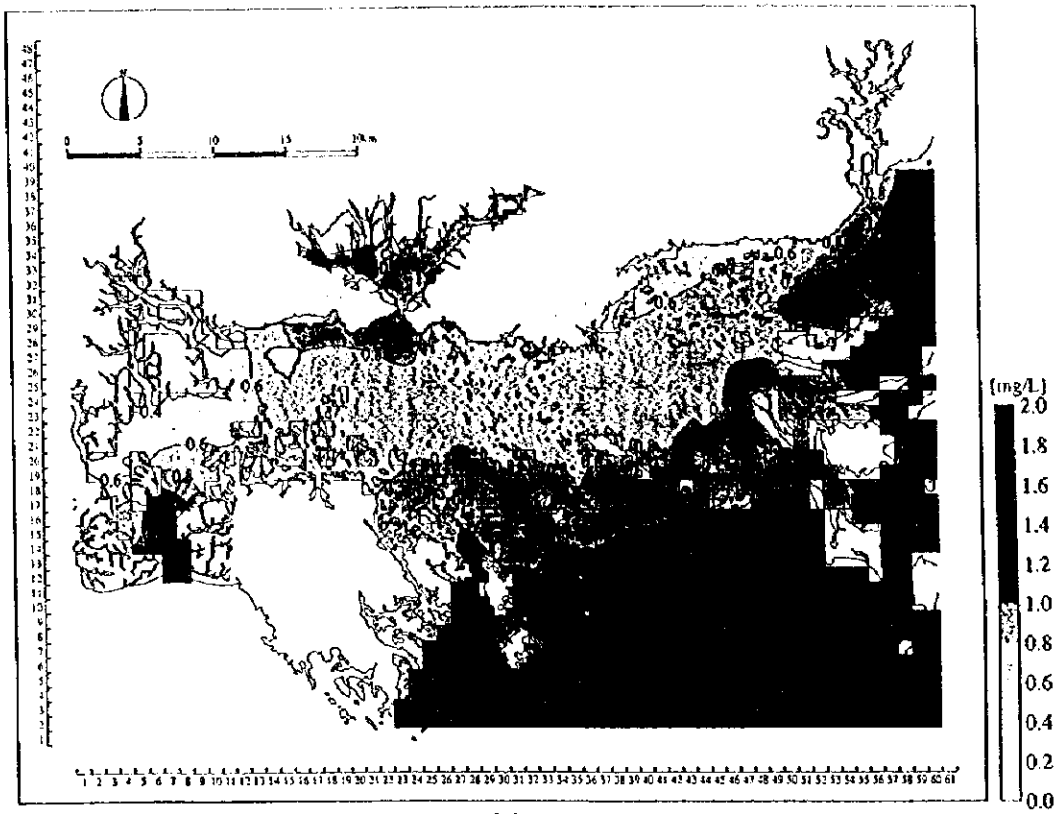
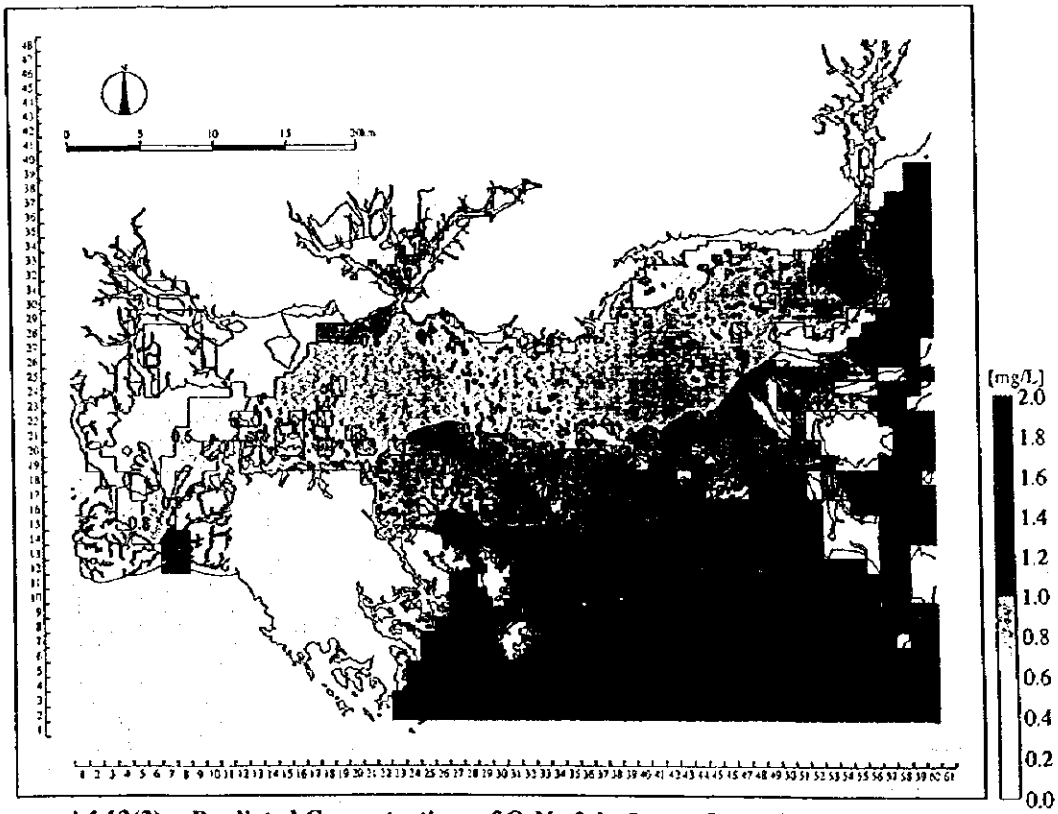


A4.13(1) Predicted Concentrations of O-N of the Upper Layer by Scenario III



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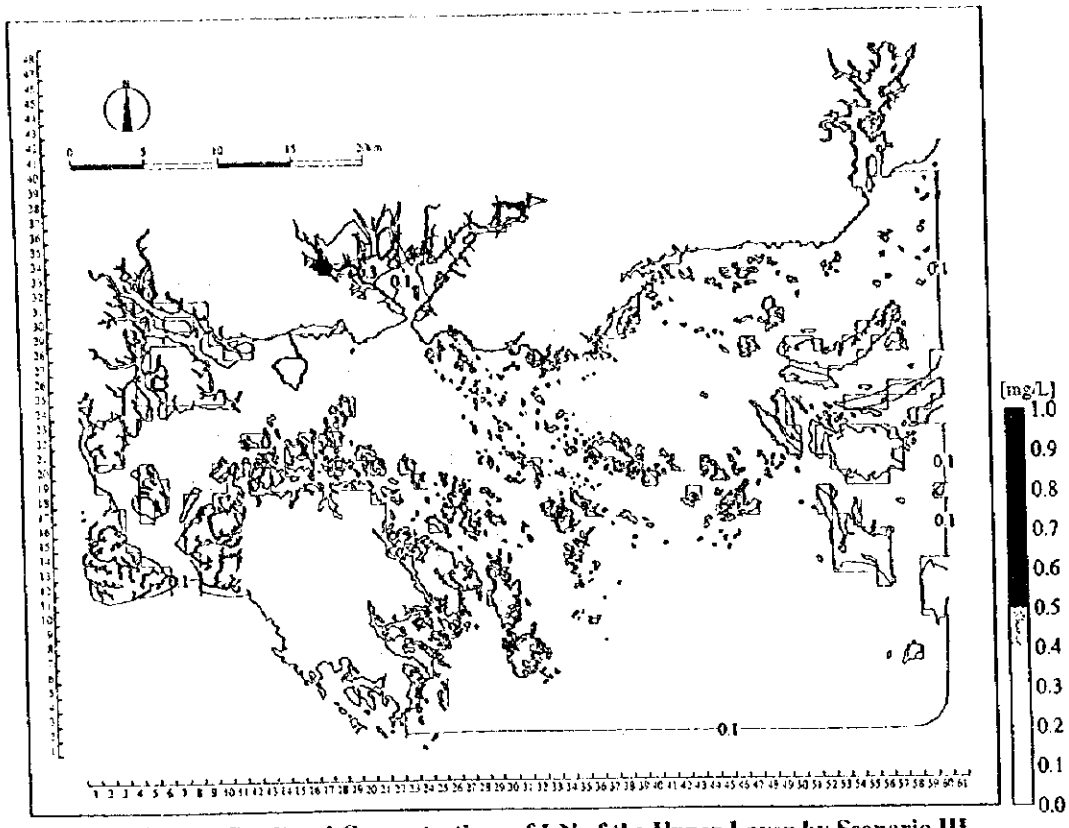

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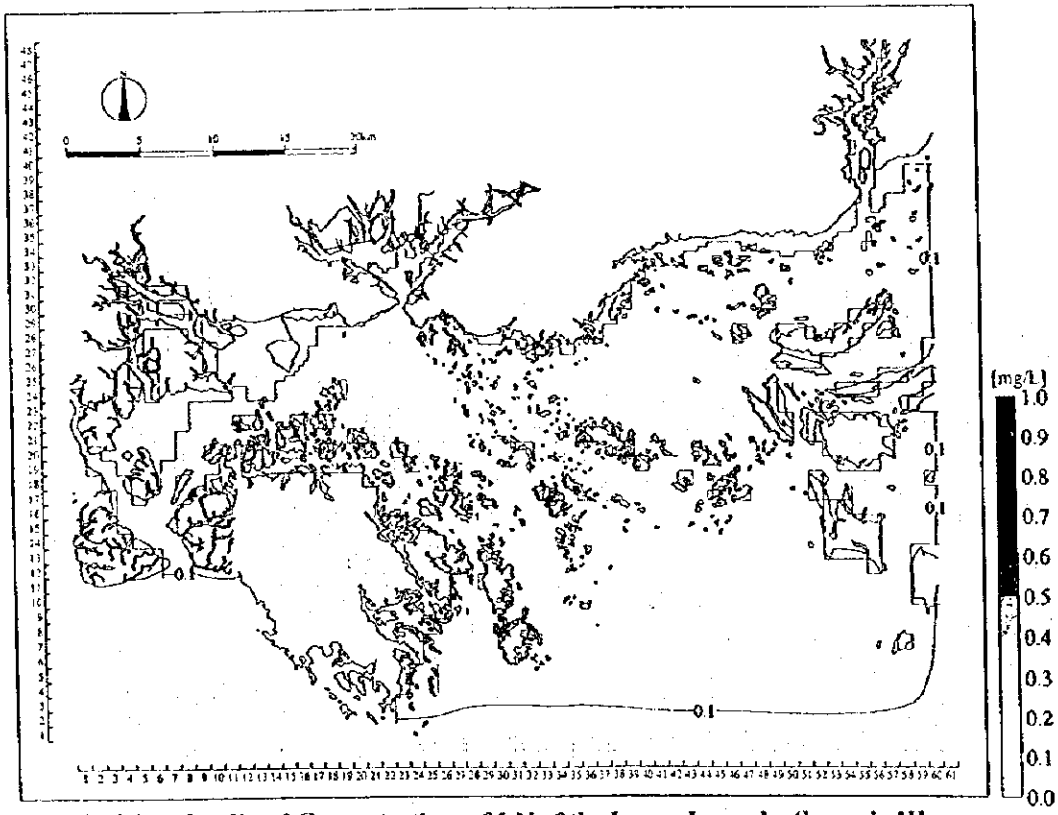
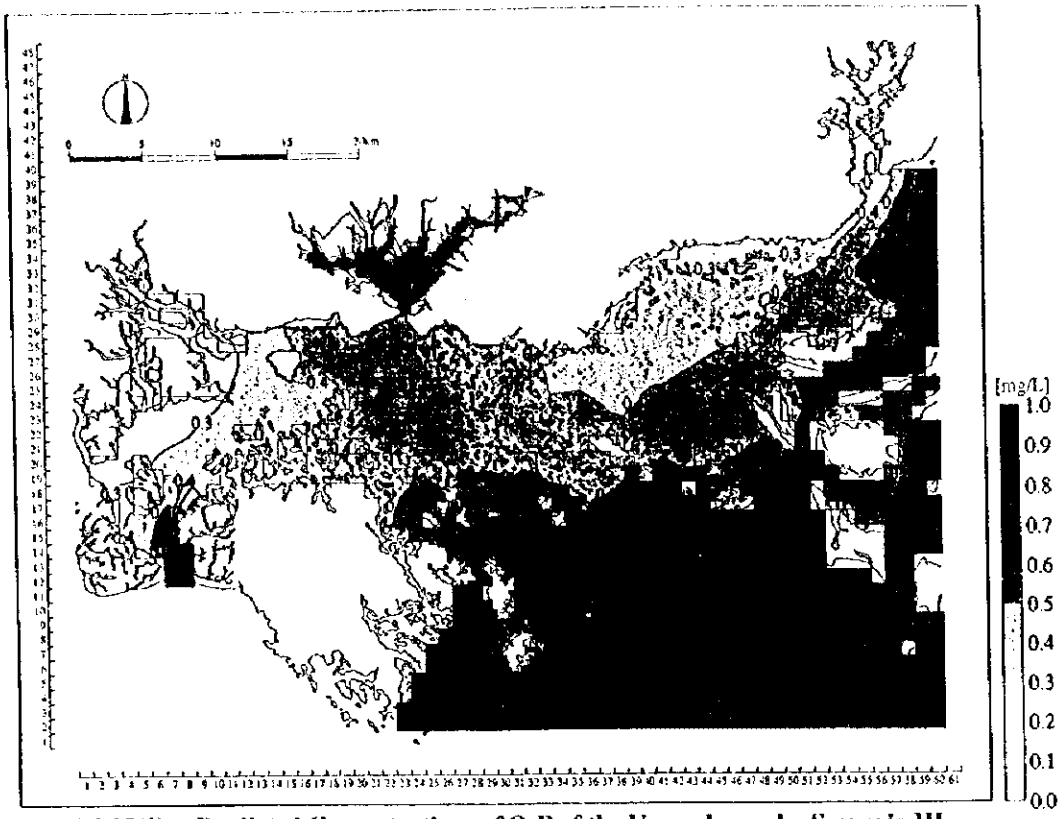
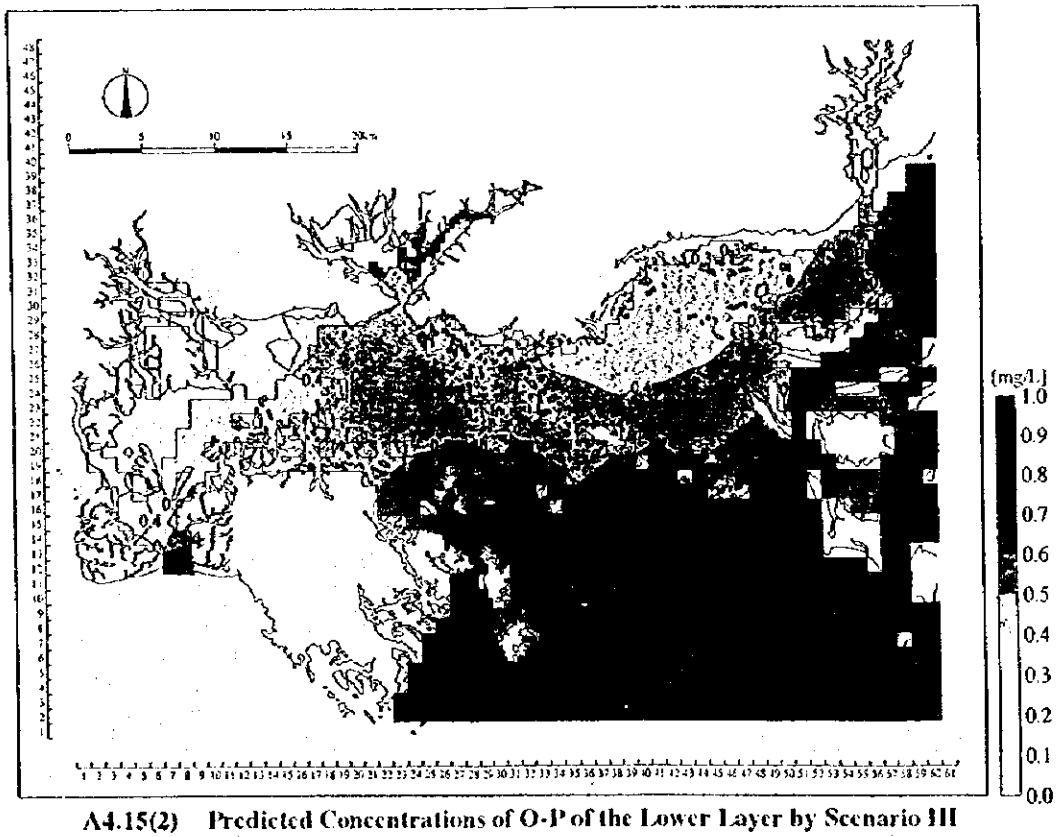


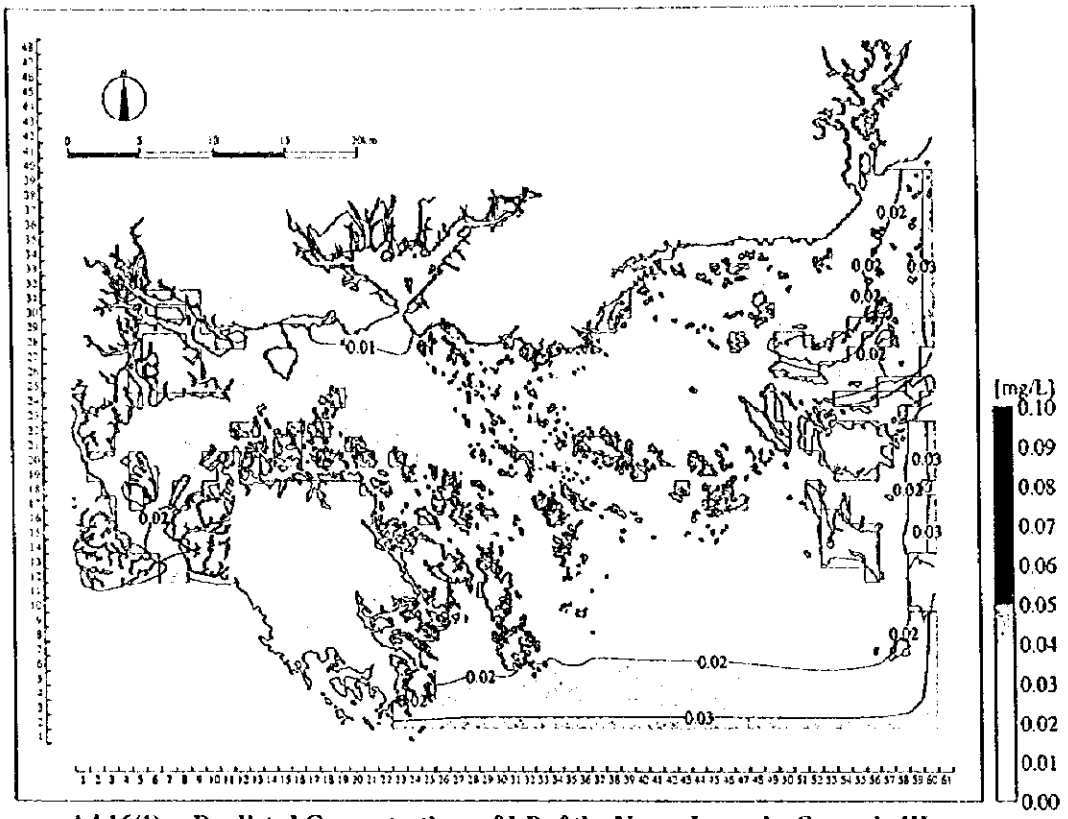
A4.14(2) Predicted Concentrations of I-N of the Lower Layer by Scenario III



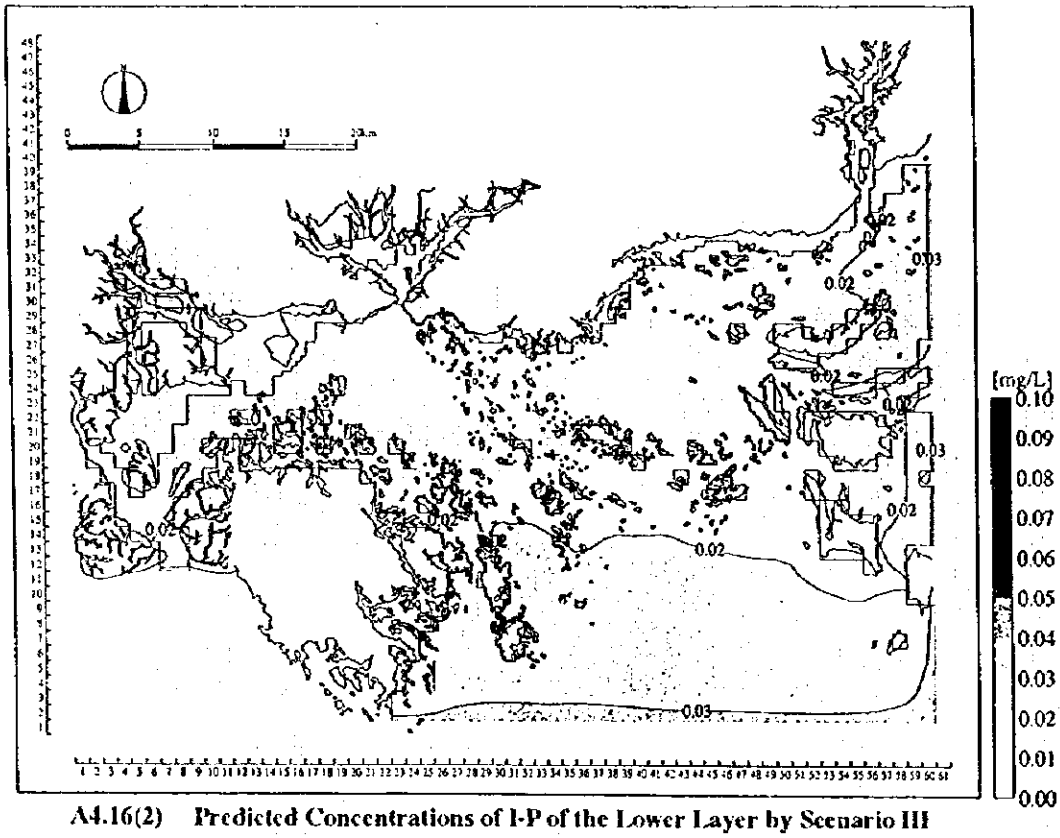
A4.15(1) Predicted Concentrations of O-P of the Upper Layer by Scenario III



A4.15(2) Predicted Concentrations of O-P of the Lower Layer by Scenario III



A4.16(1) Predicted Concentrations of I-P of the Upper Layer by Scenario III



A4.16(2) Predicted Concentrations of I-P of the Lower Layer by Scenario III

Appendix 5

Process Design, Land Requirements, Cost Estimates for WWTPs for Alternatives

A5.1 Don Dien WWTP - Alternatives 1.1, 2.1, 3.1, 4.1 (Level 1 Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic	30,000	3,600	1,140	1,140
New Industry	0	0	0	0
Ex Industry		111	5	31
Total	30,000	3,711	1,145	1,171

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	24	hrs
MLSS concentration	3000	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (mx4)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	3	
No of RAS standby pumps	1	

Final clarifiers

Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg

Sludge

Sludge production per kg BOD removal	1	kg/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 d/tSS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	5.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

LAND REQUIREMENT AND COSTS

FLOW	3,711	m3/d
LAND COST	10	US $ m2

Oxidation Ditch	972	m2
Final Tanks	314	m2
Sludge Thick Tanks	64	m2
Sludge Conditioning Tanks	13	
Sludge Storage Building	174	m2
Other Structures	415	m2
Net Area of Structures	1951	m2
Site Multiplier	2.1	
Site Area	0.41	ha
Buffer Zone	50	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	2.77	ha
Total LAND Cost inc Buffer	276,775	US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	1,145	kg/d	
Ditch volume required for BOD load	2,544	m3	
Ditch volume required for retension	3,711	m3	
Assume ditch depth	4.0	m	
Therefore required area	928	m2	area
Assume nr lanes x length x width	2	54 . 9	972
Approx volume, less 6%	3,655	m3	
Volumetric loading rate	0.31	kg BOD/m3	
Oxygen requirement	2,176	kg/d	
Power consumption	1,088	kwh/day	
Assume number of aerators	2		
Individual aerator power	45.3	kW	
Total installed Power	91	kW	
Pump capacity	309	m3/h	
RAS pump power	4.2	kW/pump	

Final clarifiers

Required surface area	309	m2	
Assume nr of tanks	1	nr	
Required diameter	19.8	m	
Say diameter	20.0	m	
DWF upward velocity	0.49	m/hr	OK
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.1	hr @ DWF	

Sludge

Sludge Production	1,084	kg DS/d	
Sludge volume	216	m3/d	
Required thickener area	54	m2	
Assume nr of tanks	1	nr	
Required diameter	8.3	m	
Say diameter	9.0	m	
Actual area	64	m2	
Sludge retention time	28.1	hr	
Surface loading	3.4	m3/m2/d	
Thickened sludge volume	35	m3/d	
Assume Nr of conditioning tanks	1		
Required conditioning tank area	12	m2	
Required dia of tank	3.9	m	
Assume dia	4	m	
Volume of dewatered sludge	4	m3/d	
Area sludge storage building	174	m2	

COST ESTIMATE FOR: 3,711 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate US $	Amount US $	Amount 000 VND
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of exc'n	3 m					
Add for channels etc	20%					
Excavation	3,187	m3		4	12,746	
Concrete walls	421	m3		240	101,063	
Concrete floors	688	m3		150	103,257	
Add for E&M Aerators etc	91	kw	1500*kW^0.87		75,680	
Total cost					292,748	3,805,724
RAS Pumping Station						
Civil works			UC1491/1		25,801	
M & E works			UC1491/1		30,279	
Total cost					56,079	729,030
Final Clarifiers	1	1 nr				
Wall thickness	0.4 m					
Freeboard	0.3 m					
Ave depth of exc'n	1 m					
Add for channels etc,	30%					
Excavation	442	442	m3	4	1,767	
Concrete walls	77	77	m3	240	18,398	
Concrete floors	187	187	3m3	150	28,055	
Concrete hopper	41	41	m3	150	6,126	
Add for E&M scrapers	200	m	UC1491/1		43,087	
Total cost of		1	Tanks		97,431	1,266,609
Sludge Thickeners	1	1				
Wall thickness	0.35	m				
Freeboard	0.3	m				
Ave depth of exc'n	3	m				
Add for channels etc	20%					
Excavation	204	204	m3	4	816	
Concrete walls	53	53	m3	240	12,732	
Concrete floors	35	35	m3	150	5,321	
Concrete hopper	8	8	m3	150	1,145	
Add for E&M stirrers	254	254	m3	UC1491/1	31,684	
Total cost of		1	tanks		51,697	672,060
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	51	51	m3	4	204	
Concrete walls	16	16	m3	240	3,739	
Concrete floors	6	6	m3	150	897	
Miscellaneous		10.0%		4,841	484	
Add for E&M		50.0%		5,325	2,662	
Sludge belt presses	85	m3/shift		500	42,449	
Sludge press building	75	m2		150	11,250	
Sludge storage building Area	174	m2		150	26,106	
Total cost of sludge dewatering and storage					87,792	1,141,295
Buildings and Miscellaneous						
Office, laboratory	150	m2		300	45,000	
Workshop	150	m2		150	22,500	
Works Pumping station	40	m2		1500	60,000	
Add for furnishing and fittings	20%			127,500	25,500	
Total cost of	bdgs				153,000	1,989,000
Sub-total					738,748	9,603,721
Add for elec dist, control, etc	15%				110,812	1,440,556
Add for site works	15%				127,434	1,656,642
Add for Prelims and Gen'l	30%				293,098	3,810,277
Total cost for	3,711	m3/d TWks			1,270,092	16,511,199
Total cost including Inlet Works and Pump Station					1,576,250	20,491,255
M&E					730,751	9,499,758
CIVIL					845,500	10,991,497

A5.2 Don Dien WWTP - Alternatives 1.2, 2.2 (Level 1 Treatment)

Influent Characteristics

	Population	Flow, m³/d	BOD, kg/d	SS,kg/d
Domestic	120,200	14,424	4,568	4,568
New Industry				
Ex Industry		111	5	31
Total	120,200	14,535	4,573	4,599

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	24	hrs
MLSS concentration	3000	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	

Final clarifiers

Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg

Sludge

Sludge production per kg BOD removal	1	kg/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2.d/SS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	4,573	kg/d	
Ditch volume required for BOD load	10,152	m3	
Ditch volume required for retention	14,535	m3	
Assume ditch depth	4.0	m	
Therefore required area	3,634	m2	area
Assume nr.lanes x length x width	6	72	9 3888
Approx volume, less 6%	14,619	m3	
Volumetric loading rate	0.31	kg BOD/m3	
Oxygen requirement	8,689	kg/d	
Power consumption	4,344	kwh/day	
Assume number of aerators	12		
Individual aerator power	30.2	kW	
Total Installed Power	362	kW	
Pump capacity	1211	m3/h	
RAS pump power	16.5	kW/pump	

Final clarifiers

Required surface area	1211	m2
Assume nr of tanks	2	nr
Required diameter	27.8	m
Say diameter	28.0	m
DWF upward velocity	0.49	m/hr OK
Vertical side wall depth	2	m
Retention time (ignoring hopper)	4.1	hr @ DWF

Sludge

Sludge Production	4,344	kg DS/d
Sludge volume	869	m3/d
Required thickener area	217	m2
Assume nr of tanks	2	nr
Required diameter	11.8	m
Say diameter	12.0	m
Actual area	226	m2
Sludge retention time	25.0	hr
Surface loading	3.8	m3/m2/d
Thickened sludge volume	141	m3/d
Assume Nr of conditioning tanks	1	
Required conditioning tank area	47	m2
Required dia of tank	7.7	m
Assume dia	8	m
Volume of dewatered sludge	17	m3/d
Area sludge storage building	695	m2

LAND REQUIREMENT AND COSTS

FLOW	14,535	m3/d
LAND COST	10	US $/m2

Oxidation Ditch	3888	m2
Final Tanks	1232	m2
Sludge Thick Tanks	226	m2
Sludge Conditioning Tanks	50	
Sludge Storage Building	695	m2
Other Structures	760	m2
Net Area of Structures	6851	m2
Site Multiplier	2.1	
Site Area	1.44	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	4.11	ha
Total Land Cost inc Buffer	411,429	US $

A5.3 Don Dien WWTP - Alternative 3.2 (Level 1 Treatment)

Influent Characteristics

	Population	Flow: m³/d	BOD, kg/d	SS,kg/d
Domestic	113,500	13,620	4,313	4,313
New Industry				
Ex Industry		111	5	31
Total	113,500	13,731	4,318	4,344

[illegible]	13,731 m3/d =	572,125 m3/hr
[illegible]	[illegible] mg/l =	[illegible] kg/d
[illegible]	[illegible] mg/l =	[illegible] kg/d

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15 kgBOD/kgMLSS
Retention at DWF	24 hrs
MLSS concentration	3000 mg/l
Depth	4 m
Oxygen requirement	2 kgO2/kgBOD
Oxygen transfer	2 kgO2/kwh
Peak factor for aerator capacity	2
BOD removal	95%
RAS flow rate (max)	2 DWF
RAS pumping head	6 m
No of RAS duty pumps	2
No of RAS standby pumps	1
Final clarifiers	
Maximum upward velocity at DWF	0.5 m/h
Side wall depth	2 m
floor slope	7.5 deg
Sludge	
Sludge production per kg BOD removal	1 kg/kgBOD.d
Solids content of surplus sludge	0.5%
Sludge thickener loading	50 m2.d/tSS
Sludge thickener wall height	4 m
Assume solids content of thickened sludge	3.0% solids
Assume sludge density	1025 kg/m3
Sludge conditioning tank retention time	1 day
Depth of conditioning tanks	3 m
Operating period for mechanical dewatering	10 hours/day
Solids content of dewatered sludge	25% solids
Storage time for dewatered sludge	60 days
Depth of storage of dewatered sludge	1.5 m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading		4,318 kg/d		
Ditch volume required for BOD load		9,596 m3		
Ditch volume required for retention		13,731 m3		
Assume ditch depth		4.0 m		
Therefore required area		3,433 m2		area
Assume nr lanes x length x width		6	68	9	3672
Approx volume, less..	6%	13,807 m3		
Volumetric loading rate		0.31 kg BOD/m3		
Oxygen requirement		8,204 kg/d		
Power consumption		4,102 kwh/day		
Assume number of aerators		12		
Individual aerator power		28.5 kW		
Total Installed Power		342 kW		
Pump capacity		1144 m3/h		
RAS pump power		15.6 kW/pump		
Final clarifiers				
Required surface area		1144 m2		
Assume nr of tanks		2 nr		
Required diameter		27.0 m		
Say diameter		27.0 m		
DWF upward velocity		0.50 m/hr OK		
Vertical side wall depth		2 m		
Retention time (ignoring hopper)		4.0 hr @ DWF		
Sludge				
Sludge Production		4,102 kg DS/d		
Sludge volume		820 m3/d		
Required thickener area		205 m2		
Assume nr of tanks		2 nr		
Required diameter		11.4 m		
Say diameter		12.0 m		
Actual area		226 m2		
Sludge retention time		26.5 hr		
Surface loading		3.6 m3/m2/d		
Thickened sludge volume		133 m3/d		
Assume Nr of conditioning tanks		1		
Required conditioning tank area		44 m2		
Required dia of tank		7.5 m		
Assume dia.		8 m		
Volume of dewatered sludge		16 m3/d		
Area sludge storage building		656 m2		

LAND REQUIREMENT AND COSTS

FLOW	13,731 m3/d
LAND COST	10 US $/m2
Oxidation Ditch	3672 m2
Final Tanks	1145 m2
Sludge Thick Tanks	226 m2
Sludge Conditioning Tanks	50
Sludge Storage Building	656 m2
Other Structures	750 m2
Net Area of Structures	6510 m2
Site Multiplier	2.1
Site Area	1.37 ha
Buffer Zone	40 m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	3.99 ha
Total Land Cost inc Buffer	399,132 US $

COST ESTIMATE FOR: 13,731 m3/d TW

Oxidation Ditch (Extended aeration)

			Rate US $	Amount US $	Amount 000 VND
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of exc'n	3 m				
Add for channels etc	20%				
Excavation	11,813 m3		4	47,252	
Concrete walls	1,238 m3		240	297,114	
Concrete floors	2,552 m3		150	382,738	
Add for E&M Aerators etc	342 kw		1500*kW^0.87	240,170	
Total cost				967,274	12,574,558
RAS Pumping Station					
Civil works			UC1491/1	45,822	
M & E works			UC1491/1	65,951	
Total cost				111,773	1,453,062
Final Clarifiers	1	2 nr			
Wall thickness	0.4 m				
Freeboard	0.3 m				
Ave depth of exc'n	1 m				
Add for channels etc	30%				
Excavation	789	1,578 m3	4	6,313	
Concrete walls	103	206 m3	240	49,417	
Concrete floors	329	659 3m3	150	98,821	
Concrete hopper	74	149 m3	150	22,330	
Add for E&M scrapers	27.0 m		UC1491/1	97,751	
Total cost of		2 Tanks		274,631	3,570,204
Sludge Thickeners	1	2			
Wall thickness	0.35 m				
Freeboard	0.3 m				
Ave depth of exc'n	2 m				
Add for channels etc	20%				
Excavation	338	677 m3	4	2,708	
Concrete walls	70	140 m3	240	33,634	
Concrete floors	61	122 m3	150	18,241	
Concrete hopper	14	27 m3	150	4,072	
Add for E&M stirrers	452	905 m3	UC1491/1	79,583	
Total cost of		2 tanks		138,238	1,797,091
Sludge dewatering and storage					
Conditioning tanks	1	1			
Wall thickness	0.3 m				
Freeboard	0.3 m				
Ave depth of exc'n	2 m				
Add for channels etc	20%				
Excavation	160	160 m3	4	638	
Concrete walls	29	29 m3	240	7,009	
Concrete floors	21	21 m3	150	3,137	
Miscellaneous		10.0%	10,784	1,078	
Add for E&M		50.0%	11,862	5,931	
Sludge belt presses	320 m3/shift		500	160,082	
Sludge press building	200 m2		150	30,000	
Sludge storage building					
Area	656 m2		150	98,450	
Total cost of sludge dewatering and storage				308,325	3,982,227
Buildings and Miscellaneous					
Office, laboratory		250 m2	300	75,000	
Workshop		250 m2	150	37,500	
Works Pumping station		60 m2	1500	90,000	
Add for furnishing and fittings		20%	202,500	40,500	
Total cost of		bdgs		243,000	3,159,000
Sub-total				2,041,241	26,536,132
Add for elec dist, control, etc		15%		306,186	3,980,420
Add for site works		15%		352,114	4,577,480
Add for Prelims and Gen'l		30%		809,862	10,528,210
Total cost for		13,731 m3/d TWs		3,509,403	45,622,245
Total cost including Inlet Works and Pump Station				4,045,195	52,587,538
		MAE		1,745,585	22,692,609
		CIVIL		2,299,610	29,894,929

A5.4 Don Dien WWTP - Alternative 4.2 (Level 1 Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic	120,200	14,424	4,566	4,566
New Industry	0	27,550	1,382	2,554
Ex Industry		111	5	31
Total	120,200	42,085	5,955	7,153

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	14	hrs
MLSS concentration	3000	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	

Final clarifiers

Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
Floor slope	7.5	deg

Sludge

Sludge production per kg BOD removal	1	kg/kgBOD.d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 d/SS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

LAND REQUIREMENT AND COSTS

FLOW	42,085	m3/d
LAND COST	10	US $/m2

Oxidation Ditch	8460	m2
Final Tanks	3832	m2
Sludge Thick Tanks	308	m2
Sludge Conditioning Tanks	64	
Sludge Storage Building	905	m2
Other Structures	880	m2
Net Area of Structures	14248	m2
Site Multiplier	2.1	
Site Area	2.99	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	5.57	ha
Total Land Cost inc Buffer	656,769	US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	5,955	kg/d	
Ditch volume required for BOD load	13,233	m3	
Ditch volume required for retention	31,584	m3	
Assume ditch depth	4.0	m	
Therefore required area	7,891	m2	area
Assume nr lanes x length x width	10	94 9	8460
Approx volume, less 6%	31,810	m3	
Volumetric loading rate	0.19	kg BOD/m3	
Oxygen requirement	11,315	kg/d	
Power consumption	5,657	kwh/day	
Assume number of aerators	12		
Individual aerator power	39.3	kW	
Total Installed Power	471	kW	
Pump capacity	3507	m3/h	
RAS pump power	47.6	kW/pump	

Final clarifiers

Required surface area	3507	m2	
Assume nr of tanks	4	nr	
Required diameter	33.4	m	
Say diameter	34.0	m	
DWF upward velocity	0.46	m/hr	OK
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.1	hr @ DWF	

Sludge

Sludge Production	5,697	kg DS/d	
Sludge volume	1,131	m3/d	
Required thickener area	283	m2	
Assume nr of tanks	2	nr	
Required diameter	13.4	m	
Say diameter	14.0	m	
Actual area	308	m2	
Sludge retention time	26.1	hr	
Surface loading	3.7	m3/m2/d	
Thickened sludge volume	184	m3/d	
Assume nr of conditioning tanks	1		
Required conditioning tank area	61	m2	
Required dia of tank	8.8	m	
Assume dia	9	m	
Volume of dewatered sludge	23	m3/d	
Aven sludge storage building	905	m2	

COST ESTIMATE FOR: 42,085 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate	Amount US $	Amount 000 VND
Wall thickness		0.45	m			
Freeboard		0.3	m			
Ave depth of exc'n		3	m			
Add for channels etc		20%				
Excavation		27,032	m3	4	108,129	
Concrete walls		2,621	m3	240	629,141	
Concrete floors		5,839	m3	150	875,845	
Add for E&M Aerators etc		471	kw	1500*kW^0.87	317,666	
Total cost					1,930,781	25,100,157
RAS Pumping Station						
Civil works				UC1491/1	74,923	
M & E works				UC1491/1	128,424	
Total cost					203,347	2,643,507
Final Clarifiers	1	4	nr			
Wall thickness	0.45	m				
Freeboard	0.3	m				
Ave depth of exc'n	1	m				
Add for channels etc	30%					
Excavation	1,244	4,974	m3	4	19,898	
Concrete walls	146	582	m3	240	139,795	
Concrete floors	579	2,316	3m3	150	347,419	
Concrete hopper	118	472	m3	150	70,818	
Add for E&M scrapers	34.0	m		UC1491/1	215,376	
Total cost of		4	Tanks		793,307	10,312,989
Sludge Thickeners	1	2				
Wall thickness	0.4	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	459	917	m3	4	3,670	
Concrete walls	93	187	m3	240	44,819	
Concrete floors	83	165	m3	150	24,773	
Concrete hopper	18	37	m3	150	5,542	
Add for E&M stirrers	616	1,232	m3	UC1491/1	89,917	
Total cost of		2	tanks		168,721	2,193,372
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	196	196	m3	4	784	
Concrete walls	34	34	m3	240	8,184	
Concrete floors	26	26	m3	150	3,909	
Miscellaneous		10.0%		12,877	1,288	
Add for E&M		50.0%		14,165	7,082	
Sludge belt presses	442	m3/eh/h		500	220,771	
Sludge press building	200	m2		150	30,000	
Sludge storage building						
Area	905	m2		150	135,774	
Total cost of sludge dewatering and storage					407,791	5,301,289
Buildings and Miscellaneous						
Office, laboratory		300	m2	300	90,000	
Workshop		300	m2	150	45,000	
Works Pumping station		80	m2	1500	120,000	
Add for furnishing and fittings		20%		255,000	51,000	
Total cost of		bdgs			306,000	3,978,000
Sub-total					3,809,947	49,529,316
Add for elec dist, control, etc		15%			571,492	7,429,397
Add for site works		15%			857,216	8,563,807
Add for Prelims and Gen'l		30%			1,511,597	19,650,756
Total cost for	42,085	m3/d TWks			6,550,252	85,153,277
Total cost including Inlet Works and Pump Station					7,426,510	96,546,626
M&E					2,928,706	36,773,194
CIVIL					4,597,803	59,771,442

A5.5 Don Dien WWTP - Alternative 5.1 (Level 1 Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic	30,000	3,600	1,140	1,140
New Industry	0	51,400	2,578	4,765
Ex Industry		111	5	31
Total	30,000	55,111	3,723	5,936

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	15	hrs
MLSS concentration	3600	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95	%
RAS flow rate (max)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	

Final clarifiers

Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg

Sludge

Sludge production per kg BOD removal	1	kg/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 d/tSS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

LAND REQUIREMENT AND COSTS

FLOW	55,111	m3/d
LAND COST	10	US $ m2

Oxidation Ditch	9288	m2
Final Tanks	4778	m2
Sludge Thick Tanks	199	m2
Sludge Conditioning Tanks	38	
Sludge Storage Building	566	m2
Other Structures	850	m2
Net Area of Structures	15691	m2
Site Multiplier	2.1	
Site Area	3.30	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	7.02	ha
Total Land Cost inc Buffer	701,562	US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	3,723	kg/d		
Ditch volume required for BOD load	8,273	m3		
Ditch volume required for retention	34,444	m3		
Assume ditch depth	4.0	m		
Therefore required area	8,611	m2		Area
Assume nr lanes x length x width	12	86	9	9288
Approx volume, less	6%	34,923	m3	
Volumetric loading rate	0.11	kg BOD/m3		
Oxygen requirement	7,074	kg/d		
Power consumption	3,537	kwh/day		
Assume number of Aerators	12			
Individual aerator power	24.6	kW		
Total Installed Power	295	kW		
Pump capacity	4593	m3/h		
RAS pump power	82.6	kW/pump		

Final clarifiers

Required surface area	4593	m2
Assume nr of tanks	4	nr
Required diameter	38.2	m
Say diameter	39.0	m
DWF upward velocity	0.48	m/hr OK
Vertical side wall depth	2	m
Retension time (ignoring hopper)	4.2	hr @ DWF

Sludge

Sludge Production	3,537	kg DS/d
Sludge volume	707	m3/d
Required thickener area	177	m2
Assume nr of tanks	2	nr
Required diameter	10.6	m
Say diameter	11.0	m
Actual area	190	m2
Sludge retention time	25.8	hr
Surface loading	3.7	m3/m2/d
Thickened sludge volume	115	m3/d
Assume nr of conditioning tanks	1	
Required conditioning tank area	38	m2
Required dia of tank	7.0	m
Assume dia	7	m
Volume of dewatered sludge	14	m3/d
Area sludge storage building	566	m2

COST ESTIMATE FOR: 55,111 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate	Amount US $	Amount 000 VND
Wall thickness	0.45	m				
Freeboard	0.3	m				
Ave depth of exc'n	3	m				
Add for channels etc	20%					
Excavation	29,661	m3		4	118,723	
Concrete walls	2,860	m3		240	686,465	
Concrete floors	6,411	m3		150	961,666	
Add for E&M Aerators etc	295	kw	1500*kW^0.67		211,106	
Total cost					1,977,958	25,713,589
RAS Pumping Station						
Civil works			UC1491/1		84,339	
M & E works			UC1491/1		150,774	
Total cost					235,113	3,056,464
Final Clarifiers	1	4 nr				
Wall thickness	0.45	m				
Freeboard	0.3	m				
Ave depth of exc'n	1	m				
Add for channels etc	30%					
Excavation	1,525	6,502	m3	4	26,008	
Concrete walls	147	667	m3	240	160,065	
Concrete floors	754	3,015	3m3	150	452,176	
Concrete hopper	155	621	m3	150	93,178	
Add for E&M scrapers	39.0	m	UC1491/1		228,152	
Total cost of		4 Tanks			959,599	12,474,787
Sludge Thickeners	1	2				
Wall thickness	0.4	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	299	599	m3	4	2,394	
Concrete walls	74	148	m3	240	35,482	
Concrete floors	52	105	m3	150	15,748	
Concrete hopper	11	23	m3	150	3,421	
Add for E&M stirrers	380	760	m3	UC1491/1	74,284	
Total cost of		2 tanks			131,328	1,707,269
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	127	127	m3	4	507	
Concrete walls	27	27	m3	240	6,527	
Concrete floors	16	16	m3	150	2,450	
Miscellaneous		10.0%		9,484	948	
Add for E&M		50.0%		10,432	5,216	
Sludge belt pressers	275	m3/e/h		500	138,023	
Sludge press building	150	m2		150	22,500	
Sludge storage building						
Area	566	m2		150	84,884	
Total cost of sludge dewatering and storage					261,056	3,393,727
Buildings and Miscellaneous						
Office, laboratory	300	m2		300	90,000	
Workshop	300	m2		150	45,000	
Works Pumping station	80	m2		1500	120,000	
Add for furnishing and fittings	20%			255,000	51,000	
Total cost of	bdge				306,000	3,978,000
Sub-total					3,871,064	50,323,831
Add for elec dist, control, etc	15%				580,660	7,548,575
Add for site works	15%				667,759	8,680,861
Add for Prelims and Gen'l	30%				1,535,845	19,965,980
Total cost for	55,111	m3/d TWks			6,655,327	86,519,246
Total cost including Inlet Works and Pump Station					7,643,595	99,366,730
M&E					2,719,150	35,348,946
CML					4,924,445	64,017,784

A5.6 Don Dien WWTP - Alternative 5.2 (Level 1 Treatment)

Influent Characteristics

	Population	Flow, m^3/d	BOD, kg/d	SS kg/d
Domestic	113,500	13,560	4,294	4,294
New Industry	0	51,400	2,578	4,765
Ex Industry		111	5	31
Total	113,500	65,071	6,877	9,090

[illegible]	65071 m3/d =	2711.292 m3/h
[illegible]	[illegible] mg/l =	6877 kg/d
[illegible]	[illegible] mg/l =	9090 kg/d

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15 kgBOD/kgMLSS
Retention at DWF	18 hrs
MLSS concentration	3000 mg/l
Depth	4 m
Oxygen requirement	2 kgO2/kgBOD
Oxygen transfer	2 kgO2/kwh
Peak factor for aerator capacity	2
BOD removal	95%
RAS flow rate (max)	2 DWF
RAS pumping head	6 m
No of RAS duty pumps	2
No of RAS standby pumps	1
Final clarifiers	
Maximum upward velocity at DWF	0.5 m/h
Side wall depth	2 m
floor slope	7.5 deg
Sludge	
Sludge production per kg BOD removal	1 kg/kgBOD.d
Solids content of surplus sludge	0.5%
Sludge thickener loading	50 m2 d/tSS
Sludge thickener wall height	4 m
Assume solids content of thickened sludge	3.0% solids
Assume sludge density	1025 kg/m3
Sludge conditioning tank retention time	1 day
Depth of conditioning tanks	3 m
Operating period for mechanical dewatering	10 hours/day
Solids content of dewatered sludge	25% solids
Storage time for dewatered sludge	50 days
Depth of storage of dewatered sludge	1.5 m

LAND REQUIREMENT AND COSTS

FLOW	65,071 m3/d
LAND COST	10 US $/m2

Oxidation Ditch	12960 m2
Final Tanks	5448 m2
Sludge Thick Tanks	353 m2
Sludge Conditioning Tanks	79
Sludge Storage Building	1045 m2
Other Structures	950 m2
Net Area of Structures	20835 m2
Site Multiplier	2.1
Site Area	4.38 ha
Buffer Zone	40 m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	6.57 ha
Total Land Cost inc Buffer	656,506 US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	6,877 kg/d	
Ditch volume required for BOD load	15,282 m3	
Ditch volume required for retention	48,803 m3	
Assume ditch depth	4.0 m	
Therefore required area	12,201 m2	area
Assume nr lanes x length x width	16 90 9	12960
Approx volume, less 6%	48,730 m3	
Volumetric loading rate	0.14 kg BOD/m3	
Oxygen requirement	13,066 kg/d	
Power consumption	6,533 kwh/day	
Assume number of aerators	16	
Individual aerator power	34.0 kW	
Total Installed Power	544 kW	
Pump capacity	5423 m3/h	
RAS pump power	73.9 kW/pump	
Final clarifiers		
Required surface area	5423 m2	
Assume nr of tanks	6 nr	
Required diameter	33.9 m	
Say diameter	34.0 m	
DWF upward velocity	0.50 m/hr OK	
Vertical side wall depth	2 m	
Retention time (ignoring hopper)	4.0 hr @ DWF	
Sludge		
Sludge Production	6,533 kg DS/d	
Sludge volume	1,307 m3/d	
Required thickener area	327 m2	
Assume nr of tanks	2 nr	
Required diameter	14.4 m	
Say diameter	15.0 m	
Actual area	353 m2	
Sludge retention time	26.0 hr	
Surface loading	3.7 m3/m2/d	
Thickened sludge volume	212 m3/d	
Assume nr of conditioning tanks	1	
Required conditioning tank area	71 m2	
Required dia of tank	9.5 m	
Assume dia	10 m	
Volume of dewatered sludge	26 m3/d	
Area sludge storage building	1045 m2	

COST ESTIMATE FOR:		65,071 m3/d TW	Rate	Amount	Amount
Oxidation Ditch (Extended aeration)			US $	US $	000 VND
Wall thickness		0.45 m			
Freeboard		0.3 m			
Ave depth of excn		3 m			
Add for channels etc		20%			
Excavation		41,355 m3	4	165,420	
Concrete walls		3,905 m3	240	937,150	
Concrete floors		8,933 m3	150	1,339,901	
Add for E&M Aerators etc		544 kw	1500*kW^0.67	360,046	
Total cost				2,802,518	36,432,736
RAS Pumping Station					
Civil works			UC1491/1	90,720	
M & E works			UC1491/1	166,439	
Total cost				257,159	3,343,059
Final Clarifiers	1	6 nr			
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of excn	1 m				
Add for channels etc	30%				
Excavation	1,244	7,462 m3	4	29,847	
Concrete walls	146	874 m3	240	209,594	
Concrete floors	579	3,474 3m3	150	521,129	
Concrete hopper	118	708 m3	150	106,227	
Add for E&M scrapers	34.0 m		UC1491/1	323,065	
Total cost of		6 Tanks		1,189,860	15,469,484
Sludge Thickeners	1	2			
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of excn	2 m				
Add for channels etc	20%				
Excavation	532	1,064 m3	4	4,256	
Concrete walls	113	225 m3	240	54,098	
Concrete floors	95	191 m3	150	28,592	
Concrete hopper	21	42 m3	150	6,362	
Add for E&M stirrers	707	1,414 m3	UC1491/1	94,967	
Total cost of		2 tanks		188,275	2,447,581
Sludge dewatering and storage					
Conditioning tanks	1	1			
Wall thickness	0.3 m				
Freeboard	0.3 m				
Ave depth of excn	2 m				
Add for channels etc	20%				
Excavation	236	236 m3	4	946	
Concrete walls	37	37 m3	240	8,774	
Concrete floors	32	32 m3	150	4,765	
Miscellaneous		10.0%	14,485	1,449	
Add for E&M		50.0%	15,934	7,967	
Sludge belt presses	510 m3/shift		500	254,952	
Sludge press building	250 m2		150	37,500	
Sludge storage building					
Area	1045 m2		150	156,796	
Total cost of sludge dewatering and storage				473,149	6,150,937
Buildings and Miscellaneous					
Office, laboratory		300 m2	300	90,000	
Workshop		300 m2	150	45,000	
Works Pumping station		100 m2	1500	150,000	
Add for furnishing and fittings		20%	285,000	57,000	
Total cost of		bdgs		342,000	4,446,000
Sub-total				5,253,061	68,289,798
Add for elec dist, control, etc		15%		787,959	10,243,470
Add for site works		15%		906,153	11,779,990
Add for Prelims and Gen'l		20%		2,084,152	27,093,977
Total cost for		65,071 m3/d TWks		9,031,326	117,407,236
Total cost including Inlet Works and Pump Station				10,096,009	131,248,114
		M&E		3,577,882	46,512,469
		CIVIL		6,518,127	84,735,667

A5.7 Dong Dang WWTP - All Alternatives except 4.1 (Level 2 Treatment)

Influent Characteristics

	Population	Flow, m³/d	BOD, kg/d	SS kg/d
Domestic	90,200	10,824	3,428	3,438
New industry				
Ex industry		25	2	55
Total	90,200	10,849	3,430	3,483

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.08 kgBOD/kgMLSS
Retention at DWF	36 hrs
MLSS concentration	3500 mg/l
Depth	4 m
Oxygen requirement	2.5 kgO2/kgBOD
Oxygen transfer	2 kgO2/kwh
Peak factor for aerator capacity	2
BOD removal	95%
RAS flow rate (max)	2 DWF
RAS pumping head	6 m
No of RAS duty pumps	2
No of RAS standby pumps	1
Sidestream flowrate to phosphorus stripper	0.2 DWF
Sidestream pumping head	8 m
No of sidestream duty pumps	2
No of sidestream standby pumps	1
Retention period in phosphorus stripper	12 hrs

Final clarifiers

Maximum upward velocity at DWF	0.5 m/h
Side wall depth	2 m
floor slope	7.5 deg

Sludge

Sludge production per kg BOD removal	0.9 kg/kgBOD r
Lime treatment of sludge	0.1 kg/kgDS
Solids content of surplus sludge	0.2%
Sludge thickener loading	50 m2.d/SS
Sludge thickener wall height	4 m
Assume solids content of thickened sludge	2.0% solids
Assume sludge density	1025 kg/m3
Sludge conditioning tank retention time	1 day
Depth of conditioning tanks	3 m
Operating period for mechanical dewatering	10 hours/day
Solids content of dewatered sludge	25% solids
Storage time for dewatered sludge	40 days
Depth of storage of dewatered sludge	1.5 m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading		2,730 kg/d			
Ditch volume required for BOD load		13,000 m3			
Ditch volume required for retention		12,390 m3			
Assume ditch depth		4.0 m			
Therefore required area		3,250 m2			area
Assume nr lanes x length x width		4	94	9	3384
Approx volume, fee	6%	12,724 m3			
Volumetric loading rate		0.21 kg BOD/m3			
Oxygen requirement		6,484 kg/d			
Power consumption		3,242 kwh/day			
Assume number of aerators		12.0			
Individual aerator power		22.5 kW			
Total installed aeration power		270 kW			
RAS Pump capacity		669 m3/h			
RAS pump power		9.4 kW/pump			
Sidestream pump capacity		69 m3/h			
Sidestream pump power		1.3 kW/pump			

Phosphorus stripper

Required volume	826 m3
Assume nr of tanks	1 nr
Assume depth of tanks	4 m
Required diameter	16.2 m
Say diameter	17.0 m

Final clarifiers

Required surface area	688 m2
Assume nr of tanks	2 nr
Required diameter	20.9 m
Say diameter	21.0 m
DWF upward velocity	0.30 m/hr OK
Vertical side wall depth	2 m
Retention time (ignoring hopper)	4.0 hr at DWF

Sludge

Sludge Production	2,334 kg DS/d
Approximate additional solids from lime	233 kg DS/d
Total DS in sludge for dewatering	2,568 kg DS/d
Sludge volume	467 m3/d
Required thickener area	117 m2
Assume nr of tanks	1 nr
Required diameter	12.2 m
Say diameter	13.0 m
Actual area	133 m2
Sludge retention time	27.3 hr
Surface loading	3.5 m3/m2/d
Thickened sludge volume	83 m3/d
Assume Nr of conditioning tanks	1
Required conditioning tank area	28 m2
Required dia of tank	6.0 m
Assume dia	6 m
Volume of dewatered sludge	9 m3/d
Area sludge storage building	373 m2

LAND REQUIREMENT AND COSTS

FLOW	8,280 m3/d
LAND COST	40 US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	3384 m2
Final Tanks	693 m2
Phosphorus Stripper	227 m2
Clarifier	68 m2
Sludge Thick Tanks	133 m2
Sludge Conditioning Tanks	28
Sludge Storage Building	373 m2
Other Structures	610 m2
Net Area of Structures	5517 m2
Site Multiplier	2.3
Site Area	1.27 ha
Buffer Zone	40 m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	3.82 ha
Total Land Cost inc Buffer	1,528,231 US $

COST ESTIMATE FOR: 8,280 m3/d TW

Oxidation Ditch (Extended aeration)

			Rate	Amount	Amount
			US $	US $	000 VND
Wall thickness		0.5 m			
Freeboard		0.5 m			
Ave depth of exc'n		3 m			
Add for channels etc		20%			
Excavation		10,973 m3	4	43,890	
Concrete walls		1,312 m3	240	314,863	
Concrete floors		2,633 m3	150	395,010	
Add for E&M Aerators etc		270 kw	1500*kW^0.87	195,702	
Total cost				949,466	12,343,064
RAS Pumping Station					
Civil works			UC1491/1	36,659	
M & E works			UC1491/1	48,741	
Total cost				85,400	1,110,194
Sidestream Pumping Station					
Civil works			UC1491/1	15,137	
M & E works			UC1491/1	14,697	
Total cost				29,834	387,837
Stripper Tanks	1	1 nr			
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of exc'n	1 m				
Add for channels etc	30%				
Excavation	327	327 m3	4	1,309	
Concrete walls	138	138 m3	240	33,094	
Concrete floors	157	157 3m3	150	23,587	
Concrete hopper	30	30 m3	240	7,082	
Add for E&M scrapers	17.0 m		UC1491/1	40,244	
Total cost of		1 Tanks		106,319	1,389,142
Reactor Clarifier					
Flow rate	1652 m3/d			94,434	
Total cost				94,434	1,227,639
Final Clarifiers	1	2			
Wall thickness	0.4 m				
Freeboard	0.3 m				
Ave depth of exc'n	1 m				
Add for channels etc	30%				
Excavation	485	970 m3	4	3,882	
Concrete walls	80	161 m3	240	38,595	
Concrete floors	205	410 3m3	150	61,477	
Concrete hopper	45	90 m3	150	13,508	
Add for E&M scrapers	21.0 m		UC1491/1	87,959	
Total cost of		2 Tanks		205,421	2,670,471
Sludge Thickeners	1	1			
Wall thickness	0.35 m				
Freeboard	0.3 m				
Ave depth of exc'n	2 m				
Add for channels etc	20%				
Excavation	391	391 m3	4	1,563	
Concrete walls	76	76 m3	240	18,179	
Concrete floors	71	71 m3	150	10,614	
Concrete hopper	16	16 m3	150	2,389	
Add for E&M stirrers	531	531 m3	UC1491/1	42,396	
Total cost of		1 tanks		76,141	976,829
Sludge dewatering and storage					
Conditioning tanks	1	1			
Wall thickness	0.3 m				
Freeboard	0.3 m				
Ave depth of exc'n	2 m				
Add for channels etc	20%				
Excavation	98	98 m3	4	391	
Concrete walls	23	23 m3	240	5,601	
Concrete floors	12	12 m3	150	1,647	
Miscellaneous	10.0%		7,839	784	
Add for E&M	50.0%		8,623	4,312	
Sludge belt presses	200 m3/shift		500	100,196	
Sludge press building	150 m2		150	22,500	
Sludge storage building					
Area	373 m2		150	56,020	
Total cost of sludge dewatering and storage				191,862	2,491,477
Buildings and Miscellaneous					
Office, laboratory	200 m2		300	60,000	
Workshop	200 m2		150	30,000	
Works Pumping station	60 m2		1,500	90,000	
Add for furnishing and fittings	20%		180,000	36,000	
Total cost of	bldgs			216,000	2,808,000
Sub-total				1,962,886	25,384,643
Add for elec dist, control, etc	30%			586,799	7,616,393
Add for site works	20%			607,663	8,600,007
Add for Prelims and Gen'l	30%			913,847	11,880,013
Total cost for	8,280 m3/d TWks			3,960,004	61,480,056
Total cost including Inlet Works and Pump Station				4,390,312	67,074,061
M&E				1,985,796	25,816,346
CIVIL				2,404,617	31,258,715

A5.8 Dong Dang WWTP - Alternative 4.1 (Level 2 Treatment)

Influent Characteristics

	Population	Flow m3/d	BOD kg/d	SS kg/d
Domestic	90 200	10,024	3 428	3 428
New Industry		27,350	1,362	2 554
Ex Industry		25	2	55
Total	90 200	38 399	4,912	6 037

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.06	kgBOD/kgMLSS
Retention at DWF	24	hrs
MLSS concentration	3500	mg/l
Depth	4	m
Oxygen requirement	2.5	kgO2/kgBOD
Oxygen transfer	2	kgO2/kWh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	2	DWF
RAS pumping head	8	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	
Sidestream flowrate to phosphorus stripper	0.2	DWF
Sidestream pumping head	8	m
No of sidestream duty pumps	2	
No of sidestream standby pumps	1	
Retention period in phosphorus stripper	12	hrs
Final clarifiers		
Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg
Sludge		
Sludge production per kg BOD removal	0.8	kg/kgBOD.d
Lime treatment of sludge	0.1	kg/kgDS
Solids content of surplus sludge	0.5%	
Sludge thickener loading	30	m2.d/tSS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operation period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

LAND REQUIREMENT AND COSTS

FLOW	38,399	m3/d
LAND COST	10	US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	10368	m2
Final Tanks	3217	m2
Phosphorus Stripper	982	m2
Clarifier	330	m2
Sludge Thick. Tanks	226	m2
Sludge Conditioning Tanks	50	
Sludge Storage Building	658	m2
Other Structures	500	m2
Net Area of Structures	16721	m2
Site Multiplier	2.3	
Site Area	3.85	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	7.81	ha
Total Land Cost inc Buffer	781,405	US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	4,912	kg/d		
Ditch volume required for BOD load	22,914	m3		
Ditch volume required for retention	38,399	m3		
Assume ditch depth	4.0	m		
Therefore required area	9,600	m2		area
Assume nr lanes x length x width	12	96	9	10368
Approx volume, inc 6%	38,984	m3		
Volumetric loading rate	0.12	kg BOD/m3		
Oxygen requirement	11,429	kg/d		
Power consumption	5,714	kwh/day		
Assume number of aerators	12.0			
Individual aerator power	39.7	kW		
Total installed aeration power	476	kW		
RAS Pump capacity	3200	m3/h		
RAS pump power	43.6	kW/pump		
Sidestream pump capacity	320	m3/h		
Sidestream pump power	5.8	kW/pump		
Phosphorus stripper				
Required volume	3,840	m3		
Assume nr of tanks	2	nr		
Assume depth of tanks	4	m		
Required diameter	24.7	m		
Say diameter	25.0	m		
Final clarifiers				
Required surface area	3200	m2		
Assume nr of tanks	4	nr		
Required diameter	31.9	m		
Say diameter	32.0	m		
DWF upward velocity	0.50	m/hr	OK	
Vertical side wall depth	2	m		
Retention time (ignoring hopper)	4.0	hr @ DWF		
Sludge				
Sludge Production	4,114	kg DS/d		
Approximate additional solids from lime	411	kg DS/d		
Total DS in sludge for dewatering	4,526	kg DS/d		
Sludge volume	823	m3/d		
Required thickener area	206	m2		
Assume nr of tanks	2	nr		
Required diameter	11.4	m		
Say diameter	12.0	m		
Actual area	226	m2		
Sludge retention time	28.4	hr		
Surface loading	3.6	m3/m2/d		
Thickened sludge volume	147	m3/d		
Assume Nr of conditioning tanks	1			
Required conditioning tank area	49	m2		
Required dia of tank	7.9	m		
Assume dia.	8	m		
Volume of dewatered sludge	16	m3/d		
Area sludge storage building	658	m2		

COST ESTIMATE FOR: 38,399 m3/d TW

			Rate	Amount	Amount
Oxidation Ditch (Extended aeration)			US $	US $	000 VND
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of each	3 m				
Add for channels etc	20%				
Excavation	33,096 m3		4	132,385	
Concrete walls	3,162 m3		240	758,802	
Concrete floors	7,149 m3		150	1,072,317	
Add for E&M Aerators etc	476 kw		1500*kW^0.87	320,448	
Total cost				2,284,062	29,693,042
RAS Pumping Station					
Civil works			UC1491/1	71,968	
M & E works			UC1491/1	121,607	
Total cost				193,575	2,516,480
Sidestream Pumping Station					
Civil works			UC1491/1	29,716	
M & E works			UC1491/1	36,669	
Total cost				66,386	863,002
Stripper Tanks	1	2 nr			
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of each	1 m				
Add for channels etc	30%				
Excavation	685	1,370 m3	4	5,479	
Concrete walls	201	402 m3	240	96,509	
Concrete floors	323	645 3m3	150	96,796	
Concrete hopper	64	128 m3	240	30,631	
Add for E&M scrapers	25.0 m		UC1491/1	94,642	
Total cost of		2 Tanks		324,087	4,213,128
Reactor Clarifier					
Flow rate	7679.8 m3/d			399,497	
Total cost				399,497	6,180,469
Final Clarifiers	1	4			
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of each	1 m				
Add for channels etc	30%				
Excavation	1,105	4,421 m3	4	17,683	
Concrete walls	137	549 m3	240	131,680	
Concrete floors	516	2,063 3m3	150	309,376	
Concrete hopper	105	418 m3	150	62,731	
Add for E&M scrapers	32.0 m		UC1491/1	209,962	
Total cost of		4 Tanks		731,431	9,508,609
Sludge Thickeners	1	2			
Wall thickness	0.35 m				
Freeboard	0.3 m				
Ave depth of each	2 m				
Add for channels etc	20%				
Excavation	338	677 m3	4	2,708	
Concrete walls	70	140 m3	240	33,634	
Concrete floors	61	122 m3	150	18,241	
Concrete hopper	14	27 m3	150	4,072	
Add for E&M stirrers	452	905 m3	UC1491/1	79,583	
Total cost of		2 tanks		138,239	1,797,091
Sludge dewatering and storage					
Conditioning tanks	1	1			
Wall thickness	0.3 m				
Freeboard	0.3 m				
Ave depth of each	2 m				
Add for channels etc	20%				
Excavation	160	160 m3	4	638	
Concrete walls	31	31 m3	240	7,348	
Concrete floors	21	21 m3	150	3,137	
Miscellaneous	10.0%		11,123	1,112	
Add for E&M	50.0%		12,235	6,118	
Sludge belt presses	353 m3/shift		500	176,612	
Sludge press building	200 m2		150	30,000	
Sludge storage building					
Area	658 m2		150	98,742	
Total cost of sludge dewatering and storage				323,707	4,208,195
Buildings and Miscellaneous					
Office, laboratory	300 m2		300	90,000	
Workshop	300 m2		150	45,000	
Works Pumping station	100 m2		1,500	150,000	
Add for furnishing and fittings	20%		285,000	57,000	
Total cost of	bdgs			342,000	4,446,000
Sub-total				4,802,802	62,426,028
Add for elec dist, control, etc	30%			1,440,601	18,727,808
Add for site works	20%			1,288,521	16,230,767
Add for Prelims and Gen'l	30%			2,247,307	29,216,380
Total cost for	38,399 m3/d TWks			9,738,460	126,599,980
Total cost including inlet Works and Pump Station				10,579,761	137,536,769
M&E				4,631,166	60,005,159
CIVIL				6,048,686	78,631,610

A5.9 Deo Sen WWTP - Alternatives 1.1, 1.2, 2.1, 2.2, 4.1, 4.2 (Level 2 Treatment)

Influent Characteristics

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Final clarifiers

Sludge

LAND REQUIREMENT AND COSTS

Extended Aeration (Oxidation Ditch)

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

Final clarifiers

Phosphorus stripper

Sludge

COST ESTIMATE FOR: 22,104 m3/d TWW — *Rate* — *Amount* — *Amount*

Oxidation Ditch (Extended aeration) — US $ — US $ — 000 VND

RAS Pumping Station

Sidestream Pumping Station

Stripper Tanks — 2 nr

Reactor Clarifier

Final Clarifiers — 2 Tanks

Sludge Thickeners — 2 Tanks

Sludge dewatering and storage

Buildings and Miscellaneous

Total cost for	22,104 m3/d TWW	8,872,876	110,144,774
Total cost including Inlet Works and Pump Station		9,182,087	114,717,182
	M&E	2,998,207	51,970,092
	CIVIL	6,183,880	66,847,041

A5.10 Deo Sen WWTP -Alternatives 3.1, 3.2, 5.2 (Level 2 Treatment)

Influent Characteristics

	[illegible]	Flow m³/d	[illegible]	[illegible]
[illegible]	164,000	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	19,740	[illegible]	[illegible]

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

[illegible]	0.08 kgBOD/kgMLSS
[illegible] DWF	16 hrs
MLSS [illegible]	3500 mg/l
[illegible]	4 m
Oxygen requirement	2.5 kgO2/kgBOD
[illegible]	2 kgO2/kWh
[illegible]	2
[illegible]	30%
RAS [illegible]	2 DWF
RAS [illegible]	8 m
[illegible]	2
[illegible]	1
[illegible]	0.2 DWF
[illegible]	8 m
[illegible]	2
[illegible]	1
[illegible]	12 hrs

Final clarifiers

Maximum upflow velocity at DWF	0.5 m/h
[illegible]	2 m
[illegible]	7.5 min

Sludge

[illegible] BOD removal	0.7 kgDS/kgBOD
[illegible]	0.1 kg/kgDS
[illegible]	0.5%
[illegible]	40 m³/m²/d
[illegible]	4 m
Assume [illegible]	3.0%
Assume sludge density	1025 kg/m³
[illegible]	1 day
[illegible]	2 m
[illegible]	10 hrs/day
[illegible]	25%
[illegible]	60 days
[illegible]	1.5 m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	6,296		
Ditch volume required for BOD load	24,595		
Ditch volume required for retention	24,510	kg/d	
Assume ditch depth	4.0	m3	
True area required area	7,444	m3	
Assume nr. lanes x length x width	18	m	
Actual volume, total	24,779	m2	area
Volumetric loading rate	0.27	[illegible]	7420
Oxygen requirement	14,911	m3	
Power consumption	7,405	kg BOD/m3	
Assume number of aerators	10.0	kg/d	
Individual aerator power	61.7	kWh/day	
Total installed aeration power	617		
RAS Pump capacity	1645	kW	
RAS pump power	22.4	kW	
Sidestream pump capacity	165	m3/h	
Sidestream pump power	3.0	kW/pump	
Phosphorus stripper		m3/h	
Required volume	1,974	kW/pump	
Assume nr. of tanks	2		
Assume depth of tanks	4	m3	
Required diameter	17.7	m	
Say diameter	18.0	m	
Final clarifiers		m	
Required surface area	1645	m	
Assume nr. of tanks	2		
Required diameter	32.4	m2	
Say diameter	33.0	m	
DWF upward velocity	0.48	m	
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.2	m/hr	OK
Sludge		m	
Sludge Production	5,332	hr @ DWF	
Approximate additional solids from lime	533		
Total DS in sludge for dewatering	5,865	kg DS/d	
Sludge volume	1,066	kg DS/d	
Required thickener area	267	kg DS/d	
Assume nr. of tanks	2	m3/d	
Required diameter	13.0	m2	
Say diameter	14.0	m	
Actual area	308	m	
Sludge retention time	27.7	m	
Surface loading	3.5	m2	
Thickened sludge volume	191	hr	
Assume nr. of conditioning tanks	1	m3/m2/d	
Required conditioning tank area	64	m3/d	
Required dia of tank	9.0		
Assume dia.	9	m2	
Volume of dewatered sludge	20	m	
Area sludge storage building	653	m	
		m3/d	
		m2	

COST ESTIMATE FOR: 19,740 m3/d TW

				Rate	Amount	Amount
Oxidation Ditch (Extended aeration)				US $	US $	000 VND
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of each	3 m					
Add for channels etc	20%					
Excavation	25,370 m3			4	101,497	
Concrete walls	2,468 m3			240	592,361	
Concrete floors	5470 m3			150	820,471	
Add for E&M Aerators etc	617 kw		1500*kW^0.87		401,516	
Total cost					1,916,840	24,903,323
RAS Pumping Station						
Civil works			UC14Q/1/1		51,794	
M & E works			UC14Q/1/1		84,460	
Total cost					136,888	1,780,849
Sidestream Pumping Station						
Civil works			UC14Q/1/1		22,189	
M & E works			UC14Q/1/1		24,445	
Total cost					46,689	608,302
Stripper Tanks	1	2 nr				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of each	4 m					
Add for channels etc	30%					
Excavation	365	730 m3		4	2,920	
Concrete walls	140	280 m3		240	68,995	
Concrete floors	175	350 m3		150	52,413	
Concrete hopper	33	66 m3		240	15,873	
Add for E&M scrapers	18.0 m		UC14Q/1/1		82,444	
Total cost of		2 Tanks			222,640	2,897,216
Reactor Clarifier						
Flow rate	3948 m3/d				213,628	
Total cost					213,628	2,777,169
Final Clarifiers	1	2				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	30%					
Excavation	1,173	2,347 m3		4	9,387	
Concrete walls	141	281 m3		240	67,469	
Concrete floors	547	1,094 m3		150	164,091	
Concrete hopper	111	222 m3		150	33,357	
Add for E&M scrapers	33.0 m		UC14Q/1/1		105,346	
Total cost of		2 Tanks			381,020	4,953,258
Sludge Thickeners	1	2				
Wall thickness	0.25 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	20%					
Excavation	447	894 m3		4	3,576	
Concrete walls	81	162 m3		240	39,044	
Concrete floors	91	183 m3		150	24,479	
Concrete hopper	18	37 m3		150	5,542	
Add for E&M stirrers	616	1,232 m3	UC14Q/1/1		89,917	
Total cost of		2 tanks			162,558	2,113,219
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	20%					
Excavation	196	196 m3		4	784	
Concrete walls	25	25 m3		240	6,324	
Concrete floors	26	26 m3		150	3,902	
Mechanical	10.0%			11,021	1,102	
Add for E&M	50.0%			14,329	7,161	
Sludge belt presses	451 m3/shift			500	225,476	
Sludge press building	200 m2			150	30,000	
Sludge storage building						
Area	853 m2			150	127,983	
Total cost of sludge dewatering and storage					408,323	5,308,205
Buildings and Miscellaneous						
Office, laboratory	300 m2			300	90,000	
Workshop	300 m2			150	45,000	
Works Pumping station	100 m2			1,500	150,000	
Add for furnishing and fittings	20%			285,000	57,000	
Total cost of	bldgs				342,000	4,446,000
Subtotal					3,829,264	49,780,432
Add for elec dist, control, etc	30%				1,148,779	14,934,130
Add for site works	20%				765,853	12,942,912
Add for Prelims and Gen'l	30%				1,792,099	23,297,247
Total cost for	19,740 m3/d TWks				7,766,747	100,964,717
Total cost including Wet Works and Pump Station					8,393,301	109,112,912
	M&E				3,990,007	51,870,092
	CIVIL				4,403,294	57,242,820

LAND REQUIREMENT AND COSTS

FLOW	19,740 m3/d
LAND COST	10 US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	7440 m2
Final Tanks	1711 m2
Phosphorus stripper	509 m2
[illegible]	165 m2
Sludge Thick Tanks	308 m2
Sludge Conditioning Tanks	64
Sludge Storage Building	653 m2
Other Structures	300 m2
Net Area of Structures	14,431 m2
[illegible]	2.9
[illegible]	2.9 ha
Buffer Zone	40 m around site perimeter
[illegible]	6.57 ha
[illegible]	616,595 US $

A5.11 Deo Sen WWTP - Alternative 5.1 (Level 2 Treatment)

Influent Characteristics

	Population	Flow, m³/d	BOD, kg/d	SS kg/d
Domestic	169,000	20,280	6,422	6,422
New Industry				
Ex Industry		60	4	141
Total	169,000	20,340	6,426	6,563

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.06	kgBOD/kgMLSS
Retention at DWF	36	hrs
MLSS concentration	3500	mg/l
Depth	4	m
Oxygen requirement	2.5	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	85%	
RAS flow rate (max)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	
Sidestream flowrate to phosphorus stripper	0.2	DWF
Sidestream pumping head	8	m
No of sidestream duty pumps	2	
No of sidestream standby pumps	1	
Retention period in phosphorus stripper	12	hrs

Final clarifiers

Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
Floor slope	7.5	deg

Sludge

Sludge production per kg BOD removal	0.9	kg/kgBOD.d
Lime treatment of sludge	0.1	kg/kgDS
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 d/kgDS
Sludge thickener wall height	4	m
Assumed solids content of thickened sludge	3.0%	solids
Assumed sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	90	days
Depth of storage of dewatered sludge	1.5	m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	6,426	kg/d	
Ditch volume required for BOD load	30,600	m3	
Ditch volume required for retention	30,510	m3	
Assume ditch depth	4.0	m	
Therefore required area	7,650	m2	Area
Assume nr lanes x length x width	10	82	9 (8280)
Approx volume, lay	6% 31,133	m3	
Volumetric loading rate	0.21	kg BOD/m3	
Oxygen requirement	15,262	kg/d	
Power consumption	7,631	kwh/day	
Assume number of aerators	10.0		
Individual aerator power	63.6	kW	
Total installed aeration power	636	kW	
RAS Pump capacity	1695	m3/h	
RAS pump power	23.1	kW/pump	
Sidestream pump capacity	170	m3/h	
Sidestream pump power	3.1	kW/pump	

Phosphorus stripper

Required volume	2,034	m3
Assume nr of tanks	2	nr
Assume depth of tanks	4	m
Required diameter	18.0	m
Say diameter	18.0	m

Final clarifiers

Required surface area	1695	m2	
Assume nr of tanks	2	nr	
Required diameter	32.9	m	
Say diameter	33.0	m	
DWF upward velocity	0.50	m/hr	OK
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.0	hr @ DWF	

Sludge

Sludge Production	5,494	kg DS/d
Approximate additional solids from lime	549	kg DS/d
Total DS in sludge for dewatering	6,044	kg DS/d
Sludge volume	1,099	m3/d
Required thickener area	275	m2
Assume nr of tanks	2	nr
Required diameter	13.2	m
Say diameter	14.0	m
Actual area	308	m2
Sludge retention time	26.9	hr
Surface loading	3.6	m3/m2/d
Thickened sludge volume	197	m3/d
Assume Nr of conditioning tanks	1	
Required conditioning tank area	66	m2
Required dia of tank	9.1	m
Assume dia	10	m
Volume of dewatered sludge	22	m3/d
Area sludge storage building	879	m2

LAND REQUIREMENT AND COSTS

FLOW	20,340	m3/d
LAND COST	10	US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	8280	m2
Final Tanks	1711	m2
Phosphorus Stripper	509	m2
Clarifier	170	m2
Sludge Thick Tanks	306	m2
Sludge Conditioning Tanks	79	
Sludge Storage Building	879	m2
Other Structures	900	m2
Net Area of Structures	12835	m2
Site Multiplier	2.3	
Site Area	2.95	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	6.51	ha
Total Land Cost inc Buffer	650,768	US $

COST ESTIMATE FOR:	20,340	m3/d TW		Rate	Amount	Amount
Oxidation Ditch (Extended aeration)				US $	US $	000 VND
Wall thickness	0.45	m				
Freeboard	0.2	m				
Ave depth of exc'n	3	m				
Add for channels etc	20%					
Excavation	26,463	m3		4	105,850	
Concrete walls	2,570	m3		240	616,881	
Concrete floors	5,716	m3		150	857,397	
Add for E&M Aerators etc	636	kw	1500*kW^0.87		412,130	
Total cost					1,992,257	25,899,341
RAS Pumping Station						
Civil works			UC1491/1		54,449	
M & E works			UC1491/1		83,322	
Total cost					137,771	1,791,019
Sidestream Pumping Station						
Civil works			UC1491/1		22,482	
M & E works			UC1491/1		25,124	
Total cost					47,607	618,886
Stripper Tanks	1	2 nr				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of exc'n	1 m					
Add for channels etc	20%					
Excavation	365	729 m3		4	2,916	
Concrete walls	146	292 m3		240	69,966	
Concrete floors	175	349 3m3		150	52,413	
Concrete hopper	33	66 m3		240	15,879	
Add for E&M scrapers	18.0 m		UC1491/1		82,444	
Total cost of		2 Tanks			223,640	2,907,316
Reactor Clarifier						
Flow rate	4068	m3/d			219,705	
Total cost					219,706	2,856,176
Final Clarifiers	1	2				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of exc'n	1 m					
Add for channels etc	30%					
Excavation	1,173	2,347 m3		4	9,387	
Concrete walls	141	283 m3		240	67,869	
Concrete floors	547	1,094 3m3		150	164,061	
Concrete hopper	111	222 m3		150	33,357	
Add for E&M scrapers	33.0 m		UC1491/1		106,346	
Total cost of		2 Tanks			381,020	4,953,258
Sludge Thickeners	1	2				
Wall thickness	0.25 m					
Freeboard	0.3 m					
Ave depth of exc'n	2 m					
Add for channels etc	20%					
Excavation	447	894 m3		4	3,576	
Concrete walls	81	163 m3		240	39,081	
Concrete floors	81	163 m3		150	24,439	
Concrete hopper	18	37 m3		150	5,542	
Add for E&M stirrers	618	1,237 m3	UC1491/1		69,917	
Total cost of		2 tanks			162,666	2,113,218
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3 m					
Freeboard	0.3 m					
Ave depth of exc'n	2 m					
Add for channels etc	20%					
Excavation	236	236 m3		4	946	
Concrete walls	35	35 m3		240	8,450	
Concrete floors	32	32 m3		150	4,765	
Miscellaneous	10.0%			14,161	1,416	
Add for E&M	50.0%			15,577	7,788	
Sludge belt presses	472	m3/shift		500	235,850	
Sludge press building	200	m2		150	30,000	
Sludge storage building						
Area	879	m2		150	131,862	
Total cost of sludge dewatering and storage					421,077	5,473,998
Buildings and Miscellaneous						
Office, laboratory	300	m2		300	90,000	
Workshop	300	m2		150	45,000	
Works Pumping station	100	m2		1,500	150,000	
Add for furnishing and fittings	20%			285,000	57,000	
Total cost of		bldgs			342,000	4,446,000
Subtotal					3,927,832	51,060,214
Add for elec dist, control, etc	30%				1,178,350	15,317,764
Add for site works	26%				1,021,184	13,275,398
Add for Prelims and Gen'l	35%				1,838,132	23,896,712
Total cost for	20,340	m3/d TWks			7,966,237	103,560,067
Total cost including Inlet Works and Pump Station					8,601,064	111,813,839
	M&E				3,990,007	51,870,092
	Civil				4,611,067	59,943,738

A5.12 Bach Dang WWTP - All Alternatives (Level 1 Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Overseas	60,000	7,200	2,280	2,280
New industry				
Ex-industry		111	5	31
Total	60,000	7,311	2,285	2,311

DESIGN CRITERIA

Sequencing Batch Reactor

Sludge loading rate	0.15	kgBOD/kgMLSS
MLSS concentration	3000	mg/l
Depth of reactor	5	m
Minimum fill/decant depth	3.5	m
Number of tanks	4	
Oxygen/carbonaceous removal requirement	1.20	kgO2/kgBOD
Nitrification oxygen requirement	4.20	kgO2/kgNH3
Oxygen recovered in denitrification	1.60	kgO2/kgNH3
Nitrification/denitrification efficiency	80%	
Oxygen transfer efficiency	2	kgO2/kWh
Peak hydraulic load factor for aerator capacity	1.1	
Removed BOD removal	95%	

Sludge

Sludge production rate for BOD removal	1.2	kg/kgBOD rl
Solids content of settled sludge	1.0%	
Sludge thickener loading	30	m2 dry SS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	5.0%	solids
Assume sludge density	1020	kg/m3
Volatile content of sludge	75%	
Oxygen demand for aerobic digestion	1.42	kgO2/kgVS destroyed
Oxygen transfer efficiency	1	kgO2/kWh
Peak aeration capacity	1.5	times average
Maximum retention in aerobic digester	10	days
Reduction of volatile matter in digester	40%	
Wall thickness of digesters	0	m
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

PROCESS DESIGN

Sequencing Batch Reactor

Total cycle time	6	hrs
Fill period (2/3rd aerated)	1.5	hrs
Aeration period	2	hrs
Clarification period	1	hrs
Effluent decant period	1	hrs
Idle period	0.50	hrs
Total reactor volume based on loading	5,076	m3
Total reactor volume based on inflow	5,483	m3
Total reactor area	1,097	m2
Length/width ratio of tanks	2	
Width of tank	14	m
Length of tank	28	m
Actual total area of reactor tanks	1568	m2
Actual total volume of reactor tanks	7840	m3
Oxygen required for carbonaceous load	2,605	kg/d
Oxygen required for nitrification	0	kg/d
Oxygen recovered from denitrification	0	kg/d
Total Oxygen Requirement	2,605	kg/d
Aeration period per day	12	hrs
Area use power consumption	1,302	kWh/d
Installed power for aeration plant	109	kW
Installed power for peak load	119	kW

Sludge

Sludge Production	2,805	kg DS/d
Sludge volume	280	m3/d
Required thickener area	70	m2
Assume nr of tanks	1	nr
Required diameter	10.0	m
Say diameter	10.0	m
Actual area	79	m2
Sludge retention time	28.9	hr
Surface loading	3.5	m3/m2/d
Thickened sludge volume	54	m3/d
Volatile content of sludge	1,954	kg/d
Required digester volume	508	m3
Required digester area	85	m2
Assume Nr of tanks	1	nr
Required dia of tank	10.4	m
Assume dia	11	m
Actual volume	570	m3
Retention in aerobic digesters	11	days
Volatile solids after digestion	1,172	kg/d
Oxygen demand	1,110	kgO2/d
Power requirement	1,110	kWh/d
Installed power	69	kW
Assume Nr of conditioning tanks	1	
Required total tank area	17	m2
Required dia of tank	4.6	m
Assume dia	5	m
Volume of dewatered sludge	7	m3/d
Area sludge storage building	292	m2

COST ESTIMATE FOR: 7,311 m3/d TW

Sequencing Batch Reactor

				Rate	Amount US $	Amount 000 VND
Reactor Tanks	1	4 nr				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	30%					
Excavation	1,120	4,478	m3	4	17,913	
Concrete walls	268	1,064	m3	240	255,382	
Concrete floors	302	1,209	m3	150	181,373	
Add for E&M Aerators etc		119	kw	1500%W*0.87	98,174	
Add for inlet manifold, etc		15.0%		550,842	82,626	
Add for decanters etc		10.0%		633,468	63,347	
Total cost of		4	Tanks		698,816	9,058,600
Sludge Thickeners	1	1				
Wall thickness	0.35 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	20%					
Excavation	245	245	m3	4	980	
Concrete walls	20	22	m3	240	5,607	
Concrete hoppers	9	9	m3	150	1,414	
Concrete floors	38	38	m3	150	5,865	
Add for E&M stirrers	314	314	m3	UC1491/1	34,441	
Total cost of		1	tanks		48,137	625,786
Aerobic Digesters	1	1				
Wall thickness	0.4 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	20%					
Excavation	1,050	1,050	m3	4	4,199	
Concrete walls	177	177	m3	240	42,496	
Concrete floors	79	79	m3	150	11,811	
Concrete roof	38	38	m3	240	9,449	
Add for insulation, etc	40%			67,954	27,182	
Add for E&M aerators	119	kW		1500%W*0.87	98,174	
Total cost of		1	tanks		187,111	2,432,439
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3 m					
Freeboard	0.3 m					
Ave depth of each	2 m					
Add for channels etc	20%					
Excavation	72	72	m3	4	290	
Concrete walls	39	39	m3	240	9,060	
Concrete floors	9	9	m3	150	1,330	
Miscellaneous		10.0%		10,683	1,068	
Add for E&M		50.0%		11,751	5,876	
Sludge belt presses	122	m3/unit		500	60,990	
Sludge press building	100	m2		150	15,000	
Sludge storage building						
Area	292	m2		150	43,762	
Total cost of sludge dewatering and storage					137,382	1,786,967
Buildings and Miscellaneous						
Office and laboratory		200	m2	300	60,000	
Workshop		200	m2	150	30,000	
Misc. Pumping stations		40	m2	1500	60,000	
Add for furnishing and fittings		20%		150,000	30,000	
Total cost of		bldg			180,000	2,340,000
Sub-total					1,249,446	16,242,792
Add for elec dist, control, etc		15%			187,417	2,436,419
Add for site works		10%			143,686	1,867,921
Add for Prelims and Cont'n		30%			474,785	6,164,139
Total cost for	7,311	m3/d TWks			2,054,713	26,711,271
Total cost including Inlet Works and Pump Station					2,463,086	32,020,288
		M&E			1,202,078	15,627,017
		CIVIL			1,261,010	16,393,252

LAND REQUIREMENT AND COSTS

FLOW	7,311 m3/d
LAND COST	40 US $/m2

Reactor Tanks	1568	m2
Sludge Thick Tanks	79	m2
Sludge Digesters	90	m2
Sludge Conditioning Tanks	20	m2
Sludge Storage Building	292	m2
Other Structures	540	m2
Net Area of Structures	2589	m2
Site Multiplier	2.3	
Site Area	0.60	ha
Buffer Zone	20	m around tank perimeter
Total Area inc. Buffer (ie site length to breadth ratio of 2)	1.41	ha
Total Land Cost inc Buffer	564,665	US $

A5.13 Cam Pha WWTP - All Alternatives (Level 1 Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic	45,000	5,400	1,710	1,710
New Industry		111	5	31
Ex Industry				
Total	45,000	5,511	1,715	1,741

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	24	hrs
MLSS concentration	3000	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	2	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	
Final clarifiers		
Maximum upward velocity at DWF	0.5	m/h
Side wall depth	3	m
floor slope	7.5	deg
Sludge		
Sludge production per kg BOD removal	1	kgTSS/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 drySS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	1,715	kg/d	
Ditch volume required for BOD load.	3,611	m3	
Ditch volume required for retention	5,511	m3	
Assume ditch depth	4.0	m	
Therefore required area	1,378	m2	Area
Assume nr lanes x length x width	2 x 82 x 9		1476
Approx volume, less 6%	5,550	m3	
Volumetric loading rate	0.31	kg BOD/m3	
Oxygen requirement	3,259	kg/d	
Power consumption	1,629	kwh/day	
Assume number of aerators	16		
Individual aerator power	8.5	kW	
Total Installed Power	136	kW	
Pump capacity	459	m3/h	
RAS pump power	6.3	kW/pump	
Final clarifiers			
Required surface area	459	m2	
Assume nr of tanks	1	nr	
Required diameter	24.2	m	
Say diameter	25.0	m	
DWF upward velocity	0.47	m/hr	OK
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.3	hr @ DWF	
Sludge			
Sludge Production	1,629	kg DS/d	
Sludge volume	326	m3/d	
Required thickener area	81	m2	
Assume nr of tanks	1	nr	
Required diameter	10.2	m	
Say diameter	11.0	m	
Actual area	95	m2	
Sludge retention time	28.0	hr	
Surface loading	3.4	m3/m2/d	
Thickened sludge volume	53	m3/d	
Assume Nr of conditioning tanks	3		
Required conditioning tank area	18	m2	
Required dia of tank	4.7	m	
Assume dia	5	m	
Volume of dewatered sludge	7	m3/d	
Area sludge storage building	261	m2	

LAND REQUIREMENT AND COSTS

FLOW	5,511	m3/d
LAND COST	10	US $/m2

Oxidation Ditch	1476	m2
Final Tanks	491	m2
Sludge Thick TANKS	95	m2
Sludge Conditioning Tanks	20	
Sludge Storage Building	261	m2
Other Structures	515	m2
Net Area of Structures	2857	m2
Site Multiplier	2.1	
Site Area	0.60	ha
Buffer Zone	40	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	2.55	ha
Total Land Cost inc Buffer	255,457	US $

COST ESTIMATE FOR: 5,511 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate	Amount US $	Amount 000 VND
Wall thickness	0.45	m				
Freeboard	0.3	m				
Ave depth of exc'n	3	m				
Add for channels etc	20%					
Excavation	4,612	m3		4	19,249	
Concrete walls	616	m3		240	147,874	
Concrete floors	1,039	m3		150	155,920	
Add for E&M Aerators etc	136	kw	1500*kW^0.67		107,556	
Total cost					430,599	5,597,789
RAS Pumping Station						
Civil works			UC1491/1		30,492	
M & E works			UC1491/1		38,311	
Total cost					69,003	897,035
Final Clarifiers	1		1 nr			
Wall thickness	0.4	m				
Freeboard	0.3	m				
Ave depth of exc'n	3	m				
Add for channels etc	30%					
Excavation	680	680	m3	4	2,719	
Concrete walls	95	95	m3	240	22,905	
Concrete floors	285	285	3m3	150	42,697	
Concrete hopper	64	64	m3	150	9,572	
Add for E&M scrapers	25.0	m	UC1491/1		47,321	
Total cost of		1	Tanks		125,213	1,627,764
Sludge Thickeners	1	1				
Wall thickness	0.4	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	299	299	m3	4	1,197	
Concrete walls	74	74	m3	240	17,741	
Concrete floors	52	52	m3	150	7,874	
Concrete hopper	11	11	m3	150	1,711	
Add for E&M scrapers	380	380	m3	UC1491/1	37,142	
Total cost of		1	tanks		65,664	853,635
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	72	72	m3	4	290	
Concrete walls	19	19	m3	240	4,516	
Concrete floors	9	9	m3	150	1,330	
Miscellaneous		10.0%		6,136	614	
Add for E&M		50.0%		6,750	3,375	
Sludge belt presses	127	m3/shift		500	63,500	
Sludge press building	75	m2		150	11,250	
Sludge storage building						
Area	261	m2		150	39,102	
Total cost of sludge dewatering and storage					124,057	1,612,743
Buildings and Miscellaneous						
Office, laboratory		200	m2	300	60,000	
Workshop		200	m2	150	30,000	
Works Pumping station		40	m2	1500	60,000	
Add for furnishing and fittings		20%		150,000	30,000	
Total cost of		bdgs			180,000	2,340,000
Sub-total					994,536	12,926,967
Add for elec dist, control, etc		15%			149,180	1,939,345
Add for site works		15%			171,557	2,230,247
Add for Prelims and Gen'l		30%			394,562	5,129,568
Total cost for	5,511	m3/d TWks			1,709,856	22,226,126
Total cost including Inlet Works and Pump Station					2,071,849	26,934,038
		M&E			924,818	12,022,632
		CIVIL			1,147,031	14,911,406

A5.14 Hoanh Bo Industrial WWTP (Class A Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic		0	0	0
New Industry		27,550	1,382	2,554
Ex Industry		0	0	0
Total	0	27,550	1,382	2,554

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15 kgBOD/kgMLSS
Retention at DWF	12 hrs
MLSS concentration	2500 mg/l
Depth	4 m
Oxygen requirement	2 kgO2/kgBOD
Oxygen transfer	2 kgO2/kwh
Peak factor for aerator capacity	2
BOD removal	95%
RAS flow rate (max)	1.5 DWF
RAS pumping head	6 m
No of RAS duty pumps	2
No of RAS standby pumps	1

Final clarifiers

Maximum upward velocity at DWF	0.5 m/h
Side wall depth	2 m
floor slope	7.5 deg

Sludge

Sludge production per kg BOD removal	1 kgTSS/kgBOD d
Solids content of surplus sludge	0.5%
Sludge thickener loading	50 m2 d/tSS
Sludge thickener wall height	4 m
Assume solids content of thickened sludge	3.0% solids
Assume sludge density	1025 kg/m3
Sludge conditioning tank retention time	1 day
Depth of conditioning tanks	3 m
Operating period for mechanical dewatering	10 hours/day
Solids content of dewatered sludge	25% solids
Storage time for dewatered sludge	60 days
Depth of storage of dewatered sludge	1.5 m

LAND REQUIREMENT AND COSTS

FLOW	27,550 m3/d
LAND COST	10 US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	3672 m2
Final Tanks	2389 m2
Sludge Thick Tanks	79 m2
Sludge Conditioning Tanks	20
Sludge Storage Building	210 m2
Other Structures	400 m2
Net Area of Structures	6829 m2
Site Multiplier	2.3
Site Area	1.57 ha
Buffer Zone	10 m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	2.14 ha
Total Land Cost inc Buffer	214,250 US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	1,382 kg/d		
Ditch volume required for BOD load	5,685 m3		
Ditch volume required for retention	13,775 m3		
Assume ditch depth	4.0 m		
Therefore required area	3,444 m2		area
Assume nr lanes x length x width	6 x 88 x 9		3672
Approx volume, less... 6%	13,807 m3		
Volumetric loading rate	0.10 kg BOD/m3		
Oxygen requirement	2,626 kg/d		
Power consumption	1,313 kwh/day		
Assume number of aerators	6.0		
Individual aerator power	18.2 kW		
Total Installed Power	109 kW		
Pump capacity	1722 m3/h		
RAS pump power	23.5 kW/pump		

Final clarifiers

Required surface area	2296 m2	
Assume nr of tanks	2 nr	
Required diameter	38.2 m	
Sav diameter	39.0 m	
DWF upward velocity	0.48 m/hr	OK
Vertical side wall depth	2 m	
Retention time (ignoring hopper)	4.2 hr @ DWF	

Sludge

Sludge Production	1,313 kg DS/d	
Sludge volume	263 m3/d	
Required thickener area	66 m2	
Assume nr of tanks	1 nr	
Required diameter	9.1 m	
Sav diameter	10.0 m	
Actual area	79 m2	
Sludge retention time	28.7 hr	
Surface loading	3.3 m3/m2/d	
Thickened sludge volume	43 m3/d	
Assume Nr of conditioning tanks	1	
Required conditioning tank area	14 m2	
Required dia of tank	4.3 m	
Assume dia	5 m	
Volume of dewatered sludge	5.3 m3/d	
Area sludge storage building	210 m2	

COST ESTIMATE FOR: 27,550 m3/d TW

Oxidation Ditch (Extended aeration)

			Rate	Amount US $	Amount 000 VND
Wall thickness	0.45 m				
Freeboard	0.3 m				
Ave depth of exc'n	3 m				
Add for channels etc	20%				
Excavation	11,813 m3		4	47,252	
Concrete walls	1,235 m3		240	297,114	
Concrete floors	2,552 m3		150	382,736	
Add for E&M Aerators etc	109 kw	1500*kW^0.67		89,138	
Total cost				816,242	10,611,146

RAS Pumping Station

Civil works	UC1491/1		56,826
M & E works	UC1491/1		84,105
Total cost			138,932

Final Clarifiers	1	2 nr				
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of exc'n	1 m					
Add for channels etc	30%					
Excavation	1,625	3,251 m3		4	13,004	
Concrete walls	167	334 m3		240	80,043	
Concrete floors	754	1,507 3m3		150	226,088	
Concrete hopper	155	311 m3		150	46,589	
Add for E&M scrapers	39.0 m		UC1491/1		114,076	
Total cost of		2 Tanks			479,799	6,237,390

Sludge Thickeners	1	1				
Wall thickness	0.35 m					
Freeboard	0.3 m					
Ave depth of exc'n	2 m					
Add for channels etc	20%					
Excavation	245	245 m3		4	980	
Concrete walls	59	59 m3		240	14,094	
Concrete floors	43	43 m3		150	6,474	
Concrete hopper	9	9 m3		150	1,414	
Add for E&M stirrers	314	314 m3	UC1491/1		34,441	
Total cost of		1 tanks			57,403	746,236

Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3 m					
Freeboard	0.3 m					
Ave depth of exc'n	2 m					
Add for channels etc	20%					
Excavation	72	72 m3		4	290	
Concrete walls	17	17 m3		240	4,082	
Concrete floors	9	9 m3		150	1,330	
Miscellaneous		10.0%		5,702	570	
Add for E&M		50.0%		6,272	3,136	
Sludge belt presses	102 m3/shift			500	51,235	
Sludge press building	100 m2			150	15,000	
Sludge storage building						
Area	210 m2			150	31,510	
Total cost of sludge dewatering and storage					107,152	1,392,980

Buildings and Miscellaneous					
Office, laboratory	150 m2		300	45,000	
Workshop	150 m2		150	22,500	
Works Pumping station	60 m2		1500	90,000	
Add for furnishing and fittings	20%		157,500	31,500	
Total cost of	bldgs			189,000	2,457,000

Sub-total		1,788,528	23,250,862
Add for elec dist, control, etc	15%	268,279	3,487,629
Add for site works	15%	308,521	4,010,774
Add for Prelims and Gen'l	30%	709,598	9,224,780
Total cost for	27,550 m3/d TWks	3,074,927	39,974,045
Total cost including inlet Works and Pump Station		3,559,992	46,279,902
M&E		1,286,164	16,720,136
CIVIL		2,273,828	29,559,767

A5.15 Cai Lan Industrial WWTP (Class A Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic		0	0	0
New Industry		23,850	1,196	2,211

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.16	kgBOD/kgMLSS
Retention at DWF	12	hrs
MLSS concentration	2500	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	1.5	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	
Final clarifiers		
Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg

Sludge		
Sludge production per kg BOD removal	1	kgTSS/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2.d/tSS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

LAND REQUIREMENT AND COSTS

FLOW	23,850	m3/d
LAND COST	10	US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	3166	m2
Final Tanks	2036	m2
Sludge Thick Tanks	64	m2
Sludge Conditioning Tanks	13	
Sludge Storage Building	182	m2
Other Structures	460	m2
Nett Area of Structures	5922	m2
Site Multiplier	2.3	
Site Area	1.36	ha
Buffer Zone	10	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	1.99	ha
Total Land Cost inc Buffer	189,713	US $

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	1,196	kg/d	
Ditch volume required for BOD load	3,189	m3	
Ditch volume required for retention	11,925	m3	
Assume ditch depth	4.0	m	
Therefore required area	2,981	m2	area
Assume nr.lenes x length x width	4 x 88	x 9	3166
Approx volume, less 6%	11,912	m3	
Volumetric loading rate	0.10	kg BOD/m3	
Oxygen requirement	2,272	kg/d	
Power consumption	1,136	kwh/day	
Assume number of aerators	4.0		
Individual aerator power	23.7	kW	
Total Installed Power	95	kW	
Pump capacity	1491	m3/h	
RAS pump power	20.3	kW/pump	
Final clarifiers			
Required surface area	1988	m2	
Assume nr of tanks	2	nr	
Required diameter	35.6	m	
Say diameter	36.0	m	
DWF upward velocity	0.49	m/hr	OK
Vertical side wall depth	2	m	
Retention time (ignoring hopper)	4.1	hr @ DWF	
Sludge			
Sludge Production	1,136	kg DS/d	
Sludge volume	227	m3/d	
Required thickener area	57	m2	
Assume nr of tanks	1	nr	
Required diameter	8.5	m	
Say diameter	9.0	m	
Actual area	64	m2	
Sludge retention time	26.9	hr	
Surface loading	3.6	m3/m2/d	
Thickened sludge volume	37	m3/d	
Assume Nr of conditioning tanks	1		
Required conditioning tank area	12	m2	
Required dia of tank	4.0	m	
Assume dia	4	m	
Volume of dewatered sludge	4.5	m3/d	
Area sludge storage building	182	m2	

COST ESTIMATE FOR: 23,850 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate	Amount US $	Amount 000 VND
Wall thickness	0.45 m					
Freeboard	0.3 m					
Ave depth of excn	3 m					
Add for channels etc	20%					
Excavation	10,201	m3		4	40,805	
Concrete walls	1,110	m3		240	266,519	
Concrete floors	2,203	m3		150	330,521	
Add for E&M Aerators etc	95	kw	1500*kW^0.67		78,605	
Total cost					716,450	9,313,855
RAS Pumping Station						
Civil works			UC1491/1		51,463	
M & E works			UC1491/1		77,189	
Total cost					128,652	1,672,475
Final Clarifiers	1	2 nr				
Wall thickness	0.45 m					
Freeboard	0.5 m					
Ave depth of excn	1 m					
Add for channels etc	30%					
Excavation	1,390	2,780	m3	4	11,122	
Concrete walls	154	308	m3	240	73,956	
Concrete floors	646	1,292	3m3	150	193,834	
Concrete hopper	132	265	m3	150	39,697	
Add for E&M scrapers	36.0	m	UC1491/1		110,305	
Total cost of		2 Tanks			428,913	5,575,874
Sludge Thickeners	1	1				
Wall thickness	0.35 m					
Freeboard	0.3 m					
Ave depth of excn	2 m					
Add for channels etc	20%					
Excavation	204	204	m3	4	816	
Concrete walls	53	53	m3	240	12,732	
Concrete floors	35	35	m3	150	5,321	
Concrete hopper	8	8	m3	150	1,145	
Add for E&M stirrers	254	254	m3	UC1491/1	31,664	
Total cost of		1 tanks			51,697	672,063
Sludge dewatering and storage						
Conditioning tanks	1	1				
Wall thickness	0.3 m					
Freeboard	0.3 m					
Ave depth of excn	2 m					
Add for channels etc	20%					
Excavation	51	51	m3	4	204	
Concrete walls	16	16	m3	240	3,816	
Concrete floors	6	6	m3	150	897	
Miscellaneous		10.0%		4,917	492	
Add for E&M		30.0%		5,409	2,704	
Sludge belt presses	69	m3/shift		500	44,340	
Sludge press building	100	m2		150	15,000	
Sludge storage building						
Area	182	m2		150	27,269	
Total cost of sludge dewatering and storage					94,722	1,231,381
Buildings and Miscellaneous						
Office, laboratory		150	m2	300	45,000	
Workshop		150	m2	150	22,500	
Works Pumping station		60	m2	1500	90,000	
Add for furnishing and fittings		20%		157,500	31,500	
Total cost of		bdgs			189,000	2,457,000
Sub-total					1,609,434	20,922,647
Add for elec dist, control, etc	15%				241,415	3,138,397
Add for site works	15%				277,627	3,609,157
Add for Prelims and Gen'l	30%				638,543	8,301,060
Total cost for	23,850	m3/d TWks			2,767,020	35,971,261
Total cost including Inlet Works and Pump Station					3,220,520	41,866,757
	M&E				1,181,202	15,355,832
	CIVIL				2,039,317	26,511,125

A5.16 Lang Bang Industrial WWTP (Class A Treatment)

Influent Characteristics

	Population	Flow m³/d	BOD kg/d	SS kg/d
Domestic		0	0	0
New Industry		2,560	106	240
Ex Industry		0	0	0
Total	0	2,560	106	240

DESIGN CRITERIA

Oxidation Ditch (Extended aeration)

Sludge loading rate	0.15	kgBOD/kgMLSS
Retention at DWF	12	hrs
MLSS concentration	2500	mg/l
Depth	4	m
Oxygen requirement	2	kgO2/kgBOD
Oxygen transfer	2	kgO2/kwh
Peak factor for aerator capacity	2	
BOD removal	95%	
RAS flow rate (max)	1.5	DWF
RAS pumping head	6	m
No of RAS duty pumps	2	
No of RAS standby pumps	1	
Final clarifiers		
Maximum upward velocity at DWF	0.5	m/h
Side wall depth	2	m
floor slope	7.5	deg
Sludge		
Sludge production per kg BOD removal	1	kg/kgBOD d
Solids content of surplus sludge	0.5%	
Sludge thickener loading	50	m2 d/tSS
Sludge thickener wall height	4	m
Assume solids content of thickened sludge	3.0%	solids
Assume sludge density	1025	kg/m3
Sludge conditioning tank retention time	1	day
Depth of conditioning tanks	3	m
Operating period for mechanical dewatering	10	hours/day
Solids content of dewatered sludge	25%	solids
Storage time for dewatered sludge	60	days
Depth of storage of dewatered sludge	1.5	m

PROCESS DESIGN

Oxidation Ditch (Extended aeration)

BOD loading	106	kg/d	
Ditch volume required for BOD load	288	m3	
Ditch volume required for retention	1,280	m3	
Assume ditch depth	4.0	m	
Therefore required area	320	m2	area
Assume nr lanes x length x width	2 x 30 x 6		360
Approx volume, less 6%	1,354	m3	
Volumetric loading rate	0.08	kg BOD/m3	
Oxygen requirement	205	kg/d	
Power consumption	103	kwh/day	
Assume number of aerators	1.0		
Individual aerator power	8.6	kW	
Total Installed Power	9	kW	
Pump capacity	160	m3/h	
RAS pump power	2.2	kW/pump	
Final clarifiers			
Required surface area	213	m2	
Assume nr of tanks	1	nr	
Required diameter	16.5	m	
Say diameter	17.0	m	
DWF upward velocity	0.47	m/hr	OK
Verbcat side wall depth	2	m	
Retention time (ignoring hopper)	4.3	hr @ DWF	
Sludge			
Sludge Production	103	kg DS/d	
Sludge volume	21	m3/d	
Required thickener area	5	m2	
Assume nr of tanks	1	nr	
Required diameter	2.5	m	
Say diameter	3.0	m	
Actual area	7	m2	
Sludge retention time	33.1	hr	
Surface loading	2.9	m3/m2/d	
Thickened sludge volume	3	m3/d	
Assume hr of conditioning tanks	1		
Required conditioning tank area	1	m2	
Required dia of tank	1.2	m	
Assume dia	2	m	
Volume of dewatered sludge	0.4	m3/d	
Area sludge storage building	16	m2	

LAND REQUIREMENT AND COSTS

FLOW	2,560	m3/d
LAND COST	10	US $/m2

Extended Aeration (Oxidation Ditch)

Oxidation Ditch	360	m2
Final Tanks	227	m2
Sludge Thick Tanks	7	m2
Sludge Conditioning Tanks	3	
Sludge Storage Building	16	m2
Other Structures	140	m2
Net Area of Structures	754	m2
Site Multiplier	2.3	
Site Area	0.17	ha
Buffer Zone	10	m around site perimeter
Total Area inc Buffer (for site length to breadth ratio of 2)	0.39	ha
Total Land Cost inc Buffer	38,996	US $

COST ESTIMATE FOR: 2,560 m3/d TW

Oxidation Ditch (Extended aeration)

				Rate	US $	'000 VND
Wall thickness	0.4	m				
Freeboard	0.3	m				
Ave depth of exc'n	3	m				
Add for channels etc	20%					
Excavation	1,220	m3		4	4,879	
Concrete walls	213	m3		240	51,121	
Concrete floors	234	m3		150	35,127	
Add for E&M Aerators etc	9	kw	1500*kW^0.87		9,703	
Total cost					100,830	1,310,784
RAS Pumping Station						
Civil works				UC1491/1	19,319	
M & E works				UC1491/1	20,458	
Total cost					39,777	517,100
Final Clarifiers	1		1 nr			
Wall thickness	0.35	m				
Freeboard	0.3	m				
Ave depth of exc'n	1	m				
Add for channels etc	30%					
Excavation	320		320 m3	4	1,279	
Concrete walls	57		57 m3	240	13,690	
Concrete floors	120		120 3m3	150	17,951	
Concrete hopper	30		30 m3	150	4,426	
Add for E&M scrapers	17.0	m		UC1491/1	40,244	
Total cost of			1 Tanks		77,591	1,008,685
Sludge Thickeners	1		1			
Wall thickness	0.3	m				
Freeboard	0.5	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	33		33 m3	4	133	
Concrete walls	16		16 m3	240	3,852	
Concrete floors	5		5 m3	150	753	
Concrete hopper	1		1 m3	150	127	
Add for E&M stirrers	28		28 m3	UC1491/1	13,273	
Total cost of			1 tanks		18,117	235,527
Sludge dewatering and storage						
Conditioning tanks	1		1			
Wall thickness	0.2	m				
Freeboard	0.3	m				
Ave depth of exc'n	2	m				
Add for channels etc	20%					
Excavation	15		15 m3	4	59	
Concrete walls	3		3 m3	240	630	
Concrete floors	1		1 m3	150	163	
Miscellaneous		10.0%		1,052	105	
Add for E&M		50.0%		1,157	579	
Sludge belt pressers	8	m3/shift		500	4,004	
Sludge press building	20	m2		150	3,000	
Sludge storage building						
Area	16	m2		150	2,462	
Total cost of sludge dewatering and storage					11,202	145,628
Buildings and Miscellaneous						
Office, laboratory		50	m2	300	15,000	
Workshop		50	m2	150	7,500	
Works Pumping station		20	m2	1500	30,000	
Add for furnishing and fittings		20%		52,500	10,500	
Total cost of		bdge			63,000	819,000
Sub-total					310,517	4,036,724
Add for elec dist, control, etc	15%				46,578	605,509
Add for site works	15%				53,564	696,335
Add for Prelims and Gen'l	30%				123,198	1,601,570
Total cost for	2,560	m3/d TWks			533,857	6,940,138
Total cost including Inlet Works and Pump Station					698,512	9,080,660
M&E					328,210	4,266,734
CIVIL					370,302	4,813,926

A5.17 Summary of Capital Costs

Domestic Treatment

Treatment Plant	Alternative	Flow, m^3/d	BOD, kg/d	Civil Cost, US$	M & E Cost, US$	Land Cost, US$	Total Cost, US$
Don Dien	1.1	3,711	1,145	845,500	730,751	213,616	1,789,866
	1.2	14,535	4,573	2,396,156	1,807,573	411,429	4,615,158
	2.1	3,711	1,145	845,500	730,751	213,616	1,789,866
	2.2	14,535	4,573	2,396,156	1,807,573	411,429	4,615,158
	3.1	3,711	1,145	845,500	730,751	213,616	1,789,866
	3.2	13,731	4,318	2,299,610	1,745,585	399,132	4,444,327
	4.1	3,711	1,145	845,500	730,751	213,616	1,789,866
	4.2	42,085	5,955	4,597,803	2,828,706	656,769	8,083,279
	5.1	55,111	3,723	4,924,445	2,719,150	701,562	8,345,157
	5.2	65,071	6,877	6,518,127	3,577,882	856,508	10,952,517
Dong Dang	1.1	10,849	3,430	2,815,122	2,320,742	439,962	5,575,827
	2.1	10,849	3,430	2,815,122	2,320,742	439,962	5,575,827
	3.1	10,849	3,430	2,815,122	2,320,742	439,962	5,575,827
	4.1	38,399	4,812	6,048,585	4,531,166	781,405	11,361,156
	5.1	10,849	3,430	2,815,122	2,320,742	439,962	5,575,827
Deo Sen	1.1	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	1.2	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	2.1	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	2.2	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	3.1	19,740	6,236	4,403,294	3,990,007	636,785	9,030,086
	3.2	19,740	6,236	4,403,294	3,990,007	636,785	9,030,086
	4.1	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	4.2	22,104	6,985	5,142,080	3,990,007	684,539	9,816,626
	5.1	20,340	6,426	4,611,057	3,990,007	650,769	9,251,833
	5.2	19,740	6,236	4,403,294	3,990,007	636,785	9,030,086
Bach Dang	All	7,311	2,285	1,261,019	1,202,078	564,665	3,027,762
Cam Pha	All	5,511	1,715	1,147,031	924,818	255,457	2,327,306

Industrial Treatment

Treatment Plant	Alternative	Flow, m^3/d	BOD, kg/d	Civil Cost, US$	M & E Cost, US$	Land Cost, US$	Total Cost, US$
Cai Lan	1.1	23,850	1,196	2,039,317	1,181,202	189,713	3,410,233
	1.2	23,850	1,196	2,039,317	1,181,202	189,713	3,410,233
	2.1						
	2.2						
	3.1						
	3.2						
	4.1	23,850	1,196	2,039,317	1,181,202	189,713	3,410,233
	4.2	23,850	1,196	2,039,317	1,181,202	189,713	3,410,233
	5.1						
	5.2						
Hoanh Bo	1.1	27,550	1,382	2,273,828	1,286,164	214,250	3,774,242
	1.2	27,550	1,382	2,273,828	1,286,164	214,250	3,774,242
	2.1	27,550	1,382	2,273,828	1,286,164	214,250	3,774,242
	2.2	27,550	1,382	2,273,828	1,286,164	214,250	3,774,242
	3.1						
	3.2						
	4.1						
	4.2						
	5.1						
	5.2						
Lang Bang	All	2,560	108	370,302	328,210	38,996	737,509

A5.18 Annual Running Costs for Preferred Alternative

DOMESTIC WWTP - ANNUAL RUNNING COSTS (2010)

Treatment Plant	Flow, m^3/year	Civil cost, US $	M & E Cost, US $	O & M costs, US $		Aeration		Pumping		General Power		Sludge Conditioning		Total
				Civil Works @ 0.60% of cost	M & E Works @ 1.75% of cost	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	MgDS/year	Annual cost, US $ @ 25 US $/MgDS	Annual Running Cost US $
Don Dien	5,011,815	2,698,742	1,745,585	16,192	30,548	1,497,267	74,863	273,123	13,656	262,800	13,140	1,497	37,432	185,831
Deo Sen	7,205,100	5,040,079	3,990,007	30,240	69,825	2,702,916	135,146	445,002	22,250	394,200	19,710	3,892	97,305	374,476
Bach Dang	2,668,515	1,825,684	1,202,078	10,954	21,036	880,430	44,022	72,712	3,636	131,400	6,570	666	16,639	102,856
Cam Pha	2,011,515	1,402,488	924,818	8,415	16,184	594,676	29,734	109,619	5,481	131,400	6,570	595	14,867	81,251
									Total Domestic WWTP 2010 Running Costs					744,415

INDUSTRIAL WWTP - ANNUAL RUNNING COSTS (2010)

Treatment Plant	Flow, m^3/year	Civil cost, US $	M & E Cost, US $	O & M costs, US $		Aeration		Pumping		General Power		Sludge Conditioning		Total
				Civil Works @ 0.60% of cost	M & E Works @ 1.75% of cost	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	kWh/year	Annual cost, US $ @ 0.05 US $/kWh	MgDS/year	Annual cost, US $ @ 25 US $/MgDS	Annual Running Cost US $
Lang Bang	934,400	409,298	328,210	2,456	5,744	37,449	1,872	50,921	2,546	131,400	6,570	37	936	20,124

Total Domestic + Industrial WWTP 2010 Running Costs **764,539 US $/year**

Appendix 6 Cost Estimate for Alternatives

A6.1 Cost Estimate for Alternative 1.1

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	1,789,566	1,790,000
Sub total for Don Dien				6,192,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	5,575,827	5,576,000
Sub total for Dong Dang				15,994,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zone				
Collection System including pump stations	km	6.3	285,000	1,796,000
Effluent Treatment Plant	L. S.	1	3,410,233	3,410,000
Sub-total for Cai Lan Ind Zone				5,206,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Effluent Treatment Plant	L. S.	1	3,774,242	3,774,000
Sub-total for Hoanh Bo Ind Zone				5,480,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 1.1				78,600,000
Engineering and supervision costs		10%		7,860,000
Institutional strengthening and pubic awareness		5%		4,323,000
Contingencies		10%		9,078,000
Total Alternative 1.1				99,861,000

A6.2 Cost Estimate for Alternative 1.2

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	4,615,158	4,615,000
Sub total for Don Dien				9,017,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.1	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Transfer pumping station	L. S.	1	479,671	480,000
Pumping main	km	8.0	170,000	1,360,000
Sub total for Dong Dang				12,258,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zone				
Collection System including pump stations	km	6.3	285,000	1,796,000
Effluent Treatment Plant	L. S.	1	3,410,233	3,410,000
Sub-total for Cai Lan Ind Zone				5,206,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Effluent Treatment Plant	L. S.	1	3,774,242	3,774,000
Sub-total for Hoanh Bo Ind Zone				5,480,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 1.2				77,659,000
Engineering and supervision costs		10%		7,769,000
Institutional strengthening and pubic awareness		5%		4,273,000
Contingencies		10%		8,973,000
Total Alternative 1.2				98,704,000

A6.3 Cost Estimate for Alternative 2.1

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	1,789,866	1,790,000
Sub total for Don Dien				6,192,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	5,575,827	5,576,000
Sub total for Dong Dang				15,994,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Sub-total for Cai Lan Ind Zones				4,408,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Effluent Treatment Plant	L. S.	1	3,774,242	3,774,000
Sub-total for Hoanh Bo Ind Zone				5,480,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 2.1				77,802,000
Engineering and supervision costs		10%		7,780,000
Institutional strengthening and pubic awareness		5%		4,279,000
Contingencies		10%		8,986,000
Total Alternative 2.1				98,847,000

A6.4 Cost Estimate for Alternative 2.2

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	4,615,158	4,615,000
Sub total for Don Dien				9,017,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Transfer pumping station	L. S.	1	479,671	480,000
Pumping main	km	8.0	170,000	1,360,000
Sub total for Dong Dang				12,258,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Sub-total for Cai Lan Ind Zones				4,408,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Effluent Treatment Plant	L. S.	1	3,774,242	3,774,000
Sub-total for Hoanh Bo Ind Zone				5,480,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub total for Lang Bang				1,161,000
Sub total for Alternative 2.1				76,891,000
Engineering and supervision costs		10%		7,689,000
Institutional strengthening and pubic awareness		5%		4,229,000
Contingencies		10%		8,881,000
Total Alternative 2.2				97,690,000

A6.5 Cost Estimate for Alternative 3.1

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	1,789,866	1,790,000
Sub total for Don Dien				6,192,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	5,575,827	5,576,000
Sub total for Dong Dang				15,994,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	90,000	104	9,360,000
Local sewerage in existing development	population	74,000	76	5,624,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,030,086	9,030,000
Sub total for Deo Sen				27,920,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan + Hoanh Bo Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Hoanh Bo Collection System including pump stations	km	5.4	316,000	1,706,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Hoanh Bo Main Pump Station	L.S.	1	733,005	733,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Hoanh Bo Pumping Main	km	8.0	240	1,920,000
Sub-total for Cai Lan + Hoanh Bo Ind Zones				8,767,000
Lang Bang				
Collection System	km	2.9	0	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 3.1				74,117,000
Engineering and supervision costs		10%		7,412,000
Institutional strengthening and pubic awareness		5%		4,076,000
Contingencies		10%		8,561,000
Total Alternative 3.1				**94,166,000**

A6.6 Cost Estimate for Alternative 3.2

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	4,444,327	4,444,000
Sub total for Don Dien				8,846,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	45,000	104	4,680,000
Local sewerage in existing development	population	38,500	76	2,926,000
Transfer pumping station	L. S.	1	479,671	480,000
Pumping main	km	8.0	170,000	1,360,000
Sub total for Dong Dang				11,609,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	90,000	104	9,360,000
Local sewerage in existing development	population	74,000	76	5,624,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,030,086	9,030,000
Sub total for Deo Sen				27,920,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan + Hoanh Bo Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Hoanh Bo Collection System including pump stations	km	5.4	316,000	1,706,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Hoanh Bo Main Pump Station	L.S.	1	733,005	733,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Hoanh Bo Pumping Main	km	8.0	240	1,920,000
Sub-total for Cai Lan + Hoanh Bo Ind Zones				8,767,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 3.2				72,386,000
Engineering and supervision costs		10%		7,239,000
Institutional strengthening and pubic awareness		5%		3,981,000
Contingencies		10%		8,361,000
Total Alternative 3.2				**91,967,000**

A6.7 Cost Estimate for Alternative 4.1

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	1,789,866	1,790,000
Sub total for Don Dien				6,192,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	11,361,156	11,361,000
Sub total for Dong Dang				21,779,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zone				
Collection System including pump stations	km	6.3	285,000	1,796,000
Effluent Treatment Plant	L. S.	1	3,410,233	3,410,000
Sub-total for Cai Lan Ind Zone				5,206,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Effluent Treatment Plant1			0	0
Sub-total for Hoanh Bo Ind Zone				1,706,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 4.1				80,611,000
Engineering and supervision costs		10%		8,061,000
Institutional strengthening and public awareness		5%		4,434,000
Contingencies		10%		9,311,000
Total Alternative 4.1				102,417,000

Note: 1. Treatment costs included in domestic wastewater treatment

A6.8 Cost Estimate for Alternative 4.2

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	8,083,279	8,083,000
Sub total for Don Dien				12,485,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Transfer pumping station	L. S.	1	479,671	480,000
Pumping main	km	8.0	170,000	1,360,000
Sub total for Dong Dang				12,258,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	100,000	104	10,400,000
Local sewerage in existing development	population	83,700	76	6,361,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,816,626	9,817,000
Sub total for Deo Sen				30,484,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan Industrial Zone				
Collection System including pump stations	km	6.3	285,000	1,796,000
Effluent Treatment Plant	L. S.	1	3,410,233	3,410,000
Sub-total for Cai Lan Ind Zone				5,206,000
Hoanh Bo Industrial Zone				
Collection System including pump stations	km	5.4	316,000	1,706,000
Hoanh Bo Main Pump Station	L.S.	1	733,005	733,000
Hoanh Bo Pumping Main	km	8.0	240	1,920,000
Effluent Treatment Plant1			0	0
Sub-total for Hoanh Bo Ind Zone				4,359,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 4.2				80,036,000
Engineering and supervision costs		10%		8,004,000
Institutional strengthening and public awareness		5%		4,402,000
Contingencies		10%		9,244,000
Total Alternative 4.2				**101,686,000**

Note: 1. Treatment costs included in domestic wastewater treatment

A6.9 Cost Estimate for Alternative 5.1

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	8,345,157	8,345,000
Sub total for Don Dien				12,747,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	50,000	104	5,200,000
Local sewerage in existing development	population	40,200	76	3,055,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	5,575,827	5,576,000
Sub total for Dong Dang				15,994,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	90,000	104	9,360,000
Local sewerage in existing development	population	79,000	76	6,004,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,251,833	9,252,000
Sub total for Deo Sen				28,522,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan + Hoanh Bo Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Hoanh Bo Collection System including pump stations	km	5.4	316,000	1,706,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Hoanh Bo Main Pump Station	L.S.	1	733,005	733,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Hoanh Bo Pumping Main	km	8.0	240	1,920,000
Effluent Treatment Plant1			0	0
Sub-total for Cai Lan + Hoanh Bo Ind Zones				8,767,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	738,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 5.1				81,274,000
Engineering and supervision costs		10%		8,127,000
Institutional strengthening and public awareness		5%		4,470,000
Contingencies		10%		9,387,000
Total Alternative 5.1				103,258,000

Note: 1. Treatment costs included in domestic wastewater treatment

A6.10 Cost Estimate for Alternative 5.2

Component	Unit	Quantity	Rate, US$	Amount, US$
DOMESTIC				
Don Dien				
Sewerage				
Main collectors including pump stations	km	13.3	128,000	1,702,000
Local sewerage in new development	population	15,000	104	1,560,000
Local sewerage in existing development	population	15,000	76	1,140,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	10,952,517	10,953,000
Sub total for Don Dien				15,355,000
Dong Dang				
Sewerage				
Main collectors including pump stations	km	10.4	208,000	2,163,000
Local sewerage in new development	population	45,000	104	4,680,000
Local sewerage in existing development	population	38,500	76	2,926,000
Transfer pumping station	L. S.	1	479,671	480,000
Pumping main	km	8.0	170,000	1,360,000
Sub total for Dong Dang				11,609,000
Deo Sen				
Sewerage				
Main collectors including pump stations	km	12.4	315,000	3,906,000
Local sewerage in new development	population	90,000	104	9,360,000
Local sewerage in existing development	population	74,000	76	5,624,000
Wastewater Treatment				
Oxidation Ditch + Phosphorus Removal	L. S.	1	9,030,056	9,030,000
Sub total for Deo Sen				27,920,000
Bach Dang				
Sewerage				
Main collectors including pump stations	km	8.7	160,000	1,392,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	20,000	104	2,080,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Sequencing Batch Reactor	L. S.	1	3,027,762	3,028,000
Sub total for Bach Dang				8,420,000
Cam Pha				
Sewerage				
Main collectors including pump stations	km	5.6	160,000	896,000
Interceptor sewers and structures	population	20,000	20	400,000
Local sewerage in new development	population	5,000	104	520,000
Local sewerage in existing development	population	20,000	76	1,520,000
Wastewater Treatment				
Oxidation Ditch	L. S.	1	2,327,306	2,327,000
Sub total for Cam Pha				5,663,000
INDUSTRIAL				
Cai Lan + Hoanh Bo Industrial Zones				
Cai Lan Collection System including pump stations	km	6.3	285,000	1,796,000
Hoanh Bo Collection System including pump stations	km	5.4	316,000	1,706,000
Cai Lan Main Pump Station	L.S.	1	595,678	596,000
Hoanh Bo Main Pump Station	L.S.	1	733,005	733,000
Cai Lan Pumping Main	km	8.4	240	2,016,000
Hoanh Bo Pumping Main	km	8.0	240	1,920,000
Effluent Treatment Plant1			0	0
Sub-total for Cai Lan + Hoanh Bo Ind Zones				8,767,000
Lang Bang				
Collection System	km	2.9	146,000	423,000
Effluent Treatment Plant	L. S.	1	737,509	735,000
Sub-total for Lang Bang				1,161,000
Sub total for Alternative 5.2				78,895,000
Engineering and supervision costs		10%		7,890,000
Institutional strengthening and pubic awareness		5%		4,339,000
Contingencies		10%		9,112,000
Total Alternative 5.2				100,236,000

Note 1. Treatment costs included in domestic wastewater treatment

Appendix 7 Example of Questionnaire for Landscape Value Monitoring

I Questionnaire for tourists

Q 1 : Where is your favorite scene among the landscape of Ha Long Bay?
Please identify three places.

Ans. : _____
_____
_____

Q 2 : Where do you like to visit to enjoy the landscape of Ha Long Bay?
Please identify three places.

Ans. : _____
_____
_____

Q 3 : Which feature of the landscape in Ha Long Bay do you like?
Please put a tick on the items that you agree. Any ticks will do.

Ans. : ☐ Diversity of landscape composed of various islands
☐ Natural impression without artificial scenes
☐ Aesthetic beauty of islands and sea
☐ Prominence that cannot be seen in other places
☐ Peculiarity of strange rocks and grottos
☐ Magnificent and spreading view
☐ Others
Please specify : _____

Q 4 : What is your favorite point of the landscape in Ha Long Bay?
Please put a tick on the items that you agree. Any ticks will do.

Ans. ☐ Shape of islands
☐ Combination of islands
☐ Surface of islands
☐ Sheer cliffs
☐ Strange rocks
☐ Grottos
☐ Water color
☐ Water clearness
☐ Trees on the islands
☐ Birds
☐ Mangrove swamps
☐ Coral reefs
☐ Sky and clouds
☐ Scene of fishing operation

☐ Scene of fishing boats
☐ Scene of sailing boats
☐ Scene of anchored boats
☐ Others
Please specify :_____

Q 5 : Do you have any dissatisfaction about the landscape of Ha Long Bay?

Ans. : ☐ Yes ☐ No

↓

Q 5-1 : If yes, what is the point that you feel dissatisfied?
Please put a tick on the items that you agree.

Ans. : ☐ The surface of islands is dirty because of landslide.
☐ The water color is dirty.
☐ The water clearness is low.
☐ The floating garbage is abundant.
☐ The oil slick is abundant.
☐ The trees on the islands is poor.
☐ Birds are few.
☐ Mangrove swamps is small.
☐ Coral reefs is poor.
☐ The sand beach is dirty.
☐ The scene of fishing village is messy.
☐ The cruising ships are visual pollution.
☐ The anchored boats are visual pollution.
☐ The landscape of mainland is messy.
☐ Others
Please specify :_____

II Questionnaire for tourism agents

Q 1 : Where are the popular tourism spots in Ha Long Bay?
Please specify five places.

Ans. : _____
_____
_____
_____
_____

Q 2 : Which route do you usually use when you guide tourists by boat?
Please draw it on the attached map.

Ans. : (Please draw it on the following map.)

Q 3 : Which feature of the landscape in Ha Long Bay do you like?
Please put a tick on the items that you agree. Any ticks will do.

Ans. : ☐ Diversity of landscape composed of various islands
☐ Natural impression without artificial scenes
☐ Aesthetic beauty of islands and sea
☐ Prominence that cannot be seen in other places
☐ Peculiarity of strange rocks and grottos
☐ Magnificent and spreading view
☐ Others
Please specify :_____

Q 4 : What is your favorite point of the landscape in Ha Long Bay?
Please put a tick on the items that you agree. Any ticks will do.

Ans. ☐ Shape of islands
☐ Combination of islands
☐ Surface of islands
☐ Sheer cliffs
☐ Strange rocks
☐ Grottos
☐ Water color
☐ Water clearness
☐ Trees on the islands
☐ Birds
☐ Mangrove swamps
☐ Coral reefs
☐ Sky and clouds
☐ Scene of fishing operation
☐ Scene of fishing boats
☐ Scene of sailing boats

☐ Scene of anchored boats
☐ Others
Please specify :_____

Q 5 : Do you have any dissatisfaction about the landscape of Ha Long Bay?
Please put a tick on the item that you agree.

Ans. : ☐ Yes ☐ No
↓
Q 5-1 : If yes, what is the point that you feel dissatisfied?
Please put a tick on the items that you agree.

Ans. : ☐ The surface of islands has changed because of landslide.
☐ The water color has become dirty.
☐ The water clearness has degraded.
☐ The floating garbage has increased.
☐ The oil slick has increased.
☐ The trees on the islands have reduced.
☐ The number of birds has reduced.
☐ The area of mangrove swamps has reduced.
☐ The area of coral reefs has reduced.
☐ The sand beach has become dirty.
☐ The scene of fisherman village has become messy.
☐ The cruising ship has become an eyesore.
☐ The anchored boat has become an eyesore.
☐ The landscape of mainland has become messy.
☐ Others
Please specify :_____

III Questionnaire for resident

Q 1 : Is there any good landscape that you willingly watch near your residence?
Please specify the name and the location of those places. (At most five places)

Ans. :

	- Name of the place -	- Location of the place -
(A)	_____	_____
(B)	_____	_____
(C)	_____	_____
(D)	_____	_____
(E)	_____	_____

Q 2 : What is your favorite point about above-mentioned place?
Please put a tick on the items that you agree. Any ticks will do.

Ans.

(Your favorite point)	(A)	(B)	(C)	(D)	(E)
- Mountain	☐	☐	☐	☐	☐
- Trees and woods	☐	☐	☐	☐	☐
- Grassy plain	☐	☐	☐	☐	☐
- Flower	☐	☐	☐	☐	☐
- Lake and pond	☐	☐	☐	☐	☐
- Sea	☐	☐	☐	☐	☐
- Beach	☐	☐	☐	☐	☐
- Sheer cliff	☐	☐	☐	☐	☐
- Rocky shore	☐	☐	☐	☐	☐
- Coral reef	☐	☐	☐	☐	☐
- Strange rock	☐	☐	☐	☐	☐
- Birds and animals	☐	☐	☐	☐	☐
- Farm	☐	☐	☐	☐	☐
- Orchard	☐	☐	☐	☐	☐
- Mangrove swamp	☐	☐	☐	☐	☐
- Row of trees	☐	☐	☐	☐	☐
- Row of houses and streets	☐	☐	☐	☐	☐
- Buildings such as dam	☐	☐	☐	☐	☐
- Night scene	☐	☐	☐	☐	☐
- Sky and clouds	☐	☐	☐	☐	☐
- Spacious view	☐	☐	☐	☐	☐
- Composition of view	☐	☐	☐	☐	☐
- Other point					

Please specify below.

(A) _____
(B) _____
(C) _____
(D) _____
(E) _____

Q 3 : Is there any places of which landscape has been degraded near your residence?
Please specify the name and the location of those places. (At most five places)

Ans. :

	- Name of the place -	- Location of the place -
(a)	_____	_____
(b)	_____	_____
(c)	_____	_____
(d)	_____	_____
(e)	_____	_____

Q 4 : What is the main reason that has degraded landscape?
Please put a tick on the items that you agree. Any ticks will do.

Ans. :

(Main reason)	(a)	(b)	(c)	(d)	(e)
- Digging mountain	☐	☐	☐	☐	☐
- Deforestation	☐	☐	☐	☐	☐
- Decrease of green	☐	☐	☐	☐	☐
- Deterioration of water quality	☐	☐	☐	☐	☐
- Decrease of birds and animals	☐	☐	☐	☐	☐
- Decrease of paddy and dry field	☐	☐	☐	☐	☐
- Construction of large building	☐	☐	☐	☐	☐
- Construction of houses and factories	☐	☐	☐	☐	☐
- Construction of road	☐	☐	☐	☐	☐
- Construction of power-transmission and steel tower	☐	☐	☐	☐	☐
- Reclamation and shoreline protection works	☐	☐	☐	☐	☐
- Clash of colors and shape of building	☐	☐	☐	☐	☐
- Messy scene under construction	☐	☐	☐	☐	☐
- Increase of wasteland and weeds	☐	☐	☐	☐	☐
- Old and outmoded building	☐	☐	☐	☐	☐
- Increase of wastes	☐	☐	☐	☐	☐
- Increase of population and so crowded	☐	☐	☐	☐	☐
- Increase of cars and motorbikes	☐	☐	☐	☐	☐
- Showy sign board	☐	☐	☐	☐	☐
- Disturbance against splendid view	☐	☐	☐	☐	☐
- Confusion caused by various factors	☐	☐	☐	☐	☐
- Deterioration of sky view caused by air pollution	☐	☐	☐	☐	☐

- Others

  Please specify below.

  (a) _____

  (b) _____

  (c) _____

  (d) _____

  (e) _____

Appendix 8 Results of Questionnaire Survey on Willingness to Pay

The detail results of the questionnaire survey, including the tourists' and local residents' WTPs for conservation of the Ha Long bay area's environment, with simple statistical analysis are summarized as below by category of interviewees in order of the question item numbers.

(1) Foreign tourists (145 samples) and Vietnamese tourists (145 samples) to Ha Long city

Q1. Name of the hotel/guest-house you are staying now ?

Sample foreign tourists were staying at 14 different guest houses or hotels in Ha Long city. Around 50 % out of the samples were staying in the Hotel I, II & III (Quang Ninh Tourist Company) at the Bai Chay side as in the below table. Hotels used by local tourists are more various. Sample Vietnamese tourists were staying at 23 different guest houses or hotels including VINACOAL guest house. More popular are the 3 hotels in the table accounting for more than 50 % of the samples.

Popular Tourist Hotels in Ha Long City

Foreign Tourists			Vietnamese Tourists		
Top 3 Popular Hotels	No. of Samples	%	Top 3 Popular Hotels	No. of Samples	%
1. Hotel I, II & III	73	50	1. Ha Long Hotel	29	20
2. Cong Doan Hotel	32	22	2. Son Long Hotel	26	18
3. Vuon Dao Hotel	12	8	3. Hong Ngoc Hotel	20	14
Total	117	80	Total	75	52

Q2. Total number of days you stayed already and will stay in Ha Long city this time ?

79 % (115 samples) of the interviewed foreign tourists and 76 % (110 samples) of the interviewed Vietnamese tourists planned to stay in Ha Long city only for 1 ~ 2 days. Tourists answering more than 4 days are 3 foreign and 10 Vietnamese samples only.

Stay Duration of Tourists in Ha Long City

Tourists	Foreign		Vietnamese	
Duration	No. of Samples	%	No. of Samples	%
1 ~ 2 days	115	79	110	76
3 ~ 4 days	27	18	25	17
5 ~ 6 days	1	1	6	4
More than 7 days	2	1	4	3
Total	145	100	145	100

Q3. Your permanent residence ?

The sample foreign tourists were coming from 21 countries including Japan. Over one third (36 %) of foreign tourists were Europeans. The most major country as the tourists' permanent residence is China followed by France and Taiwan as below :

Residence Countries	No. of Samples	%
China	36	25
France	32	22
Taiwan	22	15
Europe	20	14
Others	35	24
Total 21 countries	145	100

The sample Vietnamese tourists were coming from all over the country. Nearly two thirds (63 %) of Vietnamese tourists were from the north part of Vietnam, assumingly because of short distance for travel.

Residence in Vietnam	No. of Samples	%
North Part (including Hanoi)	92	63
Middle Part	25	17
South Part (including Ho Chi Minh)	28	19
Total	145	100

Q4. Transportation means where you entered the Ha Long city ?

All the sample foreign tourists used either hired cars (chartered bus or taxi, 89 %) or private cars (11 %) to visit Ha Long city. There were no cases of other transportation such as ship and local bus at all. As for the Vietnamese tourists, 88 % of the samples used either hired cars (chartered bus or taxi, 69 %) or private cars (19 %) to visit Ha Long city. The rest all entered into the city by local bus or private motorcycle.

Q5. Your main purpose to visit Ha Long city ?

A major part (81 %) of the foreign samples visited Ha Long city on vacation, although the rest (19 %) were on business or only stop-by for other destination. On the other hand, 71 % of the Vietnamese samples visited Ha Long city on business, while Vietnamese tourists purely on vacation account for only 21 %. It is mostly that the survey period is during tourism off-season for Vietnamese.

Q6. Number of your tour group members ?

Foreign tourists can be largely divided into a small group up to 10 members (52 %) and a large group more than 10 members (48 %), as shown below :

Number of Tour Members	No. of Samples	%
Alone	4	3
2 ~ 5 persons	38	26
6 ~ 10 persons	34	23
More than 10 persons	69	48
Total	145	100

Most of the Vietnamese tourists (about 80 %) visited Ha Long city in a small group like 2 ~ 5 members. This smallness of group size can be supposed to be related with their major purpose of business to visit the city clarified in Q5.

Q7. Places where you visited on vacation in the last 10 days before coming to Ha Long city ?

Most of the interviewed foreign tourists had visited other places on vacation before coming to Ha Long city, which means that Ha Long bay area is only one of their destinations for the present vacation trip. Other foreign countries such as Malaysia, Singapore and Thailand had been sometimes passed by in addition to Hanoi (77 samples), Ho Chi Minh (34 samples), Hue (30 samples) and other Vietnamese tourism spots.

Over 70 % of the all Vietnamese samples had visited other places on vacation, although Ha Long bay area was a single destination for 66 % (61 samples) of the tourists coming from the north part. The places depend on their residences, but more popular places for vacation are found to be Hanoi (51 samples), Hai Phong (14 samples) and Hoa Lu in Ninh Binh province.

Q8. Places where you will visit on vacation in 10 days after leaving Ha Long city ?

To this question, most foreign samples also answered to visit Hanoi (43 samples), Ho Chi Minh (38 samples) and so on for recreational purpose. It confirms that foreign tourists have multiple destinations, not only Ha Long bay area.

As for the Vietnamese samples, it is again confirmed that a major part (70 out of 92 samples) of the north-part tourists came only to Ha Long bay area on vacation although 11 samples still planned to move to Mong Cai after Ha Long city. On the other hand, overall statistics shows that about 52 % (75 samples) of the total Vietnamese samples were scheduled to go to other places following Ha Long city, including Mong Cai (38 samples) and Hanoi (19 samples).

Q9. Number of your household members including you ?

99 % of the foreign tourists samples have family members less than 7. Average number of family members per household (HH) of the foreign tourists is calculated as 3.5 persons/HH. 94 % of the Vietnamese tourists samples have family members less than 7. Average number of family members per household (HH) of the Vietnamese tourists is calculated as 4.6 persons/HH, as below.

Number of Tourists' Household Members

Tourists	Foreign		Vietnamese	
No. of HH Members	No. of Samples	%	No. of Samples	%
1 ~ 3 persons/HH	75	52	16	11
4 ~ 6 persons/HH	68	47	120	83
7 ~ 10 persons/HH	0	0	8	6
More than 10 persons/HH	2	1	1	0
Total	145	100	145	100
Average HH Members	3.5 persons / HH		4.6 persons / HH	

Q10. Amount of your household's monthly total income (before tax payment) on average during the last 12 months ?

Approximately a half of the foreign tourists obtain income less than US$ 2,000/HH/month, while another half's income is US$ 2,000 or more/HH/month. Average monthly income of the foreign tourists is US$ 2,451/HH/month and US$ 700/person/month by dividing with the average number of family members of 3.5 persons/HH (Q.9), which is equivalent to over 20 times of average monthly wage rate in Quang Ninh province (VND 400,000/person/month). Average monthly income of the Vietnamese tourists is VND 3,434,000 (US$ 260) /HH/month and VND 747,000 (US$ 57) /person/month by dividing with the average number of family members of 4.6 persons/HH (Q.9), which is nearly twice as much as the average monthly wage.

Average Monthly Income of Tourist Household

Tourist	Monthly Income / HH		Monthly Income / person		Ratio of Per-head Income to QN Wage
	US$/HH	VND/HH	US$/person	VND/person	
Foreign	2,451	32,353,200	700	9,240,000	23.1 times
Vietnamese	260	3,434,000	57	747,000	1.9 times

Note : Exchange rate = VND 13,200 / US$

In accompany with future economic activities and urban development, environment of the Ha Long city and the Ha Long bay will be degraded, conserved or improved with proper environmental protection measures. Please envisage the following three future images in your mind, and continue to answer the questions below :

Image A : Very polluted

Ha Long city will be very much polluted by water contamination, air pollution, unmanaged solid waste, etc. so that Ha Long bay's water quality and environment becomes as bad as being improper for bathing, cruising and commercial fishery at all.

Image B : No change - conserved as now

Essential anti-pollution measures will be carried out to let present environmental conditions remain at the same level as now, so that you can enjoy the similar services from the Ha Long bay tour like now.

Image C : Slightly cleaner water

Full-scale anti-pollution and conservation measures will be implemented, and environmental quality of the Ha Long bay could be a little bit more improved than now providing clear water for bathing and cruising.

Q11. In order to prevent severely degraded environmental situation of Ha Long bay (Image A described in the above), how many percentages to your household's monthly income will you donate every year ?

Q12. In order to conserve the present environmental situation of Ha Long bay (Image B described in the above), how many percentages to your household's monthly income will you donate every year ?

Q13. In order to realize slightly better environmental situation of Ha Long bay (Image C described in the above), how many percentages to your household's monthly income will you donate every year ?

As tabulated below, more than two thirds of the sample foreign tourists have some willingness-to-pay (WTP) for any conservation levels (Images A ~ C) of Ha Long bay area's environment in the future. More than three quarters of the sample Vietnamese tourists also have some WTP for conservation levels (Images B and C), although the samples less than 50 % like to donate for Image-A level. It means that these tourists expressing WTP clearly feel some value on aesthetic and recreational amenity of the area.

Willingness-To-Pay (WTP) Ratio to Tourists' Income

Percentage to Monthly Income per Tourist Household	Number of Tourist Samples											
	Q11 (Image A)				Q12 (Image B)				Q13 (Image C)			
	FN	%	VN	%	FN	%	VN	%	FN	%	VN	%
0.0 % (no interest)	51	35	76	52	37	26	36	25	31	21	23	16
Less than 0.1 %	27	19	34	23	29	20	38	26	22	15	40	28
0.1 ~ 0.5 %	32	22	25	17	43	30	44	30	38	26	40	28
0.6 ~ 1.0 %	15	10	8	6	12	8	13	9	19	13	17	12
More than 1.0 %	20	14	2	1	24	17	14	10	35	24	25	17
Total	145	100	145	100	145	100	145	100	145	100	145	100

Note : FN = Foreign tourists, and VN = Vietnamese tourists

Image B is most approximate to goals of the proposed EMP (Scenario II), so that the tourists' WTP for environmental conservation of the Ha Long bay area was calculated based on the answers to Q.12 in order to estimate benefit from conserved aesthetic and recreational amenity, as follows :

1) Average WTP of tourists for whole value (US$/HH/year)
   = [Total of (Q10 x Q12)] / 145 samples
2) Average WTP of tourists for whole value (US$/person/year) = 1) / Q9
3) Average WTP of tourists for non-use value (US$/HH/year)
   = Average of (Q10 x Q12) for samples choosing Item 2 or 3 in Q14
4) Average WTP of tourists for non-use value (US$/person/year) = 3) / Q9
5) Average WTP of tourists for use value (US$/HH/year)
   = Average of (Q10 x Q12) for samples choosing Item 1 in Q14
6) Average WTP of tourists for use vale (US$/person/year) = 5) / Q9

WTP as a whole of the interviewed foreign tourists is about 10 times as much as the Vietnamese tourists because of their higher income level. The foreign samples express use value of twice as much as the non-use value on the environmental conservation of the bay, while the Vietnamese WTP for non-use and use is almost the same level.

Average WTP of Tourists for Conservation of Ha Long Bay (Scenario II)

Tourist	Whole WTP (US$/year)		Non-use WTP (US$/year)		Use WTP (US$/year)	
	1) per HH	2) per head	3) per HH	4) per head	5) per HH	6) per head
7) Foreign	10.9	3.1	6.2	1.8	12.5	3.6
8) National	1.4	0.3	1.2	0.3	1.0	0.2
7) / 8)	8 times	10 times	5 times	6 times	13 times	18 times

Note : The Whole WTP is weighted average of the Non-use WTP and the Use WTP, not total WTP.

Q14. On your future vacation opportunities, you will ?

Possibility for Tourists to Visit the Bay Again

Possibility Item	Number of Samples			
	Foreign	%	Vietnamese	%
1. most likely visit again Ha Long city.	107	74	95	66
2. least likely visit again Ha Long city.	12	8	1	0
3. visit other places rather than Ha Long city.	26	18	49	34
Total	145	100	145	100

Nearly three quarters of the foreign tourists and two thirds of the Vietnamese tourists are possible repeaters to Ha long bay. The tourists from the middle and south parts of Vietnam expressed more possibilities of repetition rather than those from the north part, in terms of sample ratio.

And here it is assumed that tourists both showing any WTP in Q11 ~ 13 and choosing Item 2 or 3 in Q14 put some non-use value on Ha Long bay's environment, while tourists both showing any WTP in Q11 ~ 13 and choosing Item 1 in Q14 feel use value. Combining data of Q12 and Q14 under this assumption, WTP-holders ratios can be calculated for non-use and use values as shown in the next. Both the foreign and Vietnamese tourists who put use value on the bay are more than those putting non-use value. From this table, it is also recognized that three quarters of the whole interviewed tourists feel some benefit from environmental conservation of the bay area.

Ratio of WTP Holders in Tourists for Environmental Conservation

Tourist	Foreign	Vietnamese
1. Ratio expressing WTP for Non-use Value (%)	14	21
2. Ratio expressing WTP for Use Value (%)	61	53
1+2. Total Ratio expressing WTP either for Non-use or Use Value (%)	75	74

Q15. Your general impression on Ha Long bay ?

Points for each aspect in the questionnaire are regarded as "bad impression" for 1 ~ 3, "acceptable level" for 4 ~ 7 and "good impression" for 8 ~10. The table below shows ratios of these impressions of foreign tourists by aspect of the bay area.

Aspects more related to the proposed EMP activities are No.1, 2 and 9 ~ 12. At least 80 % of the foreign tourists and 89 % of the Vietnamese tourists have acceptable or good impression on these 6 key aspects of Ha Long bay area. Therefore, the EMP conservation

scenario (II) rather than improvement scenario (III) of the present environment is quite appropriate from the major viewpoints of foreign tourists.

It is also noted that about 40 % of Vietnamese samples complain on high price level in Ha Long bay area.

General Impression of Tourists on Ha Long Bay Area

No.	Aspects of Ha Long Bay	% of "Bad"		% of "Acceptable"		% of "Good"		Total
		FN	VN	FN	VN	FN	VN	200/2
1	Beach	20	11	45	68	35	21	100
2	Water in the bay	15	4	43	59	46	37	100
3	Services in restaurants	6	2	42	86	52	12	100
4	Food in restaurants	3	3	43	54	53	43	100
5	Price level	6	39	65	61	38	1	100
6	People's hospitality	3	3	40	80	57	17	100
7	Transportation to Ha Long	36	26	56	72	17	2	100
8	Boat service in the bay	6	7	56	83	39	10	100
9	Cleanliness of the city	14	3	68	94	17	2	100
10	Noise and air	20	10	59	86	21	5	100
11	Scenery in the city	7	6	54	65	39	29	100
12	Scenery in the bay	1	1	11	6	88	93	100

Note : FN = Foreign tourists, and VN = Vietnamese tourists

Q16. What is your favorite point of the landscape in Ha Long Bay ?

Among various points presented in the questionnaire, the following 4 points were felt highly favorite by over 40 % of both the foreign and Vietnamese tourists. These 4 points should be especially considered in the proposed conservation plan for landscape management. And it is interesting that a sample tourist coming from U.S.A. expressed favor to coal mine, although this case might be quite exceptional.

Favorite Points of Ha Long Landscape to Tourists

Favorite Points	Foreign Tourists		Vietnamese Tourists	
	No. of Samples	% (/ 145)	No. of Samples	% (/ 145)
Shape of islands	104	72	125	86
Grottos (caves)	90	62	124	86
Combination of islands	60	41	107	74
Scene of fishing boats	60	41	105	72

Q17. Do you have any dissatisfaction about the landscape of Ha Long bay ?

65 % (94 samples) of the foreign tourists as well as 80 % (116 samples) expressed dissatisfaction about the landscape of Ha Long bay. These rates are very contradictory compared with Q15's ratios of "bad impression" on beaches (No.1), water in the bay (No.2), cleanliness of the city (No.9), scenery in the city (No.11) and scenery in the bay

(No.12), all of which are 20 % and 11 % at most for foreign and Vietnamese samples respectively. So it could be assumed that some part of "acceptable impression" ratios of Q15 were reflected on these figures of 65 and 80 %.

Q18. If yes to Q17, what is the point that you feel dissatisfied ?

Among various dissatisfactory points, the followings were pointed out by over 40 % of both the dissatisfied 94 foreign and 116 Vietnamese tourists in Q17. These 4 major points have to be duly considered in environmental conservation or improvement planning under the proposed EMP.

Dissatisfactory Points of Ha Long Landscape to Tourists

Dissatisfactory Points	Foreign Tourists		Vietnamese Tourists	
	No. of Samples	% (/ 94)	No. of Samples	% (/ 116)
Floating garbage has increased.	53	57	102	88
Sand beach has become dirty.	40	43	82	71
Water clearness has degraded.	60	64	70	60
Oil slick has increased.	40	43	48	41

(2) Local residents in Quang Ninh province (215 samples)

Q1. Your address ?

Numbers of interviewed samples are allocated into 13 city, towns or districts all over the province, as described in Section 10.2.2.

Q2. Number of your household members including you ?

90 % of the local samples have family members between 3 and 6. Number of family members is averaged to 4.2 persons/household (HH).

Q3. Main occupations your household members live on ?

Top 4 major occupations of the samples' households are as follows :

Occupation	No. of Samples	% (/215)
Public civil servant	81	38
Agriculture/Forestry	73	34
Private services	56	26
Coal-mining/processing industry	41	19

Q4. Amount of your household's monthly total income (before tax payment) on average during the last 12 months ?

91 % of the local samples get income less than VND 2000,000/HH/month. Average income of the samples is approximately VND 1,049,000 (US$ 79) /HH/month or VND 250,000 (US$ 19) /person/month by dividing with the average number of family members of 4.2 persons/HH (Q2).

Q5. You or your household members have visited the Ha Long city or Ha Long bay for recreational purpose, not for working ?

Frequency	No. of Samples	%
1. Never	20	9
2. Less than one time a year	120	56
3. 2 ~ 5 times a year	71	33
4~6. More than 5 times a year	4	2
Total	215	100

65 % (Item 1 + Item 2) of the sample local residents have not been to Ha long bay for recreational purpose on an annual basis. And here it is assumed that local residents both showing any WTP in Q8 ~ 10 and choosing Items 3 ~ 6 in Q5 feel use value while local residents both showing any WTP in Q8 ~ 10 and choosing Item 1 or 2 in Q5 put some non-use value on Ha Long bay's environment. Combining data of Q9 and Q5 under this assumption, 30 % and 53 % of local residents are calculated to express use value and non-use value respectively.

Q6. How do you usually come to the coast of the Ha Long city ?
170 sample residents (79 %) come to the city by local line-bus, hired car or private motorbike, while 19 samples use boats or ships.

Q7. Average stay-duration when you visit the Ha Long city or Ha Long Bay on vacation ?
106 samples answered that they stayed at least one over-night, while 85 samples stay less than 10 hours/visit.

Q8. In order to prevent severely degraded environmental situation of Ha Long bay (Image A), how many percentages to your household's monthly income will you donate every year ?

Q9. In order to conserve the present environmental situation of Ha Long bay (Image B), how many percentages to your household's monthly income will you donate every year ?

Q10. In order to realize slightly better environmental situation of Ha Long bay (Image C), how many percentages to your household's monthly income will you donate every year ?
As tabulated below, more than 60 % of the sample local residents have some WTP for any conservation levels (Images A ~ C) of Ha Long bay area's environment in the future. These local residents expressing WTP clearly feel some value on aesthetic and recreational amenity of the area.

Percentage of Monthly Income/HH	Number of Samples					
	Q8 (Image A)	%	Q9 (Image B)	%	Q10 (Image C)	%
0.0 % (no interest)	39	18	35	16	23	11
Less than 0.1 %	42	20	45	21	42	20
0.1 ~ 0.5 %	88	41	89	41	96	45
0.6 ~ 1.0 %	43	20	42	20	42	20
More than 1.0 %	3	1	4	2	12	6
Total	215	100	215	100	215	100

Image B is most approximate to goals of the proposed EMP (Scenario II), so that local residents' WTP for environmental conservation of the Ha Long bay area was calculated based on the answers to Q9 in order to estimate benefit from conserved aesthetic and recreational amenity, as follows :

1) Average WTP of local residents = [Total of (Q4 x Q9 / Q2)] / 215 samples
= US$ 0.1 /resident/year

2) Average WTP of local residents as non-use value
= Average of (Q4 x Q9) for samples choosing Item 1 or 2 in Q5
= US$ 0.3 /HH/year

3) Average WTP of local residents for use value
= Average of (Q4 x Q9) for samples choosing Items 3 ~ 6 in Q5
= US$ 1.1 /HH/year

Q11. Is there any good landscape that you willingly watch near your residence ?
Major places having better landscape are ranked as below :

Places (city/town/district)	No. of Samples
1. Yen Tu (Uong Bi district)	63
2. Tra Co (Mong Cai district)	50
3. Quan Lan island (Van Don district)	30
4. Qua Ong pagoda (Cam Pha town)	20
5. Long Tien pagoda & Bai Tho limestone (Ha Long city)	19
6. Vang island (Van Dong district)	16
7. Quynh pagoda & An Sinh temple (Dong Trieu district)	7

Q12. What is your favorite point about above-mentioned places ?

Major favorite points are classified into mountain, trees & woods, beach, spacious view, composition of view, historical heritage and so on.