Incident	Measure
Destruction of stalactite in Dong Tien Lake (Fairy Cave)	200,000 VND fine
Destruction of stalactite in Thien Cung Cave	500,000 VND charged
Tree cutting, rock destruction in Bu Xam Cave	Report and picture appeared in newspaper and radio for public awareness
Violation of environmental protection in aquaculture	Temporary seizure of aquaculture certificate
Trading corals near Tam Cung cave	Confiscation
Violation of environmental protection, decision on administrative penaltics issued by QNPC	1 million VND fine + 5 million VND compensation
Destruction of corals near Ba Ham	Confiscation
Oil leakage from boats (3 cases)	20 million VND fine
Dynamite fishing (numerous cases)	Several hundred thousands VND fine

Table 18.4.1 Violation of Environmental Protection Regulation in Heritage Area

Source: Ha Long Bay Management Board, 1998

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of Environmental Plan for Tourism)	
Table 18.4.2 Estimated Costs & Schedule (Development	

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Note : Cost rounded to the order of 4th digit, before adjustment of discount rate.

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O&M	O&M	Labor	person/month	c	0	0	000	200	200	200	222	3		ļ	22
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		Uther	Lacibity/vear	9	0	0	×	×	×	×	×	×	<		
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OEM	OEM	Labor	X0/pers./month		0	0	4X.000	4K,000	000 X*	000	40.000	10.00	200.04		320.000
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		Other	2.000/facil/vear	0	0	0	16.000	16,000	16,000	16,000	10.000	16.000	0.00	0.00	000.021
		Continuence / 2044		0	0	0	21,000	21.000	21.000	_	21,000	21,000	21.000	33.17	104.401
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Crand Total Note : Cost rounded to 4th dight, before adjustment of discount rate

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Table 18.4.4 Estimated Costs & Schedule (Improvement of Sanitation Condition - Phase 2)

ر المسعد المسعد ال	1414000	Work	Unit	Vew 2000	1002 202	Year 2002	Year 2003	- Year 2001	: V ar 201	Vi Vest Day	of Year 200	7 Vear 2413	VINE TON	1 ()	I OLAI CHERRE JULI
00 1 Desig		1.5×	Derson/month	-	5	=	2	-	-	Ĩ	2	÷	5		2
	2 Collection System	Mobile Station	hoat	2	0	-	C				5	0	0	10	
		Stationary Station	tacility	1	:	=	\$	-		-	0	•	-		
		[loat (Wastewater Island)	hoat	5	=	=	≎				-	-	0	0	
		Hoat (Solid Waste - Island)	bnat	=	0	÷	°	-		_	0	-	0		
		1 otter	tacility	3	=	=	2				2	5	0	0	-
0.614		abor	person/month	-	0	=	(°				CX.	0x	KIN NC	08	CE
		Filet & Other	hoat/vear	3	\$	=	2		-	-	K C	C X	X U	803	22
		L BAST	factintizeran	=	=	-	=			-	-	2			-1

Category	l Work	Unit Cost (USS)	Year 2000	Year 2000 Year 2001 Year 2002 Year 2003 Year 2004	(car cixic)	Year 2003	1 car 2014	Year 2001	Year 2006	(car 2005) Year 2005; Year 2007; Year 2008; Year 2009; Year 2010	Year 200X	Year 2000		['atal (_2006.2010)
	Design	1000 hers /month	-	-	¢	12,000	13	÷	(1	1 11	6	0		12,000
	Contineeder (20%a)		•	=	\$	2,000	¢	=	0	4	•	9	11	2,0,0
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2. Collection Boat	Mohile Station	27,000/boat/vear	3	0	0	0	27.(N.N.)	27,4891	27,0XM)	0	C.	0	0	ene, tx
	Stationary Station	13,0000/facil rear	2	•	0	0		13,600	13,000	0	0	()	0	26.000
	(Eloat (Wastewater : Island)	27.0XN/boat/vear	0	0	3	0	0	0	27,0041	10	•	0	0	1640/22
	(Hoat (Solid Waste : Island)	27.000/hoal/year	:	9	÷	3	0	27,000	27,000	0	0	0	0	000,42
	Toulet	30.000/facil/New	5	0	0	0	120,000	120.000	120,000	0	10	0		360.000
	Contingency (20%)		3	2	\$	0	29,000	37,000	(XX) 🖓	0	0	0	10	109,000
	Subtotat		0	0	0	0	176.000	CXXXTCC	257,000	0	10	0	0	617,000
	Total		=	0	()	14,000	176,000	224,000	257,000	0	0	0	0	671.000
	Labor	KU/pers./month	0	:D	3	÷	A	0	0	6.000	6,000	6.000	6 CXX1	000,440
-	Fuel & Other	S.(XK)/hoat/vear	¢	- D	с 	0	0	0	Ċ	60,0001	641,083	60,000	60,0XK3	240,000
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	Suhtotal		\$	0	0	5	0	2	9	108,000	108,000	108,000	108,0001	132.001
	Total		0	3	0	0	0	0	0	108,000	108,000	108,000	108.000	132,000
Crand Final	14)	0	9	14,6840	176.000	000 720	257 (KN)	100,000	100,801	108,000	10X 000	1,105,000

Note : Cost rounded to 4th digit, before adjustment of discour-

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		Roat	boat	0	0	0	1	0	1	0	-	0	-	•
100		T abou	menon/month	0	0	200	230	260	290	320	350	380	410	2,440
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		Fuel & Other	boat/year	0	0 0	61	ſ.			t	c	0	0	A.**
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Tume	Cutowood 1	1 Work	Unit Cost (USS)	Year 2000 Year 2	001 Year 2002	Year 2003 Yea	w 2004 Ye	ar 2005 Ye	ar 2006 Y.	car 2007	Ycar 2008	Year 2009	Year 2010	Year 2006 Year 2001 Year 2002 Year 2003 Year 2003 Year 2005 Year 2006 Year 2007 Year 2007 Year 2008 Year 2010 Total (2000-2010)
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	11. COMP	Casicon (20%)		0	0	0	0	0	0	0	0	0	0	0

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	1	Carlingen (20%)			°	0	0	0	0	0	0	0	0	0	0
		Subtotal		0	0	2.000	0	c	1.000	0	0	0	¢	0	3.000
; .	, Boat	Baat	27.000/host	0	0	54,000	0	27,000	0	27,000	0	27.000	0	27.000	162.000
		Continenses (20%)		0	0	11.000	°	5.000	0	5.000	0	5.000	0	5.000	21.000
		Subtotal		•	0	65.000	0	32.000	0	32.000	0	32,000	0	32,000	193,000
		Total		0	0	67,000	0	32,000	1,000	32,000	0	32.000	0	32,000	196,000
201	140	T abov	100/nem./month	0	0	0	20.000	23.000	26,000	29.000	32.000	35.000	38.000	41.000	244.000
		Fuel & Other	1.5.000/hoat/vear	0	0	0	30.000	38,000	45,000	53.000	60.000	68,000	75.000	83.000	452.000
•	•	Contingency (20%)		0	0	0	10.000	12,000	14.000	16.000	18.000	21.000	23.000	25.000	139,000
•		Suhtotal		0	0	0	60.000	73.000	85.000	98,000	110.000	124.000	136.000	149.000	835.000
		Total		0	0	0	60,000	73.000	\$5.000	98,000	110,000	124.000	136.000	149.000	835.000
	Cond Total	tal		0	0	67.000	60.000	105,000	86,000	130.000	110,000	156.000	136,000	181.000	1,031,000

Note : Cost rounded to 4th digit, before adjustment of discount rate.

1) 1) 1) 1) 1) 1) 1) 1) 1) 1)	Table 18.5.1 Estimated Costs & Schedule (Reforestation in Bare Arcas)	stimate	in Costs										
Type Category Work Investigation Design & I. Design Preliminary Investigation Construction 2. Bud Preparation Seedlings (Trues) 3. Reforestation Seedlings (Trues) 3. Reforestation Needlings (Trues) 7. Vegetation with Grass Troo Planting Oxen Vegetation Work Type Cate Category Work Design & I. Design Protect Design Construction Bud Preparation Construction Bud Preparation 2. Bud Preparation Bud Preparation 2. Bud Preparation Bud Preparation Contruction Bud Preparation 3. Reforestation Bud Preparation Contruction Bud Preparation Contragency (20%) 3. Reforestation Bud Preparation Contragency (20%) 3. Reforestation Receptation Work		-	2005	1000	2003	1002	2005	2006	2007	2008	5003	2010	Total (2000-2010)
Design &     1. Design &       Design &     1. Design &       Construction     2. Bod Preparation       Station     Project Design       3. Reforestation     Seedungs (Trous)       3. Reforestation     Needungs (Trous)       Revegetation     Work       Troo     Planting       Cost     Vogetation       Troo     Preventation       Cost     Vogetation       Cost     Vogetation       Design &     Vork       Distign &     1. Design       Project Design     Preliminary Investigation       Construction     Sub-notal       2. Bod Preparation     Bod Preparation       3. Reforestation     Bod Preparation       3. Reforestation     Bod Preparation	Unit C	-+	+				<	24	ž	0	6	0	711
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2. Bod Preparation Bod Preparation       3. Reforestation     Socdunts (Trees)       3. Reforestation     Socdunts (Trees)       A.O.&.M     Vegetation       Oreat     Vegetation       Cost     Vegetation       Cost     Vegetation       Cost     Vegetation       Cost     Vegetation       Cost     Vegetation       Contraction     Personnel (Saff of FPA)       Contraction     Personnel (Saff of FPA)       Construction     Project Design       Construction     Project Design       2. Bod Preparation     Bod Preparation       3. Reforestation     Southered       3. Reforestation     Southered			072	260	300	90) 1	300	300	300	300	300	3	
3. Reforestation     Sections (Trees)       3. Reforestation     Reversation with Grass       Down     4.00kM     Vegetation       Cost     Vegetation     Nork       Cost     Vegetation     Nork       Troo     Performance (Staff of FPA)       Design     Preliminary Investigation       Construction     1. Design     Protoct Design       Construction     2. Bed Preparation     Sub-total       3. Reforestation     Southered (Tress)       3. Reforestation     Southered (Tress)	14	∔	+	┢	Ł	000 020	000 050	375 000	375,000	375,000	375.000	375.000	W1-C77.4
Cost     Reveretation with Crass       0.00M     4.000M       4.000M     Vegetation       Cost     Vegetation       Cost     Vegetation       Design     Vegetation       Design &     Work       Design &     Nork       Design &     Preliminary Investigation       Construction     Project Design       Construction     Bed Preparation       2. Bed Preparation     Bed Preparation       3. Reforestation     Subrotal       3. Reforestation     Seedings (Tress)	cach	() >	∔	·+	∔	-	┢	ļ	6.	140	150	150	1.250
OkeM     Tree Plantut;       OkeM     4.O.K.M     Vegetation       Cost     Vegetation       Foreign     Presonnel (Staff of FPA)       Cost     Work       Durign &     I. Design       Project Design     Project Design       Contingency (20%s)     Sub-total       2. Bed Preparation     Bothreaden       3. Reforestation     Sub-total	ha	0	81	ğ	8	3	3		Ş	0,1	140	150	0521
OxeAd     4.O.00.M     Vegetation       Cost     Vegetation       Type     Category     Work       Design &     1. Design     Project Design       Construction     Project Design     Contracted       Construction     Project Design     Sub-total       2. Bed Preparation     Bed Preparation     Sub-total       3. Reforestation     Contingency (Tress)       3. Reforestation     Receptation With Orass	ęų	0	100	100	8	8	ŝ	P.	2	2000	1	0000	6.250
NeMI 4.000M Vegetation Type Category Work m K 1. Design Pretimmary invertigation arruction Proparation Bed Preparation 2. Bed Preparation Bed Preparation 3. Reforestation Seedings (Trees) 3. Reforestation Seedings (Trees)	- 4	c	0	0	300	ş	650	202	305	3,-	3	2.4	904
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Type         Category         Work           gn &         1. Design         Preliminary Investigation           atruction         Project Design         Sub-lotal           atruction         Bed Preparation         Bed Preparation           2. Bed Preparation         Bed Preparation         Sub-lotal           3. Reforestation         Seedings (Trees)         Sub-rotal           3. Reforestation         Recontingency (20%)         Sub-rotal													
Type         Category         Work           gn &         1. Design         Preliminary Investigation           gn w         1. Design         Project Dusign           struction         Project Dusign         Sub-total           2. Bed Preparation         Bed Preparation         Sub-total           3. Reforestation         Seed Preparation         Sub-total           3. Reforestation         Red Bregardy (20%)         Sub-total			$\left  \right $					2000	100-	8000	2009	2010	Total (2000-2010)
Design         Preliminary Investigation         1001           1. Design         Project Design         1001           2. Bed Preparation         Bed Preparation         Bed Preparation           3. Reforestation         Sub-total         Sub-total           3. Reforestation         Bed Preparation         Bed Preparation	Unit Cost (USS) 20	2000	5001	202	2003	2004	c007	0007	) N		4		000 01
<ol> <li>Design Preliminary Investigation 1001</li> <li>Project Design 1001</li> <li>Project Design 1001</li> <li>Bud Proparation Bed Proparation</li> <li>Bud Proparation Bed Proparation</li> <li>Bud Proparation Seedings (Trees)</li> <li>Revegeration with Gruss</li> </ol>			000	4 000	0	0	0	8	2.000	0	D	>	
an Project Dusien 1007 Contagency (20%) 2. Bed Preparation Bed Preparation Contagency (20%) 3. Reforestation Seedings (Trees) 3. Reforestation Recegnation with Grass		1			e	c	0	000	2.000	0	0	- 0	14,000
Contagency (20%) Sub-total 2. Bed Preparation Ded Preparation Contagency (20%) 3. Reforestation Receitings (Trees) Receitings (Trees)	100/pcrs./mo.	_	1					ş	000	0	0	0	6.000
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Sub-total 3. Reforestation Seculings (Trees) Revertion with Grass		_	╞	200 V	1000	77 000	72,000	72,000	72,000	72,000	72,000	72,000	000,4469
3. Reforestation Seedings (Trees) Reverences with Grass		_+	4	NV.V0	1 1 1	000.00	000 04-	10000	30.000	30.000	30,000	30.000	250,000
	.08 cach	0	_	20,000	20,000	<b>NUN7</b>	000	000 41	12 000	12.000	12,000	12,000	100.000
	s/08	0		8 ×	x,000	8.000	200 V	000 24	23,000	23.000	000°EZ	23,000	195,000
I Lee Flanting	155/ha	0	16,000 1	16,000	16.000	10,000	10.000	200.02	12 000	13,000	13,000	13,000	110.000
		0	9,000	9,000	000.6	800	9,000	12,000	000°CT	000	000.06	72 000	655,000

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Vegetation 10/7PA) 40/pers./month

Contingency (20%) Sub-total

Total

Revegetation with Grass Tree Planting Contingency (20%)

Sub-rotal

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Table 18.5.2 Estimated Costs & Schedule (Rehabilitation of Mangrove Swamps)

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2001

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person/month Unit

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Note : Cost rounded to the order of 4th days, before adjustment of discount rate.

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Note : Cost rounded to 3rd digit, before adjustment of discount rate.

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Note : Cost rounded to 4th digit, before adjustment of discount rate.

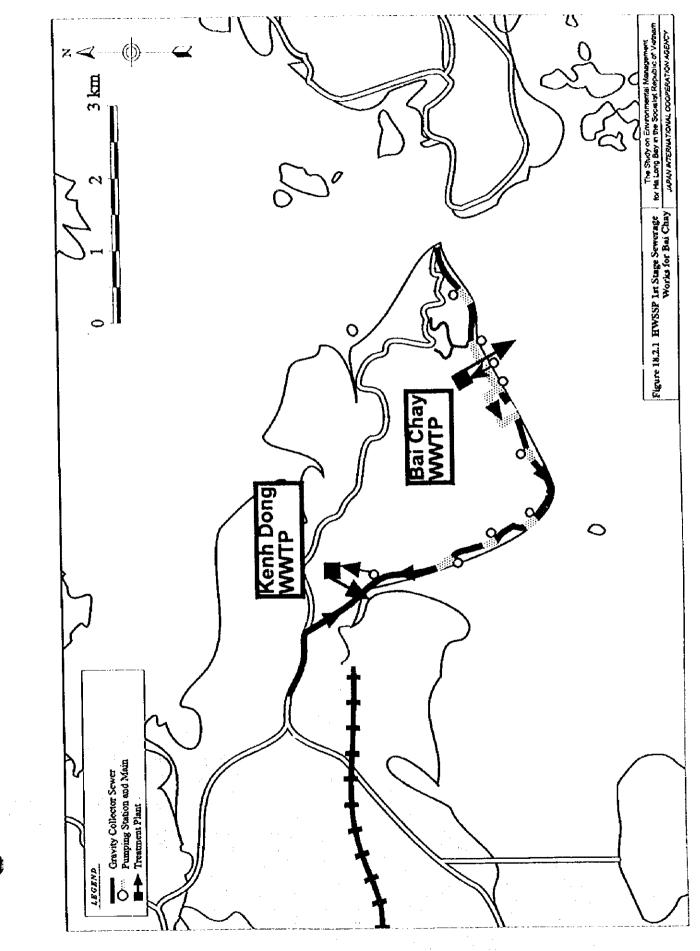
Table 18.5.5 Estimated Costs & Schedule (Reinforcement of Patrolling Capability for Shipping Activities)

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Note : Cost rounded to 3rd digit, before adjustment of discount rate.

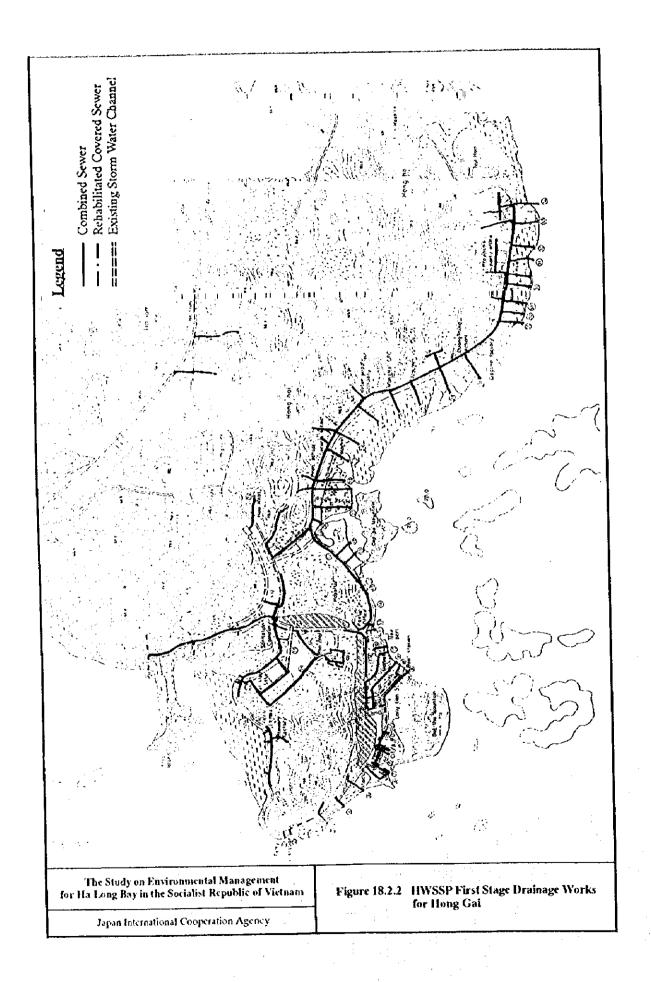
## FIGURES



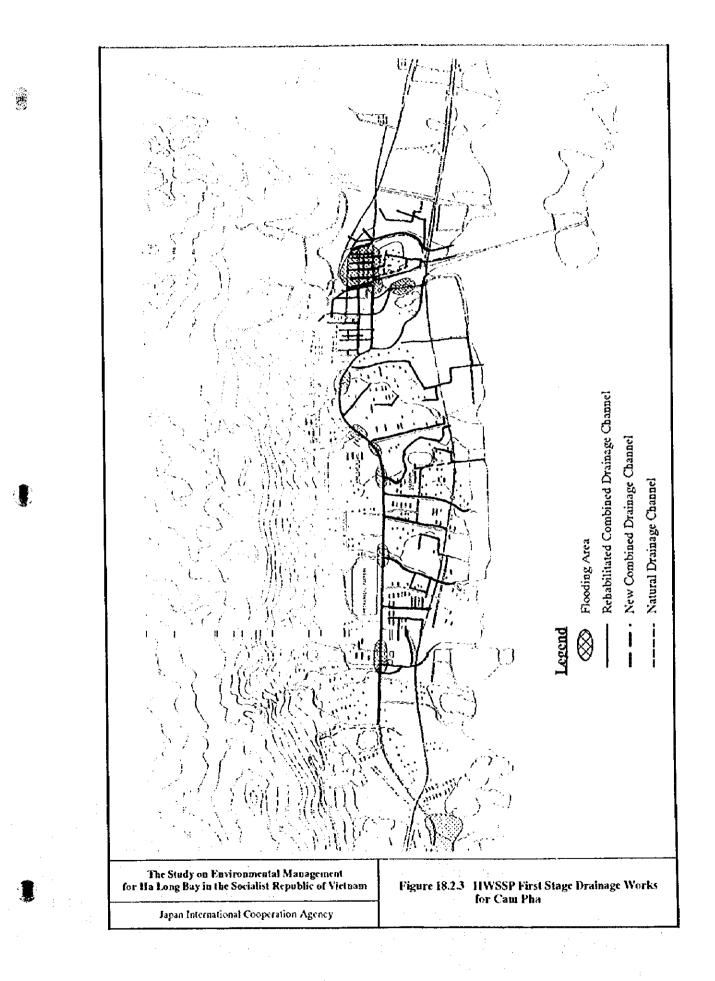
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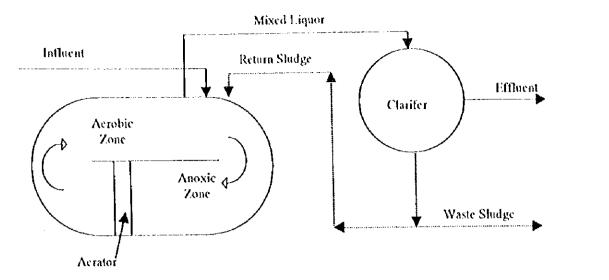
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Figure 18.2.4 Combined Nitrification/Denitrification in an Oxidation Ditch

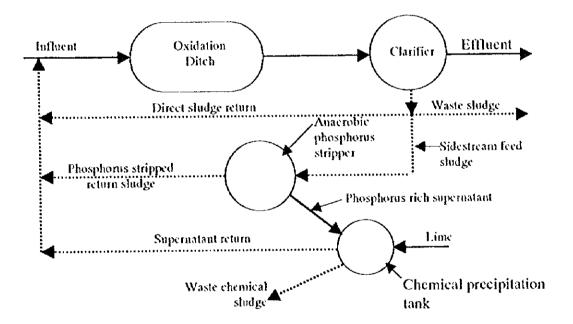
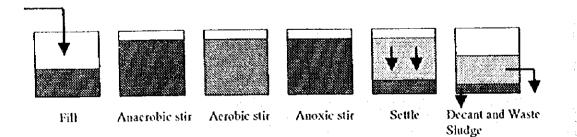
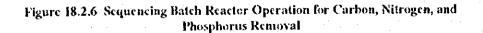


Figure 18.2.5 Oxidation Ditch with Side Stream Phosphorus Removal Process





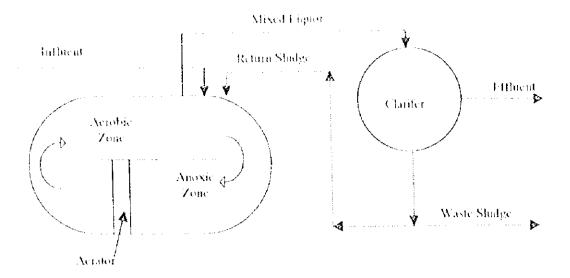


Figure 18.2.4 Combined Nitrification Denitrification in an Oxidation Ditch

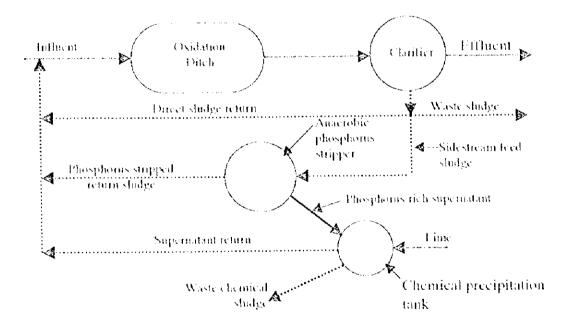


Figure 18.2.5 Oxidation Ditch with Side Stream Phosphorus Removal Process

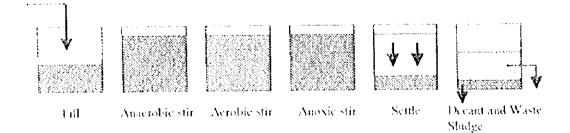
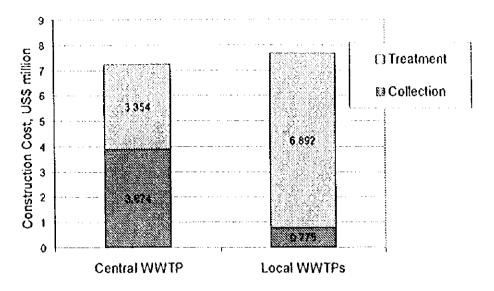
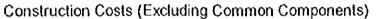
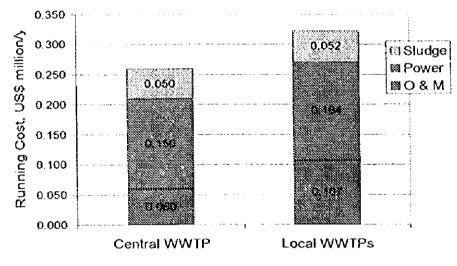
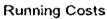


Figure 18.2.6 Sequencing Batch Reactor Operation for Carbon, Nitrogen, and Phosphorus Removal









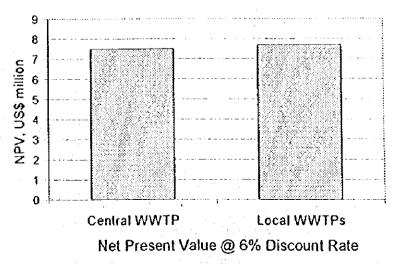
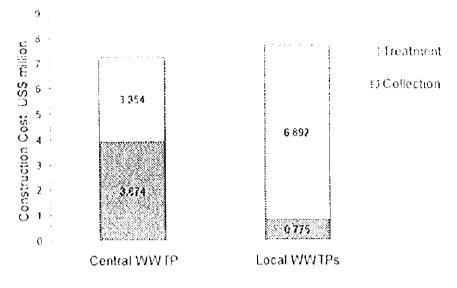
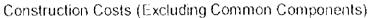


Figure 18.2.7 Cost Comparison of Central versus Local Treatment Schemes





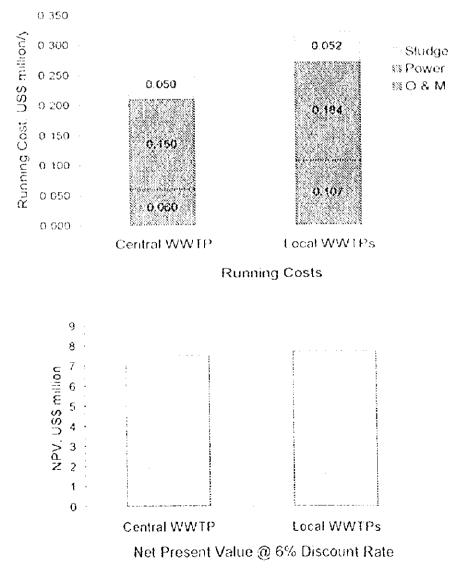
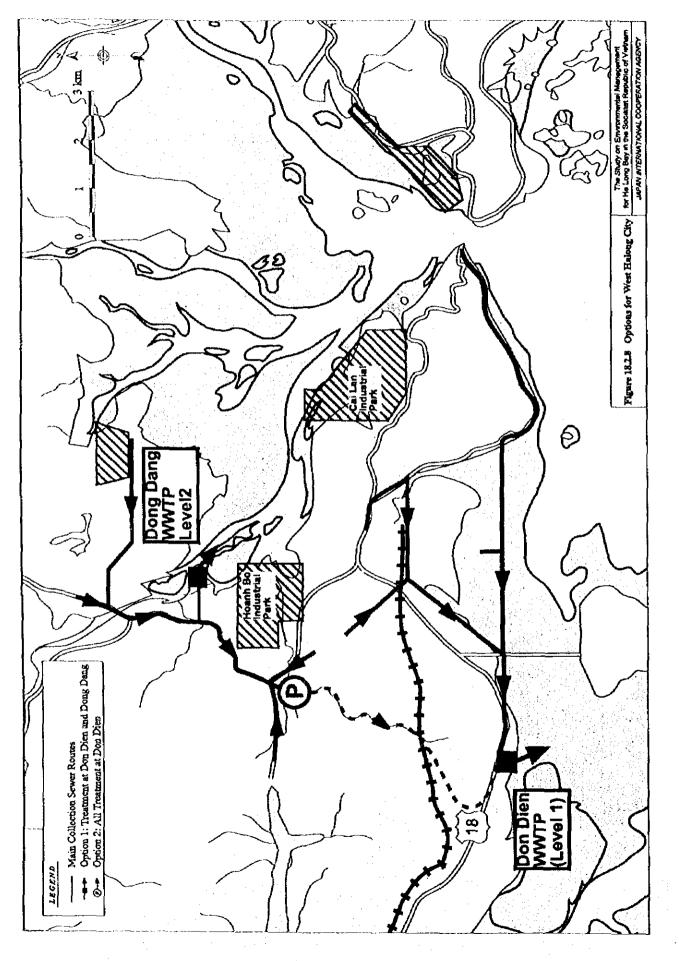
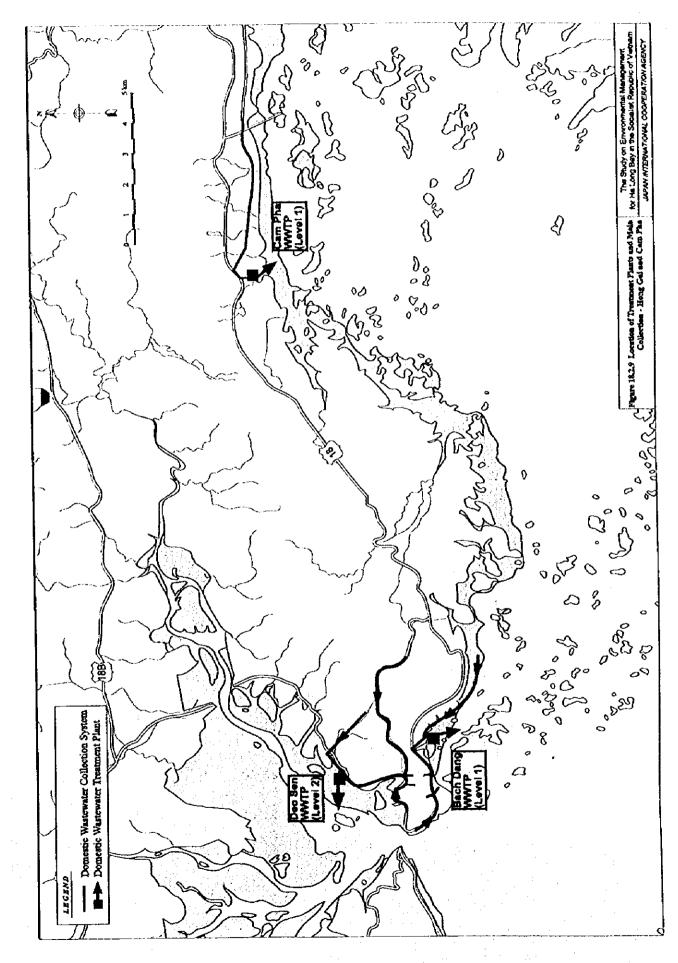


Figure 18.2.7 Cost Comparison of Central versus Local Treatment Schemes



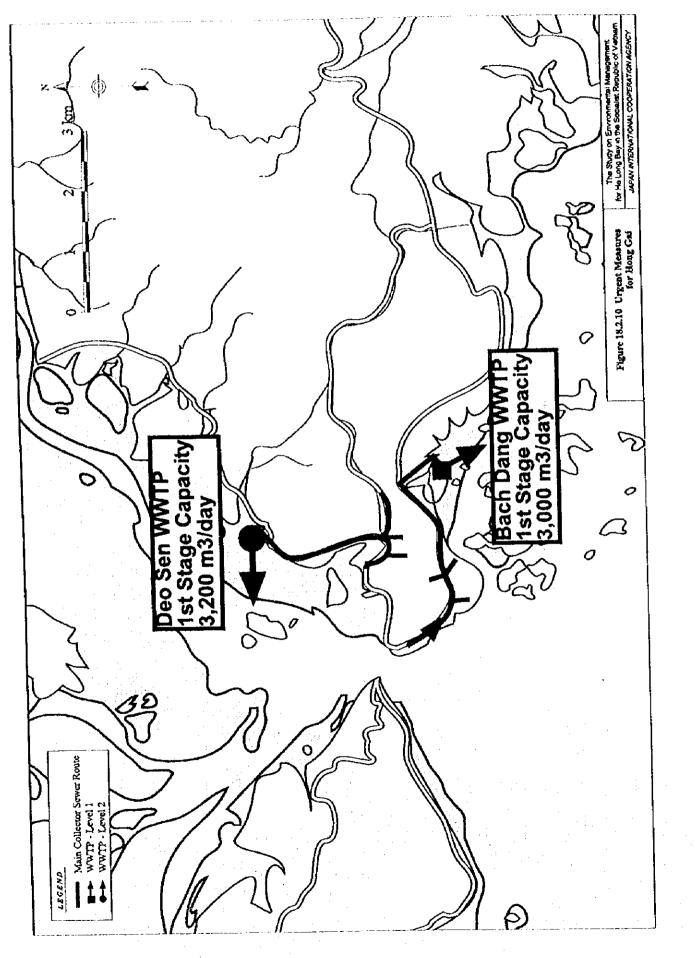
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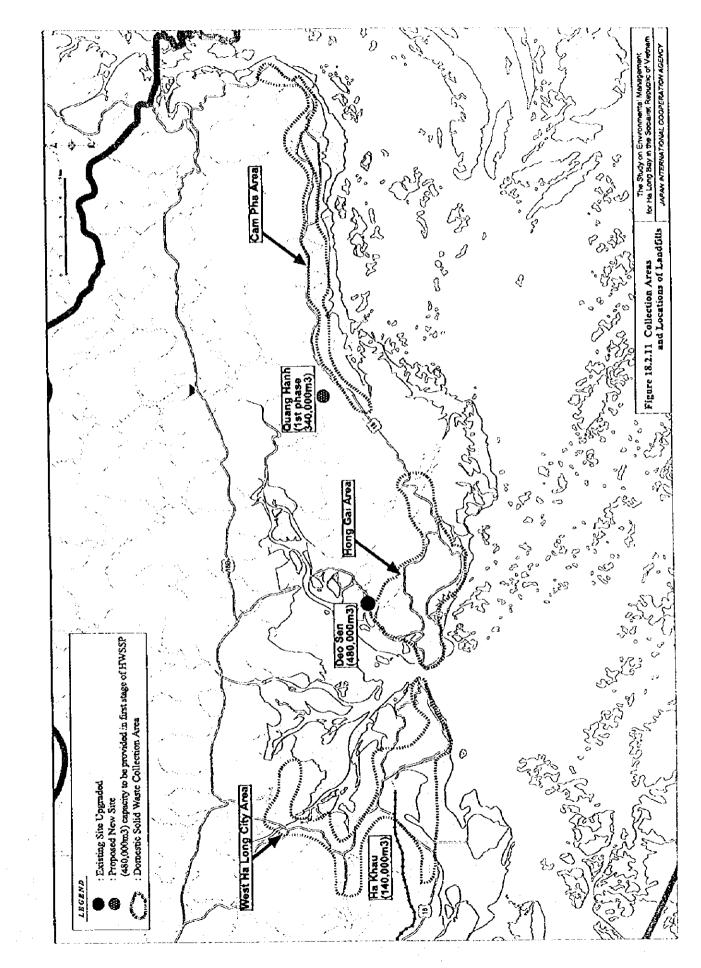
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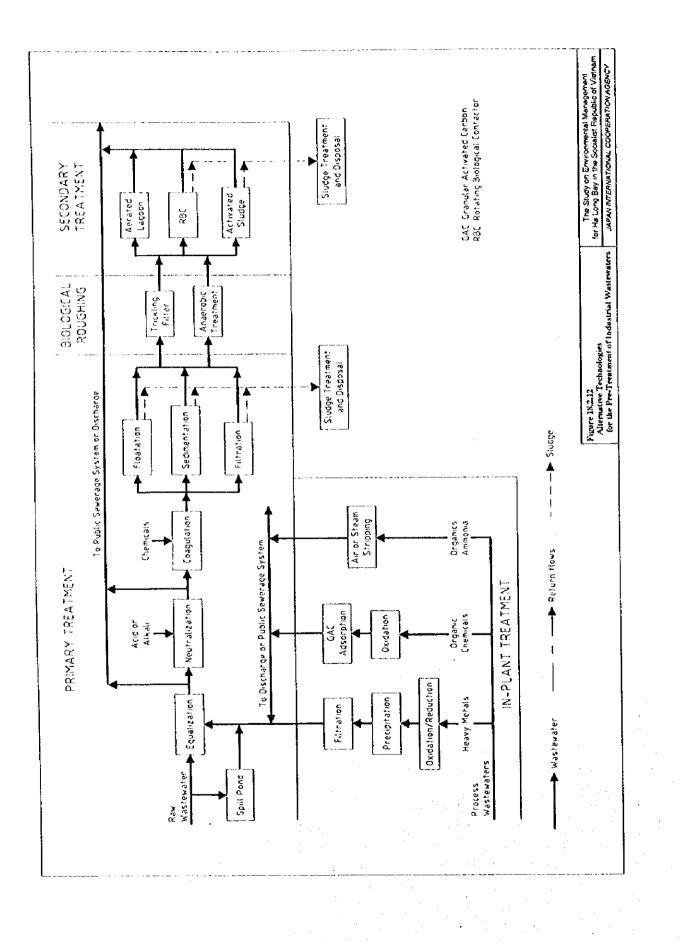
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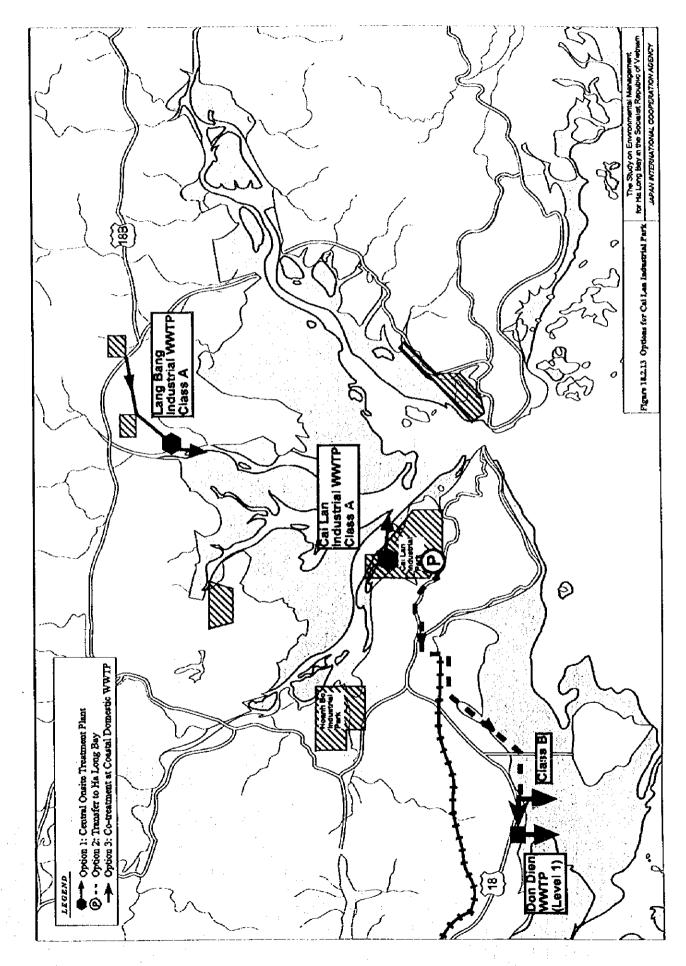
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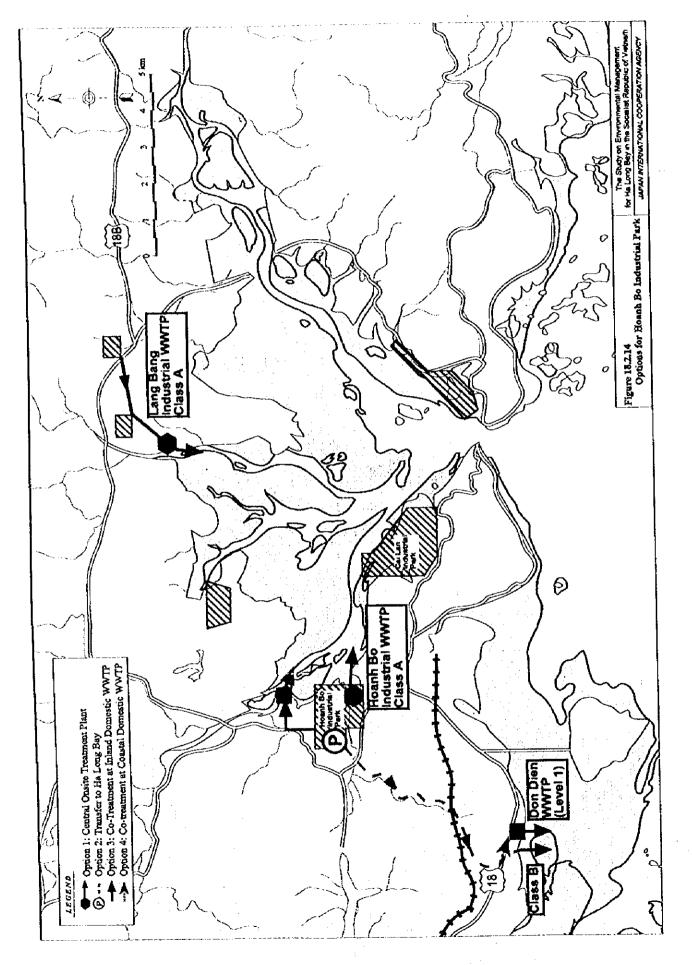
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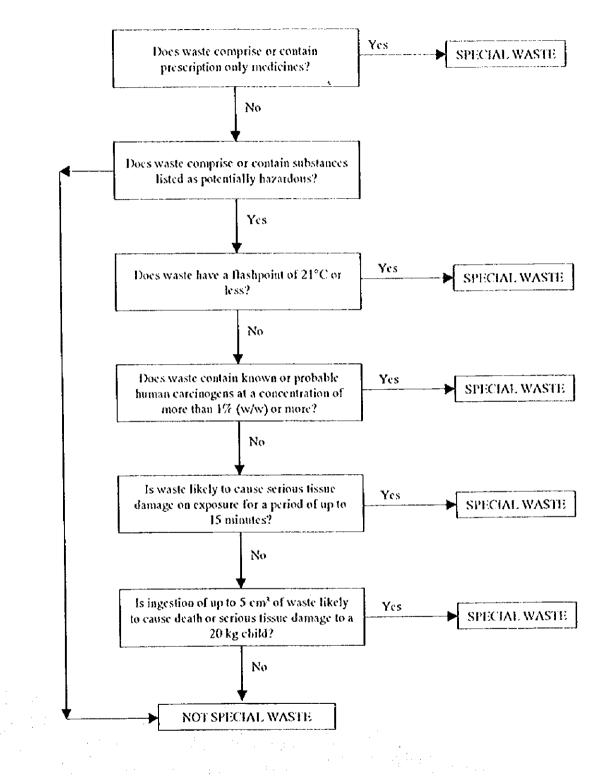
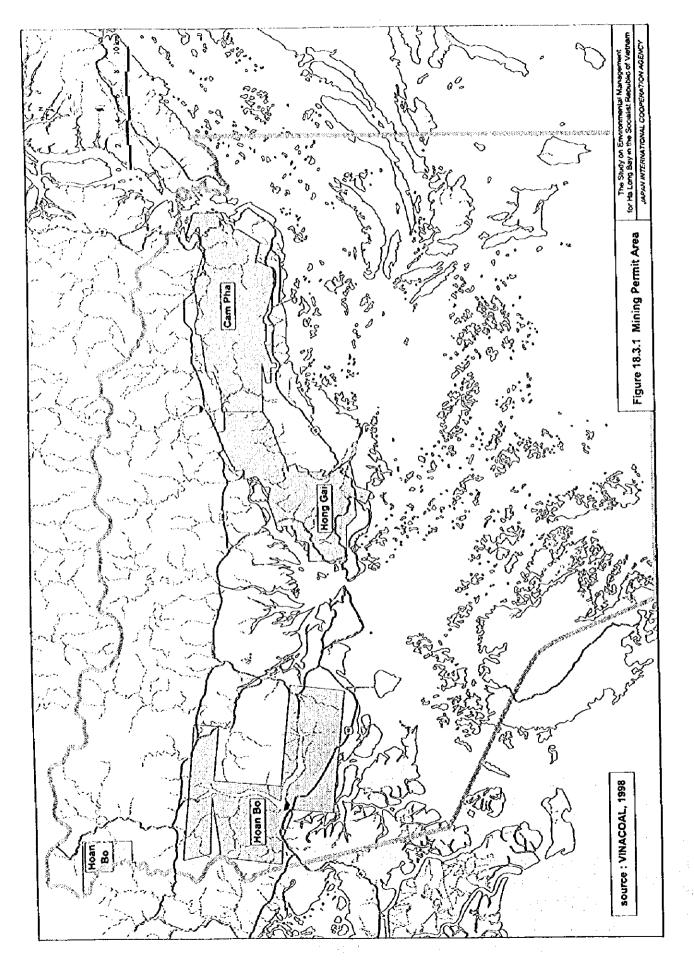
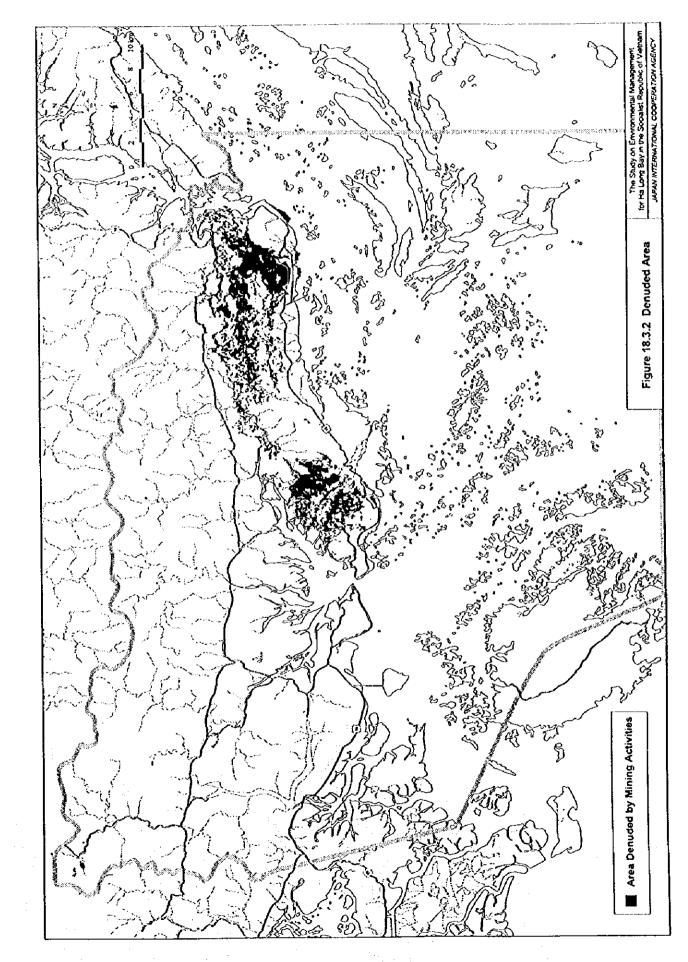


Figure 18.2.15 Special Waste Assessment Procedure Diagram



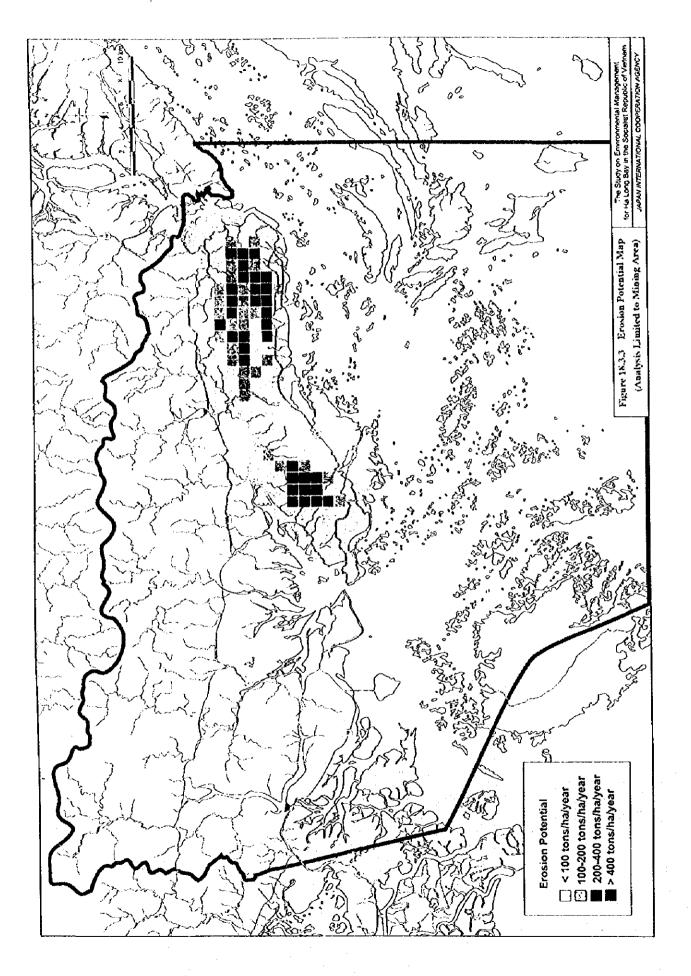
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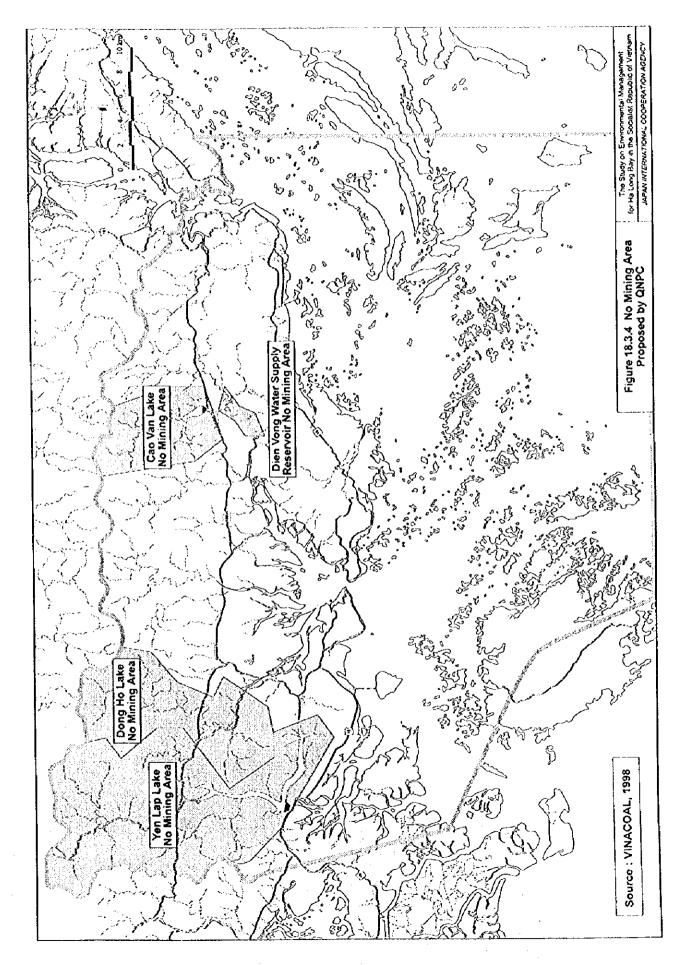
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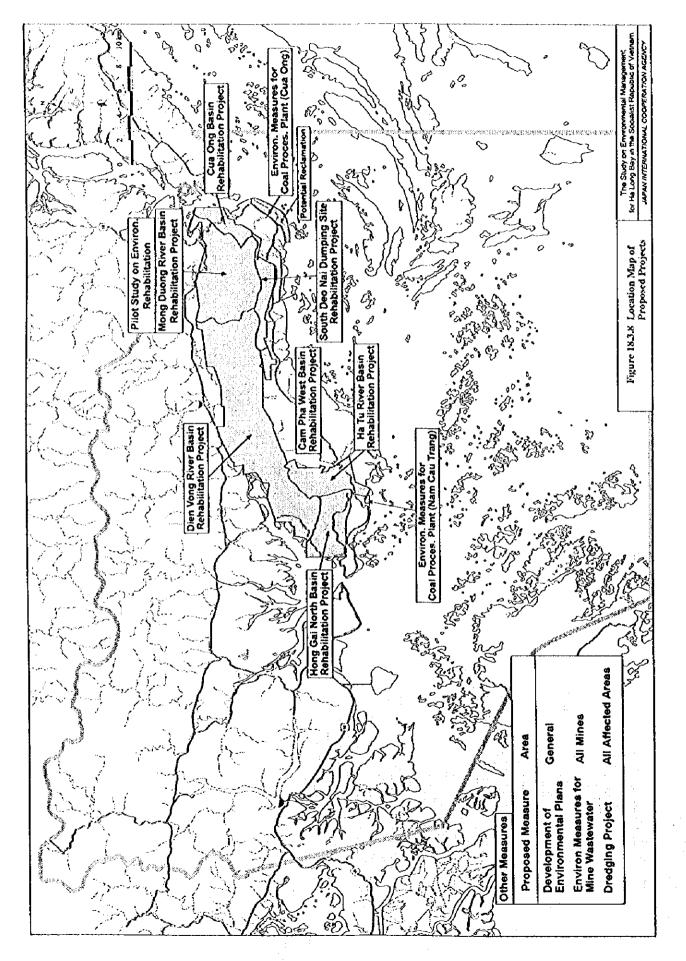
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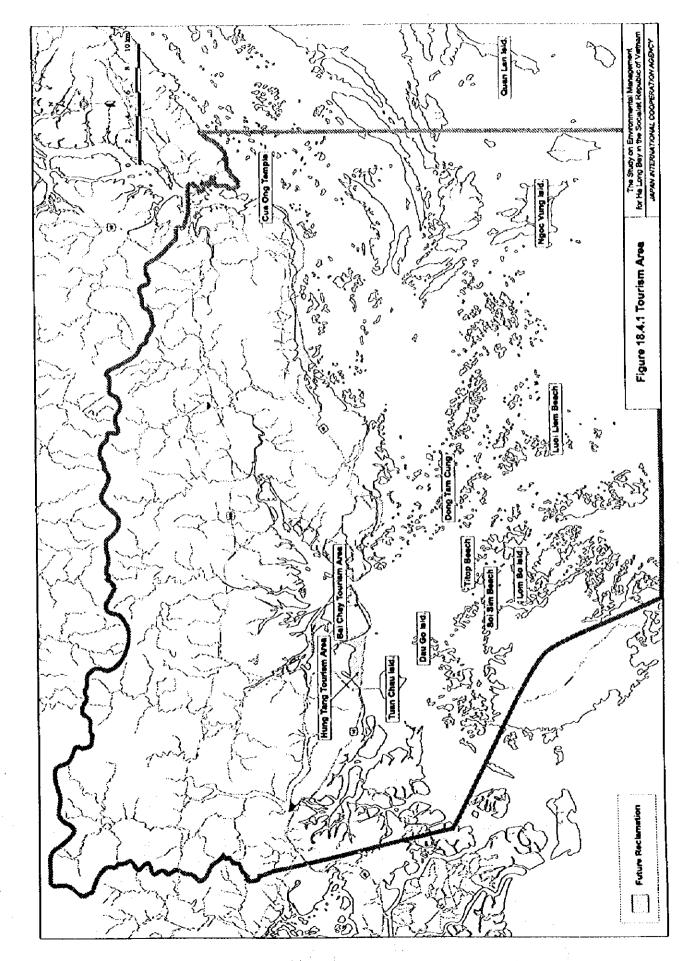
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## **CHAPTER 19**

## CHAPTER 19 COMPARISON OF ALTERNATIVE PLANS

#### **19.1** Setting Alternatives

#### 19.1.1 Methodology

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In Chapter 18, possible environmental measures were considered by each pollution source to achieve the proposed conservation criteria in 2010. Each component of the measures was validated from a viewpoint of technical soundness and social acceptance. Alternatives of component of the measures were also analyzed in the sector studies. Among them, however, it is necessary to analyze alternatives by combining the environmental measures of domestic wastewater and industrial wastewater. Because generated pollution loads from them were concentrated on Bai Chay bay, applicable combination of the measures for domestic and industrial wastewater should be required to manage them effectively and efficiently. Thus, the optimum environmental measures of domestic and industrial wastewater were selected by the following process:

- 1) Identification of areas, items, components for alternative setting,
- 2) Preparation of alternatives considering technical feasibility,
- 3) Estimation of investment cost of each alternative, and
- 4) Selection of the optimum measures by the least cost method.

## 19.1.2 Areas, Items, and Components for Alternative Setting

#### (1) Areas

Most planned development projects such as industrial parks are concentrated around the Bai Chay bay, and a remarkable population increase is expected around the bay and vicinity area. Moreover, the water quality of Bai Chay bay has close relation with those of the Bai Chay coastal area and the Hong Gai coastal area as well as the World Heritage area. On the other hand, the Binh Houng estuary seems to have more room of self-purification capacity compared with other areas in AMZ. Therefore, Bai Chay bay, Binh Houng estuary, Bai Chay coastal area, and Hong Gai coastal area are to be the areas considered for

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alternative plans. In Cam Pha and Cua Ong area, mining activities produce major problems. Considering the crucial conditions, such problems are to be managed by measures for mining locally and urgently. Therefore, it is not appropriate to set alternatives in this area.

### (2) Items

Normally, organic pollution loads of BOD and COD are main treated items of domestic wastewater control. In the case of discharging treated wastewater into Bai Chay bay, treatment methods which remove nutrients pollution loads will be required to prevent the progress of cutrophication. Hence, to meet the conservation criteria, nutrient pollution loads in terms of T-N and T-P are to be taken into account.

Alternatives are to be drawn up to attain the allowable pollution loads into Bai Chay bay, because it is essential to meet the conservation criteria. Total allowable pollution loads set for Bai Chay bay are 3,300 kg/day in BOD, 7,200 kg/day in T-N, and 2,900 kg/day in T-P as shown in Chapter 18. Among them, for example, the amounts of runoff load in BOD from domestic and industrial sources into Bai Chay bay account for 40% and 50%, respectively. Because it is difficult to control pollution loads from livestock and non-specific sources, the allowable pollution loads from domestic and industrial sources into Bai Chay bay are calculated by subtracting total allowable loads from loads of livestock and non-specific sources. The obtained allowable domestic and industries loads are as follows:

- BOD 1,300 kg/day - COD 2,200 kg/day - T-N 1,200 kg/day - T-P 160 kg/day

### (3) Components

The following domestic and industrial wastewater treatment plants (WWTPs) including collection systems and pumping stations are selected as the components for alternative setting. Based on the combinations of these components such as discharge point of treated wastewater, and/or whether or not industrial wastewater is connected with the sewerage system, necessary sewered population and facilities like pumping stations are changed. In the case of the industrial

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wastewater to be discharged into the sewerage system, a pre-treatment is required to keep good treatment conditions in the WWTP of sewerage system.

Category	Facility
Domestic wastewater	1. Dong Dang WWIP
	2. Don Dien WWTP
	3. Deo Sen WWTP
Industrial wastewater	1. Hoanh Bo Industrial WWIP
	2. Cai Lan Industrial WWIP

Note: WWTP means wastewater treatment plant.

#### 19.1.3 Description of Alternatives

The alternatives are drawn up on the basis of discharge points of treated wastewater from the industrial parks, whether they are to be discharged directly into Bai Chay bay or Binh Huong estuary, or to be connected with sewerage systems. These considerations led to five alternatives. In addition, the option of developing Dong Dang wastewater treatment plant (WWTP) was also considered. If the Dong Dang WWTP is not developed, the domestic wastewater is to be conveyed to Don Dien WWTP. Accordingly, ten possible alternatives are drawn up as follows, and their brief descriptions are summarized here.

WWIP	Dischar. Point	1 Allernative 1 /		Altern	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Alt.1.1	Alt.1.2	Alt.2.1	Alt.2.2	Alt.3.1	Alt.3.2	Alt.4.1	Alt.4.2	Alt.S.1	Alu5.2	
Dong Dang	BC	0	х	0	X	0	X	0	X	0	Х	
Don Dien	BH	0	0	0	0	Ô	0	0	0	0	0	
Deo Sen	BC	0	0	0	0	0	Q	0	0	0	0	
Hoanh Bo	BC	0	0	0	0	X	X	X	X	X	X	
industrial	BH	X	X	X	X	0	0	X	X	X	X	
	SS	X	X	X	X	X	X	0	0	0	0	
Cai Lan	BC	0	0	X	X	Х	X	0	0	X	X	
industrial	Bff	X	X	0	0	0	0	X	Х	X	X	
ļ	SS	X	X	X	X	X	X	X	Х	0	0	

**Description of Alternatives** 

Note: 1) BC; Bai Chay bay, BH; Binh Huong estuary, SS; Sewerage system, 2) O : applicable, X : not applicable

## (1) Alternative 1.1 and 1.2 (see Figure 19.1.1)

Two alternatives are drawn up on the basis of treated wastewater from both Hoanh Bo and Cai Lan industrial parks to be discharged into Bai Chay bay. Corresponding to this, Dong Dang WWTP is considered in the alternative 1.1, while it is not considered in the alternative 1.2. Instead, domestic wastewater is to be conveyed to the Don Dien WWTP in the alternative 1.2.

Alterna- tive	Measures	Treatment level	Discharge point	Necessary facility
Alt. 1.1	Dong Dang WWTP (100,700)	Level 2	Bai Chay bay	-
	Don Dien WWTP (15,000)	Level 1	Binh Huong estuary	-
	Deo Sen WWTP (210,400)	Level 2	Bai Chay bay	-
	Iloanh Bo industrial WWFP	Class A	ditto	-
	Cai Lan industrial WWIP	ditto	ditto	-
Alt. 1.2	Dong Dang WWTP (-)	-	-	Pump St.
	Don Dien WWTP (111,700)	Level 1	<b>Binh Huong estuary</b>	-
	Deo Sea WWIP (210,400)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWIP	Class A	ditto	-
	Cai Lan industrial WWIP	ditto	ditto	-

Note: Numbers in parenthesis show sewered population including sub-catchments 2 and 3 for Don Dien WW1P.

## (2) Alternative 2.1 and 2.2 (see Figure 19.1.2)

Two alternatives are drawn up on the basis of the treated wastewater form one industrial park such as the Cai Lan industrial park to be discharged into the Binh Huong estuary area, other industrial park: The Hoanh Bo industrial park into Bai Chay bay. Thus, the Dong Dang WWTP is considered in the alternative 2.1, while it is not considered in the alternative 2.2. Instead, domestic wastewater is to be conveyed to the Don Dien WWTP in the alternative 2.2.

Alterna- tive	Measures	Treatment level	Discharge point	Necessary facility
Alt. 2.1	Dong Dang WWTP (92,200)	Level 2	Bai Chay bay	-
••••	Don Dien WWTP (15,000)	Level 1	Binh Huong estuary	_
	Deo Sen WWTP (190,200)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Class A	Bai Chay bay	-
	Cai Lao industrial WWIP	Class B	<b>Binh Huong estuary</b>	Pump St.
Alt. 2.2	Dong Dang WWIP (-)	-	-	Pump St.
	Don Dien WWTP (105,000)	Level 1	Binh Huong estuary	-
	Deo Sen WWTP (183,700)	Level 2	Bai Chay bay	
	Hoanh Bo industrial WWIP	Class A	Bai Chay bay	- · ·
	Cai Lan industrial WWIP	Class B	Binb Huong estuary	Pump St.

Note: Numbers in parenthesis show sewered population including sub-catchments 2 and 3 for Don Dien WWIP.

(3) Alternative 3.1 and 3.2 (see Figure 19.1.3)

Two alternatives are drawn up on the basis of the treated wastewater from both the Hoanh Bo and Cai Lan industrial parks to be discharged into Binh Huong estuary. Correspondingly, the Dong Dang WWTP is considered in the alternative 3.1, while it is not considered in the alternative 3.2. Instead, domestic wastewater is to be conveyed to the Don Dien WWTP in the alternative 3.2.

Alterna- tive	Measures	Treatment fevel	Discharge point	Necessary facility
Alt. 3.1	Dong Dang WWTP (87,500)	Level 2	Bai Chay bay	-
	Don Dien WWTP (15,000)	Level 1	Binh Huong estuary	-
	Deo Sen WWTP (164,000)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Class B	Binh Huong estuary	Pump St.
	Cai Lan industrial WWTP	ditto	ditto	Pump St.
Alt. 3.2	Dong Dang WWIP (-)	-	•	Pump St.
	Don Diea WWTP (98,500)	Level 1	Binh Huong estuary	-
	Deo Sen WWTP (164,000)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Class B	Binh Huong estuary	Pump St.
	Cai Lan industrial WWIP	ditto	ditto	Pump St.

Note: Numbers in parenthesis show sewered population including sub-catchments 2 and 3 for Don Dien WWTP.

## (4) Alternative 4.1 and 4.2 (see Figure 19.1.4)

Two alternatives are drawn up on the basis of the wastewater form the Hoanh Bo industrial park to be connected with the public sewerage system, and the wastewater from the Cai Lan industrial park is to be discharged into Bai Chay bay. Therefore, the Dong Dang WWTP is considered in the alternative 4.1, while it is not considered in the alternative 4.2. Instead, domestic wastewater is to be conveyed to the Don Dien WWTP in the alternative 4.2.

Alterna- tive	Measurés	Treatment level	Discharge point	Necessary facility
Alt. 4.1	Dong Dang WWTP (94,200)	Level 2	Bai Chay bay	-
	Don Dien WWTP (15,000)	Level 1	Binh Huong estuary	•
	Deo Sen WWTP (185,700)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Pretreatment	Sewerage system	-
	:	_	(Dong Dang WWTP)	
	Cai Lan industrial WWTP	Class A	Bai Chay bay	-
Alt. 4.2	Doug Dang WWTP (-)	-	-	Pump St.
	Don Dien WWTP (105,000)	Level 1	Binh Huong estuary	-
	Deo Sen WWIP (185,700)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Pretreatment	Sewerage system	Pump St.
			(Don Diea WWTP)	
	Cai Lan industrial WWIP	Class A	Bai Chay bay	

Note: Numbers in parenthesis show sewered population including sub-catchments 2 and 3 for Don Dien WWTP.

## (5) Alternative 5.1 and 5.2 (see Figure 19.1.5)

Two alternatives are drawn up on the basis of the wastewater from both the Hoanh Bo and Cai Lan industrial parks to be connected with the public sewerage systems. Thus, the Dong Dang WWTP is considered in the alternative 5.1, while it is not considered in the alternative 5.2. Instead, domestic wastewater is to be conveyed to the Don Dien WWTP in the alternative 5.2.

Alterna- tive	Measures	Treatment level	Discharge point	Necessary facility
Alt. 5.1	Dong Dang WWFP (92,200)	Level 2	Bai Chay bay	•
	Don Dien WWFP (15,000)	Level 1	Binh Huong estuary	
	Deo Sen WWTP (169,000)	Level 2	Bai Chay bay	-
	Hoanh Bo industrial WWTP	Pretreatment	Sewerage system (Dong Dang WWTP)	Pump St.
	Cai Lan industrial WWTP	ditto	Sewerage system (Don Dien WWTP)	Pomp St.
Alt. 5.2	Dong Dang WWTP (-)	-	-	Pump St.
•	Don Dien WWFP (98,500)	Level 1	Binh Huong estuary	•
	Deo Sen WWFP (169,000)	Level 2	Bai Chay bay	•
	Hoanh Bo industrial WWTP	Pretreatment	Sewerage system (Don Dien WWTP)	Pump St.
	Cai Lan industrial WWFP	ditto	ditto	Pump St.

Note: Numbers in parenthesis show sewered population including sub-catchments 2 and 3 for Don Dien WWIP.

### 19.2 Study on Alternative Selection

## 19.2.1 Evaluation

Cost estimation of each alternative was carried out for their evaluation. Estimated costs including those of construction, operation, and maintenance are as shown in Appendices 6.1 to 6.10 and summarized below. Alternative 3.2 is the least-cost alternative followed by alternative 3.1. Alternative 5.1 is the most expensive.

Compar	ison o	f Alte	rnat	ives
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		(Un	it: US\$ x 10
Alternatives	Domestic WWTP	Industrial WWTP	Total
Alt.1.1	85	15	100
Alt.1.2	84	15	99
Alt.2.1	85	14	99
Alt.2.2	84	14	98
Alt.3.1	82	13	95
Alt.3.2	79	13	92
Alt.4.1	92	10	102
Alt.4.2	88	14	102
Alt.5.1	91	13	104
Alt.5.2	88	13	101

Notes: 1) Sewerage costs does not include those of 1st stage of HWSSP

2) Sewerage costs include those of sewerage systems of Bach Dang.

 In case of industrial wastewater to be treated to class B, cost for that is not included.

4) Industrial wastewater treatment costs include these of Lang Bang.

## 19.2.2 Selected Alternative

As the result of evaluation of alternatives by the least cost method, alternative 3.2 was selected as the optimum combination of measures to achieve the conservation criteria of the water quality in Bai Chay bay area in 2010 set for the EMP. The components of the selected alternative 3.2 are summarized below:

- Don Dien WWTP:	Sewered population 98,500 (in 2010)				
	Additional main collectors including pump station				
	13 km				
	Oxidation Ditch treatment				
- Deo Sen WWTP:	Sewered population 164,000 (in 2010)				
	Additional main collectors including pump station				
	12 km				
	Oxidation Ditch treatment and Phosphorus				
	removal				
- Hoanh Bo Industrial WWTP	: Collection system including pump station 5.4 km				
	Main pump station				
	Wastewater treatment plant to be prepared by				
	industrial park				

Collection system including pump station 5.4 km Main pump station

- Cai Lan Industrial WWTP:

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# Wastewater treatment plant to be prepared by industrial park

The proposed domestic and industrial WWTPs aim to reduce organic, nutrients, and SS loads. Based on the selected alternative, the allowable SS runoff load of non-specific sources is calculated for sub-catchments of No.4 to 7, where the increase of denuded area is comparatively large. The calculated allowable SS load from non-specific source is 83 tons/day, and hence total 463 km² of green coverage will be required in sub-catchments of No.4 to 7.

## 19.3 Prediction of Water Quality by the Selected Plan

To predict the effect of the Selected plan, the best alternative considered in the Study, the model was run again replacing Scenario II by the optimum plan. The discharges and pollution loads for Scenario II were changed to those for the optimum plan as shown in Figure 19.3.1 and Table 19.3.1 under the same pollution load levels as Scenario II.

## (1) Prediction of Currents by the Selected Plan

The hydrodynamic model was run to provide hydrodynamic conditions for the selected plan to be used in the prediction of water quality. The only changes of the conditions from Scenario II were the new discharge of No. 1.1 and the additional discharge of No. 13 in Table 19.3.1. No significant change was found in the circulation patterns shown in Figure 19.3.2~19.3.4 compared to the results by Scenario II.

## (2) Prediction of Water Quality

Predicted concentrations of water quality parameters for the selected plan were shown in Figure 19.3.5~19.3.14. BOD concentrations were estimated from COD by the conversion factor of BOD = COD/4.9 derived from the Field Survey for reference.

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The concentrations by the selected plan decreased in Bai Chay bay and increased in western side of the causeway compared to the results by Scenario II except I-P. This shift corresponded to the relocation of pollution loads discharged inside Bai Chay bay in Scenario II to the western side of the causeway in the selected plan as No. 1.1 in Figure 19.3.1 and Table 19.3.1.

The causeway toward Tuan Chau island clearly separated the distributions of all water quality parameters in a similar way to the results by Scenario II. These influences were not found in the results by the present condition targeting 1998 in Section 12.5 because just less than half of the construction of the causeway was completed as of 1998.

(3) Difference between the Results by the Selected Plan and those by Scenario II

To show the effect by the selected plan, the differences of the water quality parameters compared to the results by Scenario II were obtained as shown in Figure 19.3.15~19.3.24.

The causeway toward Tuan Chau island clearly separated the decreased and increased area of the concentrations caused by the reallocations of pollution loads. The reduction effects of the pollution loads inside Bai Chay bay are remarkable for most water quality parameters especially near the mouth of Troi River, the discharge point No. 4 in Figure 19.3.1. On the other hand, local increases of the concentrations were found near the new discharge point No. 1.1 in Figure 19.3.1 for all water quality parameters except I-P.

Compared with the simulated water quality and the conservation criteria, the simulated water quality by the selected plan met the conservation criteria.

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## TABLE

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No.	Name of Sub-catchment	Discharge	SS	COD	T-N	T-P	I-N *	1-P*
		(m3/s)	(kg/day)	<u>(kg/day)</u>	(kg/day)	(kg/day)	<u>/T-N</u>	/ <b>F</b> -P
1	Mip River	23.6	32,100	3,060	2,340	1,140	0.17	0.035
1.1		0.7	4,726	2,907	1,922	225	0.50	0.066
2	Hong Thang Basin	0.7	2,000	270	150	80	0.15	0.049
3	Bai Chay Basin	0.8	1,200	200	110	60	0.50	0.049
4	Troi River	18.7	26,500	2,680	2,290	950	0.50	0.066
5	Man River	11.2	16,800	1,680	1,250	620	0.50	0.053
6	Dieng Vong River	24.4	39,100	3,780	2,690	1,090	0.50	0.062
7	Hong Gai North Basin	1.6	7,392	632	397	155	0.50	0.016
8	Hon Hay South Basin	0.8	2,673	993	788	147	0.50	0.016
9	Ha Tu Basin	3.3	23,000	1,470	980	350	0.20	0.040
10	Cam Pha West Basin	3.2	11,500	1,510	740	210	0.12	0.029
11	Cam Pha Central Basin	2.0	11,428	1,028	850	189	0.23	0.036
12	Cam Pha East Basin	1.5	18,300	1,740	690	120	0.05	0.035
13	Cua Ong Basin	3.7	4,900	580	360	80	0.20	0.042
14	Mong Duong River	10.1	22,500	1,390	1,320	460	0.20	0.042
15-1	Cat Ba Island	3.5	3,267	437	367	160	0.15	0.049
15-2	Cat Ba Island	3.5	3,267	437	367	160	0.15	0.049
15-3	Cat Ba Island	3.5	3,267	437	367	160	0.15	0.049
	Total	116.8	233,920	25,231	17,978	6,356	-	-

Table 19.3.1

Discharges and Pollution Loads by the Selected Plan

 rotal
 10.8
 2.33,920
 25,231
 17,978
 6,356

 Note: * The ratio of I-N/T-N and I-P/T-P were used based on the Field Survey data with some calibration to estimate inorganic part and organic part in the loads separately.

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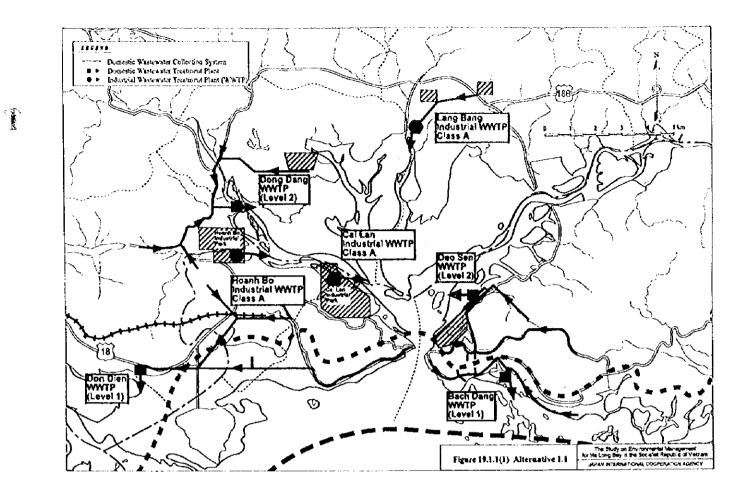
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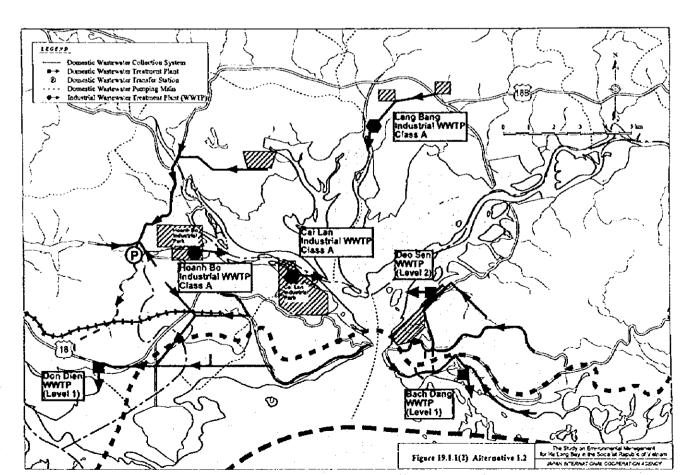
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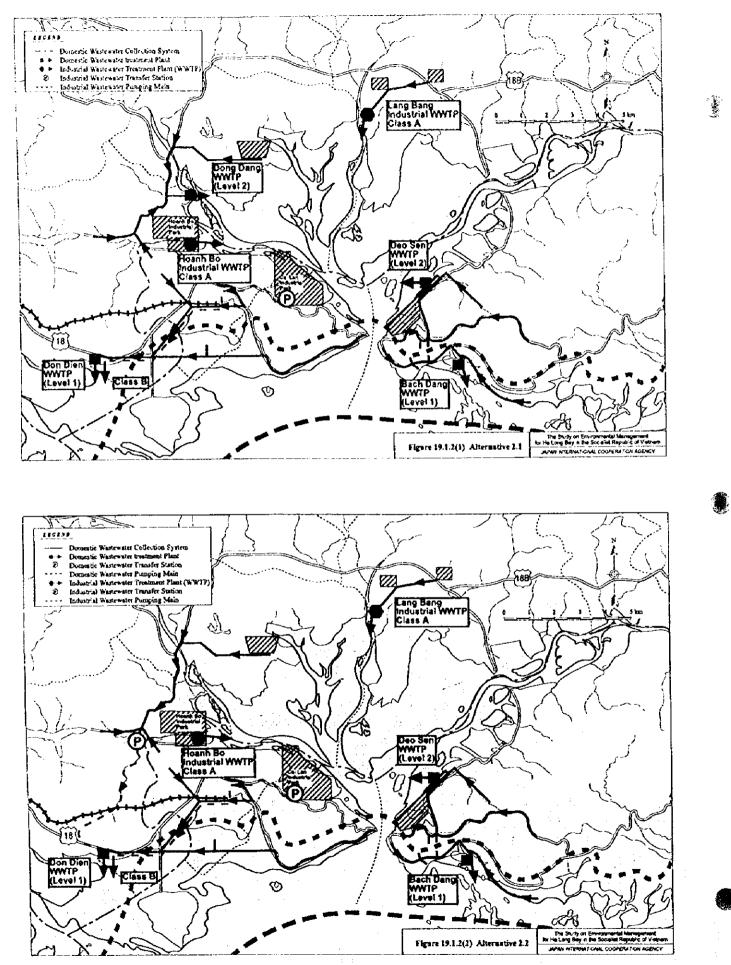
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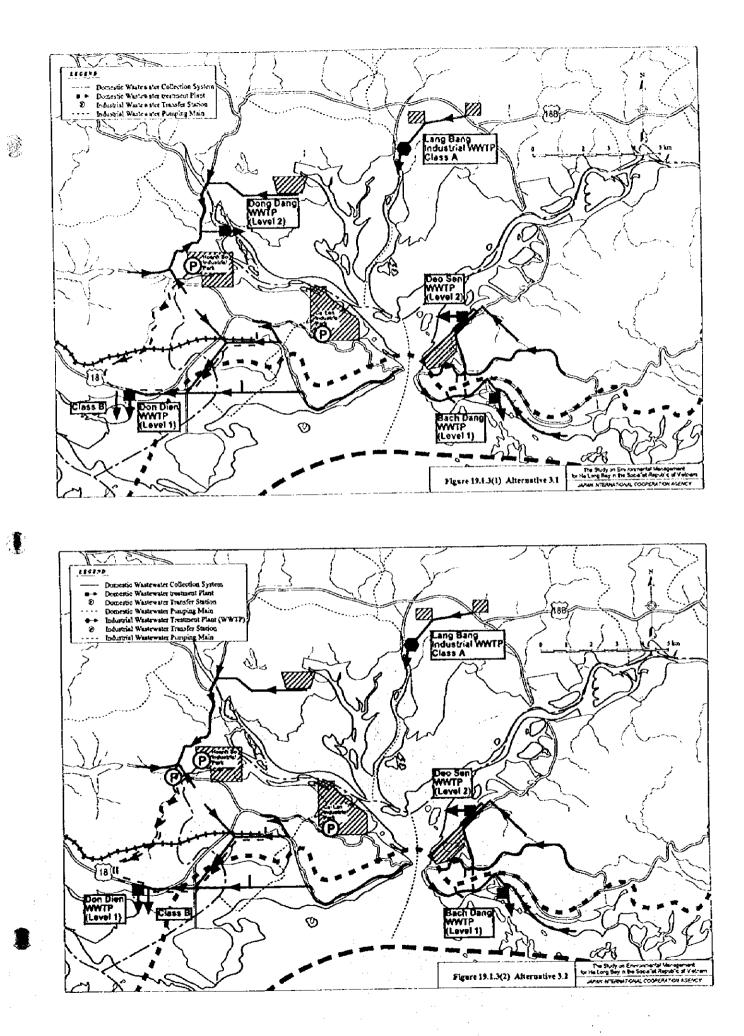
## FIGURES



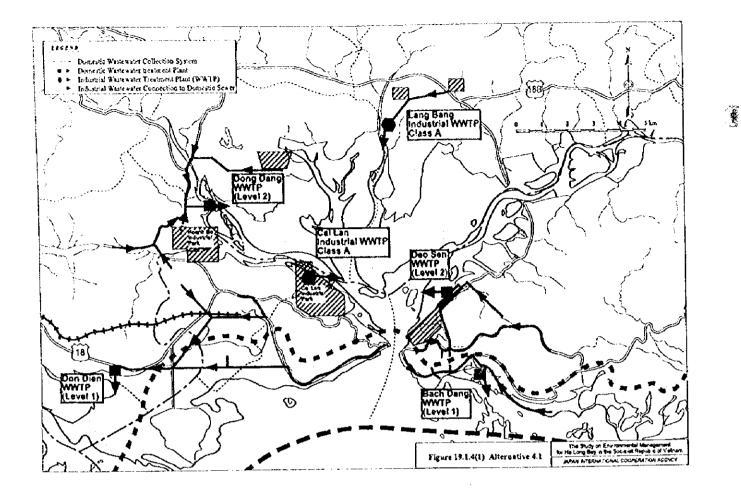


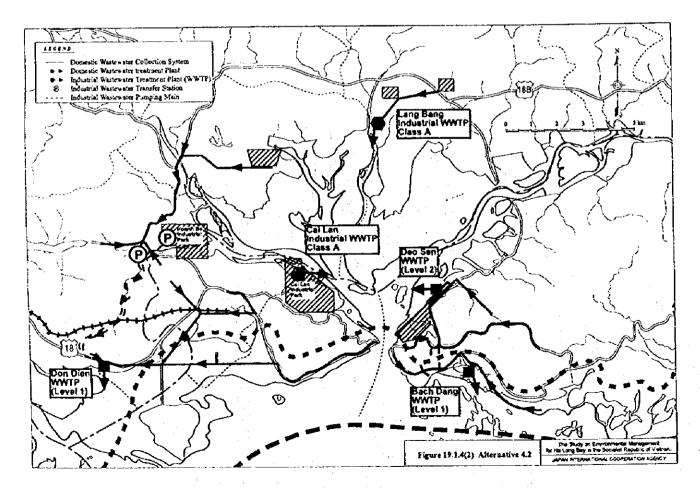






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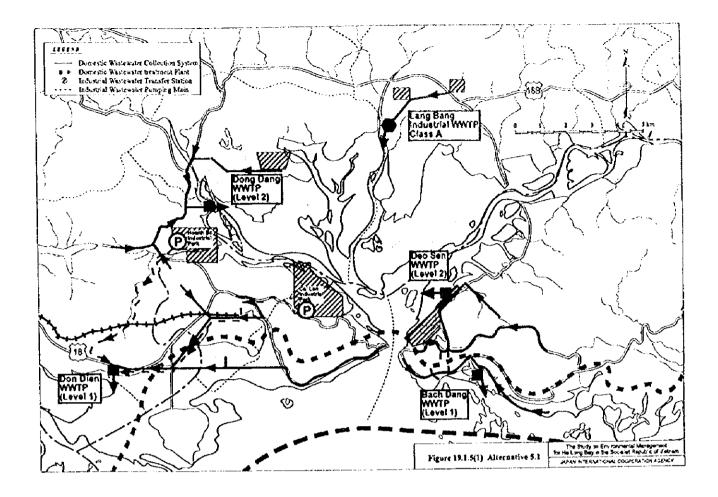


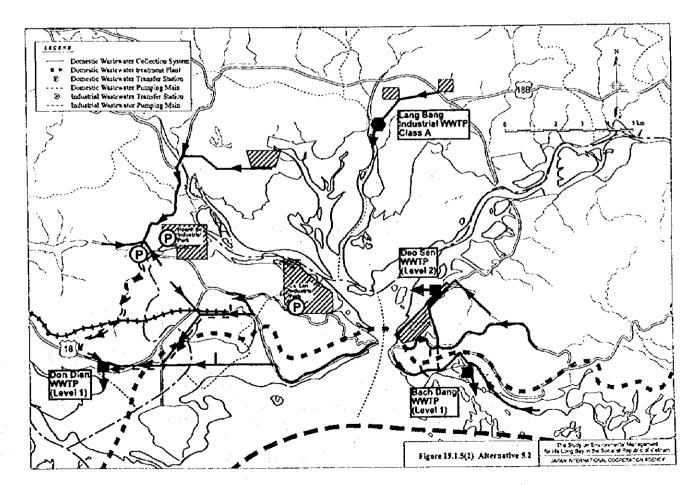
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