CHAPTER 9

CHAPTER 9 ENVIRONMENTAL MEASURES TO ATTAIN CRITERIA

9.1 Basic Concept of Environmental Measures

9.1.1 Management Method of Each Target

(1) Management Method of Water Quality

1) Basic strategy of pollution loads control

To achieve the conservation criteria of water quality, total pollution load control is required in addition to the concentration control. The sea area in the EMP area was divided into three environmental zones: Special Conservation Zone (SCZ), Conservation Zone (CZ), and Active Management Zone (AMZ). Among them, AMZ is located along the coastal line of the hinterland where most of the future development activities are planned. Thus, the pollution loads flowing into AMZ should be controlled firstly, to control total pollution loads flowing into the bays.

To achieve the conservation criteria of AMZ is prerequisite to achieve those of CZ and SCZ. Basic strategy of pollution loads control is show below.

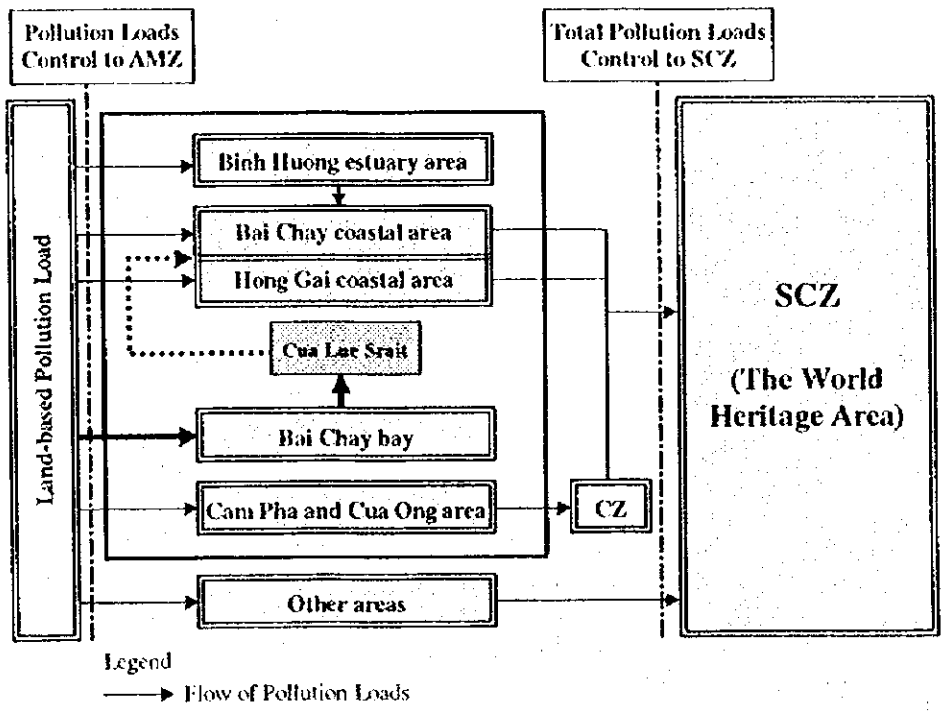


Figure 9.1.1 Basic Strategy of Pollution Loads Control

2) Allowable pollution loads

In order to achieve the conservation criteria of AMZ, allowable runoff pollution loads flowing into each area of AMZ were calculated by mass balance analysis. Allowable runoff pollution loads are summarized below:

Environ. Zone	Applied area	BOD (kg/day)	T-N (kg/day)	T-P (kg/day)	SS (kg/day)
AMZ	Bai Chay coastal area	170	240	100	2,300
	Hong Gai coastal area	420	670	150	2,500
	Cam Pha and Cua Ong area	1,550	3,100	820	56,800
	Bai Chay bay area	3,300	7,200	2,900	93,000
	Binh Huong estuary area	950	2,500	1,200	37,800

3) Management methods

For the water quality management especially pollution loads control, wastewater control for specific pollution sources is required in the first place. This is because that effects of measures for specific sources are clear and direct. Most management measures for specific pollution sources are sewerage system and/or individual wastewater treatment system such as industrial wastewater treatment. Most livestock are being raised in agricultural land and/or near markets and farmers houses. It is assumed that the wastewater of livestock will be treated by sewerage system together with domestic or market wastewater if it is in a sewered area.

In addition to this, measures for nonspecific pollution sources such as greening are required especially for control of SS. To control runoff SS from coal mining areas, the conservation criterion for the mining area was set based on the size of denuded area.

(3) Management Methods of Environmental Resources

1) Management methods of natural environment

In order to manage environmental resources, implementation of monitoring and inspection are required. Hardware type measures such as reforestation and rehabilitation of mangrove swamps are also required as mitigation to compensate for the lost environment. In addition to this, indispensable software type measures

such as land use and land reclamation controls and enforcement of regulation should be taken into consideration.

2) Management method of landscape

To achieve the conservation criteria of landscape, preparation of landscape management guideline, and enforcement of patrol and inspection will be required.

9.1.2 Required Measures by Environmental Zones

In the EMP area, most of human origin pollution loads are generated in DZ. Lots of development projects and socioeconomic growth together with increase in population are planned there in the future. Therefore, to control total pollution loads from them into the bays, sewerage system and/or individual wastewater treatment system are required in DZ before the generated pollution load flowing into the bays through AMZ. Similarly, rehabilitation of coal mining areas as well as treatment of mine wastewater is also required mainly in DZ.

Domestic and industrial solid wastes management is also required mainly in DZ. The collection of floating solid wastes, however, should be carried out in SCZ, CZ, and AMZ.

Measures for tourism and landscape are mainly required in SCZ to improve sanitation conditions there, and keep attractive and beautiful landscape. In case of natural environment, its management measures should be implemented based on the distribution of each resource, for example measure for tidal flats and mangrove swamps are should be developed in AMZ, and those for fish and shellfish are in SCZ and CZ, while reforestation is necessary for the whole catchment area.

The required measures by environment zones are summarized below.

Required Measures by Environmental Zones

Environ. Zones	Conservation Criteria	Necessary Actions	Required Measures
SC	1) Water quality - Trans.: 3.0~3.5m - BOD: 1.0~1.5 mg/ℓ - COD: 4.5~7.0 mg/ℓ - T-N: 1.1~1.3 mg/ℓ - T-P: 0.5~0.6 mg/ℓ - SS: 4~5 mg/ℓ 2) Environmental resources - Forest coverage : 464 km^2 - Tidal flats: 1,120 ha - Mangrove swamps: 200 ha - Coral reefs: present condition - Fish and shellfish: no illegal fishing - Landscape: no island changed artificially, no islands having bald spot, no cargo ship anchored in the Word Heritage area	1) Keeping attractive and beautiful landscape - Water quality control - Solid wastes control - Landscape element management 2) Conservation of natural environment (forest, tidal flats, mangrove swamps, coral reefs) 3) Sustainable use of fishing ground	1) Sea area - Improvement of sanitation condition (management of wastewater and solid wastes of islands and tourist boats) - Reinforcement of patrolling capability - Fishing activity control - Measures for landscape 2) Catchment area - Forest reserve area
CZ	1) Water quality - Trans.: 3.0m - BOD: 1.0 mg/ℓ - COD: 4.5 mg/ℓ - T-N: 1.1 mg/ℓ - T-P: 0.5 mg/ℓ - SS: 5 mg/ℓ 2) Environmental resources - Forest coverage : 208 km^2 - Fish and shellfish: no illegal fishing	1) Keeping good water quality - Water quality control - Solid wastes control 2) Conservation of natural environment (forest) - Forest protection - Reforestation 3) Sustainable use of fishing ground	1) Sea area - Water quality: to be controlled in AMZ and DZ - Fishing activity control 2) Catchment area - Reforestation in bare areas
AMZ	1) Water quality - Trans.: 0.5~1.5m - BOD: 1.1~1.3 mg/ℓ - COD: 5.0~7.5 mg/ℓ - T-N: 1.6 mg/ℓ - T-P: 0.7 mg/ℓ - SS: 5~15 mg/ℓ 2) Environmental resources - Tidal flats: 17,300 ha - Mangrove swamps: 3,800 ha - Fish and shellfish: No illegal fishing	1) Water quality control aimed at control in SC and CZ - Protection of decrease in tidal flats coverage - Upgrading of mangrove swamps 2) Conservation of natural environment 3) Sustainable use of fishing ground	- Water quality: keeping a water purification capacity - Reclamation control at tidal flats - Rehabilitation of mangrove swamps - Fishing activity control

Environ. Zones	Conservation Criteria	Necessary Actions	Required Measures
DZ	1) Water quality - TCVN (5942) 2) Environmental resources - Forest coverage: 228 km^2	1) Total pollution loads control flowing into AMZ - Wastewater treatment - Solid wastes management - Reforestation 2) Upgrading forest coverage - Reforestation 3) Preventive measures for soil erosion - Reforestation	1) Development of sewerage system - Drainage system - WWTP 2) Development of industrial WWTP 3) Solid wastes management - Collection vehicles and equipment - Landfill sites - Incineration of clinical and hazardous wastes 4) Measures for mining - Mine wastewater treatment - Measures for coal processing plants - Rehabilitation of dumping sites and river basins - Dredging 5) Measures environ. resources - Reforestation in bare areas

Note: Trans. means transparency.

With regard to measures in rural areas and/or in the upper stream areas of the bays' catchment, the present progress of the measures such as installation of a septic tank for domestic wastewater treatment are enough to attain the conservation criteria due to the relatively small runoff pollution loads from these areas. It should be noted, however, that the forest reserve areas should be managed strictly, and illegal deforestation activities there should be prohibited.

9.2 Sanitation Measures

9.2.1 Existing Plans for Wastewater Facilities

Studies for a World Bank funded water supply and sanitation project in Quang Ninh have been in progress since 1994. The first phase was for preparation of feasibility and pre-feasibility studies to define a priority investment project to upgrade the water supply, drainage, and sanitation services in Ha Long city and Cam Pha. The second stage, for which Kampsax International are the consultants,

includes, firstly, detailed design and construction supervision of the water supply component and, secondly, completion of the feasibility study and detail design of the sanitation and drainage component.

A draft final report for the Sanitation Feasibility Study was submitted in April 1998 but the World Bank requested some changes to this report and the final version was not approved until February 1999. Detail design of the first phase was commenced in Spring 1999 and the construction program is expected to extend over a 4½ year period. The total cost of the first stage works is estimated to be about US$ 38 million, broken down by component and area below.

(Unit: US$ $\times 10^6$)

Component	Bai Chay	Hong Gai	Cam Pha	Total
Sewerage and Sewage Treatment	3.1	1.2	1.2	5.5
Drainage	1.0	2.8	3.4	7.2
Solid Wastes Management	2.4	2.9	4.5	9.8
Technical Assistance	-	5.3	-	5.3
Sanitation Revolving Fund	-	0.5	0.5	1.0
Total Baseline Cost	6.5	12.7	9.6	28.8
Physical Contingencies	1.0	1.0	1.3	3.3
Price Contingencies	1.4	2.1	2.1	5.6
Total Project Costs	8.9	15.8	13.0	37.7

Source: Kampsax International, March 1999

The sewerage and sewage treatment project for the Bai Chay area includes a collector system comprising 3 km of gravity sewer and 6 km of pumping main with a total of eight pumping stations to deliver sewage to a treatment plant at Kenh Dong. The route of this interceptor sewer is indicated in Figure 9.2.1. Initially flow from the ferry and central areas will be delivered to the Bai Chay bathing beach wastewater treatment plant. However, it is intended in future that all the sewage will be treated at the Kenh Dong plant. The main collector will receive flow from overflow devices on the drainage channels and also by direct connections from properties along the main road. The works for Bai Chay are to be given the highest priority to encourage tourism in the area.

The Kenh Dong wastewater treatment plant is to be located in an expanse of brackish water which separates Gieng Day and Bai Chay and where there is sufficient area available to construct waste stabilization ponds. The area required is 8.5 ha which includes a 50 m wide buffer area. The treatment plant, which was designed to treat a flow of 3,500 m^3/day, comprised anaerobic, facultative and

maturation ponds as well as a septage treatment facility to serve septic tanks in the Bai Chay area. However, an alternative design of the same capacity using the compact sequencing batch reactor process has been prepared and is presently under consideration.

The project's first stage proposals for Hong Gai with regard to sewerage and sewage treatment were modified during the approval process for the final report. They no longer include a main collector sewer system or any wastewater treatment facilities, although a treatment facility at Deo Sen for septage is included. The emphasis of the first stage works is to alleviate flooding and convey sewage by a combined drainage system to the coast where it will be discharged through outfalls which will be extended a short distance into the sea. The drainage works will comprise rehabilitation of 3 km of existing drainage channels and construction of 15 km new sanitary drainage channels and pipelines.

Similarly to Hong Gai, the first stage works program for Cam Pha does not include a main collection system or wastewater treatment. Flooding is considered to be the major immediate problem in Cam Pha and the emphasis of the works will be to improve the drainage system by extensive rehabilitation of existing sanitary drainage channels and construction of some new combined drainage channels. In addition, a treatment facility for septage will be located some 4 km west of the town center. The works in Cam Pha are scheduled to commence after those in Hong Gai.

9.2.2 Strategies for Development of Wastewater Management Plan

(1) Design Loads

The design loads for domestic wastewater in 2010 are as follows:

Parameter	Loads in 2010
Flow	120 ℓ/c/day
Biochemical Oxygen Demand (BOD_5)	54 g/c/day
Chemical Oxygen Demand (COD_{Mn})	24 g/c/day
Suspended Solids (SS)	40 g/c/day
Total Nitrogen (T-N)	9.1 g/c/day
Total Phosphorus (T-P)	1.0 g/c/day
Reduction of BOD_5 in septic tanks	30%
Reduction of COD_{Mn} in septic tanks	10%
Reduction of SS in septic tanks	30%
Reduction of T-N in septic tanks	5%
Reduction of T-P in septic tanks	0%

As described in the previous chapter, two levels of treatment for domestic wastewater will have to be considered for alternative schemes to achieve the target conservation criteria. The discharge standards for Level 1 and 2 treatment are given in Chapter 8.

(2) On-Site Sanitation

The recommended on-site sanitation strategies for the different sectors are as follows:

1) Tourism and commercial areas

The use of flush toilets in new construction should be universal. Septic tanks discharging to sewers or sanitary drains should be used in all cases in existing developed areas. Developers should be required to provide separate sewer systems in all major new developments.

2) High density residential areas

The use of pour flush toilets is recommended and, at least in the short term, septic tanks should be provided. In the long term, separate sewerage systems should be provided in high density areas.

3) Low density residential and rural areas

The use of double vault pit latrines in these areas for properties without piped water supplies is generally acceptable. For houses with piped water supplies, pour flush toilets with septic tanks are recommended. Septic tank effluent should be discharged to soakaways where ground conditions allow.

4) Tourist boats and boat residents

Tourist boats should be required to install toilets on board and to either store or treat the wastewater. The most practical system for the majority of tourist boats will be to store the wastewater in a holding tank and provide a pump installation at the port to empty the tanks. Boat residents generally do not have the space or resources to install sanitation facilities and holding tanks on their boats. It is recommended that an adequate number of public latrines are provided within easy access of the areas where the boats are moored and that an education program is conducted to persuade boat residents to use these facilities.

(3) Sewerage

The results of the Field Survey indicate that the largest sources of pollution to Ha Long bay arise from non-specific sources. A part of the non-specific pollution will result from domestic wastewater that is either flushed overland to the sea during rainfall or pollutes groundwater that enters the rivers and sea. In order to reduce the pollution loads from this source it is necessary to collect wastewater by a sewerage system and then to provide treatment to the required effluent standard.

It is recommended that conventional piped sewerage should be provided in all new development areas. The strategies for provision of sewerage facilities in areas of existing development will depend on both the timing of the works and the type of development. The various strategies proposed are discussed below.

1) Urgent measures

Although the long term objective should be to establish separate sewer systems, the most effective method of achieving immediate improvements will be to retain the existing combined sanitary drainage system as the collection system initially and to intercept wastewater flows for treatment.

2) High density residential areas

An analysis of the costs of small bore and conventional piped sewer systems has been carried out and the results are presented in the Supporting Report. The per capita cost of the small bore system is estimated to be US$ 76 compared to US$ 104 for the conventional system. The small bore system also shows savings

in terms of net present value and it can be recommended for areas of existing development where the majority of houses have septic tanks.

3) Low density and rural areas

These areas in general have a low priority for piped sewerage and it is recommended that systems should only be provided where necessary to protect groundwater resources. Where piped sewerage is required, there will be significant savings through adopting small bore sewers.

(4) Wastewater Treatment

An analysis of the investment and running costs of treatment processes that could be used for Level 1 and Level 2 treatment is included in the Supporting Report. The competitive processes for Level 1 treatment in terms of net present values are, in ascending order of cost, waste stabilization ponds, oxidation ditches, and sequencing batch reactors. For Level 2 treatment there is no significant difference between the costs of oxidation ditches with side stream phosphorus removal and sequencing batch reactors.

1) Recommended processes for level 1 treatment

The advantages and disadvantages of the processes that are competitive are summarized in Table 9.2.1 and the following conclusions can be drawn:

- Waste stabilization ponds have some cost and operational benefits and should be adopted where sufficient suitable low cost land is available. However, the availability of large areas of flat land in or near urban areas in the EMP area is very limited and it is unlikely that sites for waste stabilization ponds will be available in the future.
- Oxidation ditches have a much smaller land requirement than waste stabilization ponds and have some cost and operational advantages over sequencing batch reactors. They are therefore the preferred method of treatment for most locations.
- Where there is insufficient land available for oxidation ditches, sequencing batch reactors is a suitable compact treatment method.

2) Recommended processes for level 2 treatment

Oxidation ditches with side stream phosphorus removal are preferred to sequencing batch reactors because the process is more robust and requires less operational skill.

3) Strategy for locating wastewater treatment plants

It is normal practice in developed countries for wastewater treatment facilities for urban areas to be centralized and for flows from different catchment areas to be transferred to a limited number of plants for treatment. However, it can be argued that, for the coastal strip development and steep catchments common in the Ha Long bay area, it may be cheaper to adopt a system using small treatment plants serving local areas and thereby avoid the costs of long main collection systems. An outline analysis of the costs of centralized and local treatment schemes to serve the Hong Gai area has therefore been carried out and the results of the analysis are illustrated in Figure 9.2.2. The analysis shows little difference in the overall costs of the two strategies, but given the much greater operational difficulties of running a large number of small plants, the centralized approach is still the most appropriate for the EMP area.

9.2.3 Alternative Sewerage Schemes for Urban Areas

(1) West Ha Long City

The planned sewerage works under the first stage of HWSSP for the Bai Chay area have been described at the start of this section and it is taken as a given condition for this Study that these works will be executed. While these measures will provide a solution in the short term for the Bai Chay area, it is also necessary to consider the longer term requirements of the whole of west Ha Long city.

The area to the west of Cua Luc strait is planned to be a major focus of development with large tourism, commercial, and residential developments in the Hung Thang area; a large industrial park in Cai Lan; and major industrial and residential development in Hoanh Bo. The area contains two natural catchments, the southern coastal area and the inland areas that drain to Bai Chay bay, and two

basic options have been considered for domestic wastewater management. In the first option flows from the two catchments would be treated separately. Flows from the coastal area would be conveyed to a treatment plant at Don Dien, west of the World Heritage buffer area. This location for the treatment plant allows effluent to be discharged well away from the bathing beaches and buffer zone and, in consequence, Level 1 treatment is adequate. Flows from the inland catchment would be collected at a central treatment plant at Dong Dang from where the effluent would be discharged to Bai Chay bay. Level 2 treatment would be necessary at this plant to meet the target conservation criteria for Bai Chay bay. The locations of the treatment plants and the main collection systems are shown on Figure 9.2.3.

The second option, which is also indicated in Figure 9.2.3, would be to transfer the flow from the inland catchment to the coast for treatment at Don Dien. The advantage of this option is that treatment to Level 1 would be adequate for the combined flows from the two catchments.

The key parameters for the treatment plants required for the two options are summarized below and full details are included in the Supporting Report. Land areas quoted include appropriate buffer areas.

Details of Domestic Wastewater Treatment Plants for West Ha Long City

Treatment Plant	Population Served (2010)	Process	Land Area Required (ha)
Option 1			
Don Dien	30,000	Oxidation Ditch	2.8
Dong Dang	90,200	Oxidation Ditch + Nutrient Removal	3.8
Option 2			
Don Dien	120,000	Oxidation Ditch	4.1

In the long term it is assumed that the flows from the Bai Chay area would be transferred to the Don Dien treatment plant rather than being treated at Kenh Dong. However, the waste stabilization ponds that will be constructed under the first stage HWSSP program could continue to serve Bai Chay for many years.

(2) Hong Gai Area

The population of the Hong Gai area is projected to increase to nearly 300,000 by 2010 and it will be the source of the largest domestic wastewater flows in the

EMP area. There are again two natural catchments, the northern area, which drains to Bai Chay bay, and the coastal area, which drains to Ha Long bay. The northern area has the majority of the population with a projected 2010 figure of some 200,000.

Similar options to those in the west Ha Long City area are not feasible because of the difficulty of finding a site in the southern part of Hong Gai large enough for a treatment plant to serve the total population. Therefore, it is necessary for Hong Gai to have separate treatment plants for the northern and southern areas. The northern plant, which will be sited near the proposed HWSSP septage treatment plant at Deo Sen, will have to treat to Level 2 standard to meet the target conservation criteria for Bai Chay bay. In order to minimize collection costs it is desirable to locate the southern plant near the central area where the need for treatment is most urgent. Preliminary investigations indicate that it should be possible to reclaim land on the south side of an island in the Bach Dang area and locate a compact treatment plant on this site. Level 1 treatment is adequate for this location.

The locations of the treatment plants and the main collector sewers are shown in Figure 9.2.4. The key parameters for the treatment plants required are summarized below and full details are included in the Supporting Report. The land area quoted for Deo Sen includes an appropriate buffer area but the area quoted for Bach Dang is the net area of the treatment facilities.

Details of Domestic Wastewater Treatment Plants for the Hong Gai Area

Treatment Plant	Population Served (2010)	Process	Land Area Required, ha
Deo Sen	164,000	Oxidation Ditch + Nutrient Removal	6.4
Bach Dang	60,000	Sequencing Batch Reactor	0.6

Note: The population quoted for Deo Sen is for Alternative 3.2. Some alternatives require a larger population to be served.

(3) Cam Pha

Cam Pha is the second major urban area in the EMP area with a projected 2010 population of nearly 150,000. The development is all in the coastal strip draining to Bai Tu Long bay. This layout is suitable for a coastal collector system to a central treatment plant. The most suitable location for the treatment plant is at the

proposed HWSSP septage treatment plant, which is located at the western end of the town.

The locations of the treatment plant and main sewer collection system are shown in Figure 9.2.4. The first stage of the treatment plant to be provided within the time frame of the EMP will have capacity to serve a population of 45,000. Treatment to Level 1 standard will be sufficient to meet the target conservation criteria in Bai Tu Long bay and the provision of an oxidation ditch is recommended. Full details of the treatment plant are included in the Supporting Report. The estimated cost of the recommended program for Cam Pha is about US$ 7.5 million including O&M cost from 2007 to 2010.

9.2.4 Basis of Cost Estimation for Sewerage

(1) Collection Systems

Collection systems are considered in three sections: the main collection system, local collection systems in existing development, and local collection systems in new development. Rates for main collection systems have been developed on a unit length basis for each catchment area. The build up of the rates for each catchment is shown in Table 9.2.2. Local collection in existing development is assumed to use the small bore system whilst conventional sewer systems are used for new development. Cost estimates for local collection systems are determined on a population served basis using per capita rates of US$ 76 and US$ 104 for small bore and conventional systems, respectively.

(2) Wastewater Treatment

The use of unit rates for estimation of treatment costs is not suitable for comparative cost analyses since it ignores economy of scale, which can be a significant factor. The cost estimates for treatment plants have therefore been derived by costing preliminary designs for each treatment plant. Details of the designs and cost estimates are included in the Supporting Report.

9.2.5 Priority Areas and Urgent Measures for Wastewater Management

The priority areas for wastewater management are the Bai Chay area because of its influence on tourism development and the central areas of Hong Gai for public health reasons and because it is the administrative and commercial center of Ha Long city. Cam Pha, where flooding is the main problem, has a lower priority for sewerage.

The first stage works of HWSSP for the Bai Chay area constitute a suitable urgent measures package to deal with the present wastewater problems and it is therefore unnecessary to consider any other urgent measures for this area in the EMP.

The situation in Hong Gai is different since sewage collection and treatment have now been omitted from HWSSP first stage program. It is therefore proposed that collection and treatment of sewage from the commercial center and densely populated central areas should be regarded as an urgent measure in the EMP. The recommended approach is to construct main collection systems to intercept flows from the sanitary drainage system that will be upgraded in HWSSP first stage program. As described above, two treatment plants will be required, one at Deo Sen and the other near Bach Dang. It is recommended that the capacity provided at Deo Sen in the urgent measures should be 25% of the projected 2010 capacity. This equates to an initial population served of about 40,000. For the Bach Dang plant, 50% of the projected 2010 capacity should be provided and this would serve a population of about 30,000.

The extent of the urgent measures main collection systems and the locations of the treatment plants are shown in Figure 9.2.5. The estimated cost of these measures is approximately US$ 15 million.

9.2.6 Existing Plans for Solid Wastes Facilities

The Feasibility Study for the Sanitation Component of HWSSP has proposed a first stage program for solid waste collection and disposal and detail design for this program has commenced recently. The overall targets for collection coverage in Ha Long city and Cam Pha in the first stage program are 65% and 50%

respectively. The first stage program includes the provision of vehicles and collection equipment to replace existing equipment and to provide capacity to meet the first stage targets. With regard to disposal of solid wastes, the first stage works program includes the following:

i) Upgrading of the Deo Sen landfill for reception of wastes from Hong Gai until about 2010.

ii) Construction a new sanitary landfill at Quang Hanh initially for wastes from Cam Pha but, in the long term to serve the whole urbanized area.

iii) Construction of a new sanitary landfill at Ha Khau to serve Bai Chay for at least 10 years and possibly longer if the planned bridge across the Cua Luc strait is not constructed.

The locations of the landfill sites and their capacities are shown in Figure 9.2.6. The landfills will include leachate treatment, separate facilities for dried sludge disposal, and weigh bridges. The estimated costs of the solid wastes component of the first stage program of HWSSP are shown in Section 9.2.1.

9.2.7 Criteria for Development of Solid Wastes Management Plan

(1) Waste Generation Criteria

The domestic wastes generation criteria proposed are as follows.

Area	Present		2010	
	Collection potential (g/c/day)	Collection potential (ℓ/c/day)	Collection potential (g/c/day)	Collection potential (ℓ/c/day)
Hong Gai and Bai Chay	550	1.38	710	1.78
Cam Pha	485	1.21	630	1.57

(2) Street Sweeping

Based on present experience, the amounts that will be collected are assumed to be 20% of the household wastes collection potential in Hong Gai and Bai Chay, and 13% of the potential in Cam Pha.

(3) Commercial, Market and Institutional Wastes

Based on present collection records, the amounts that will be collected are taken to be 18%, 25%, and 12% of the household wastes collection potential in Hong Gai, Bai Chay, and Cam Pha, respectively.

(4) Hospital Wastes

Again, based on existing records the amounts that will be collected are taken as 2.0%, 0.2%, and 0.06% of the household wastes collection potential in Hong Gai, Bai Chay and Cam Pha, respectively.

(5) Industrial Wastes

Any industrial wastes collected now by the environment companies is included in the figures given in Section (3) above. It is recommended that, in future, industrial solid wastes should be considered separately from municipal solid waste.

(6) Projected Domestic Solid Wastes Quantities

The target areas for the domestic solid wastes management plan are the built up urban areas within the study area. The collection areas are indicated in Figure 9.2.6. The estimated 2010 domestic solid wastes collection potential in the Hong Gai, Bai Chay and Cam Pha areas are presented below.

Solid Wastes Source	Hong Gai		Bai Chay		Cam Pha	
	ton/year	m^3/year	ton/year	m^3/year	ton/year	m^3/year
Household Wastes	75,542	188,856	31,007	77,518	33,458	83,644
Street Sweeping	15,108	37,771	6,201	15,504	4,350	10,874
Commercial, Market, etc.	13,598	33,994	7,752	19,380	4,015	10,037
Hospital Wastes	1,511	3,777	31	78	33	84
Total	105,759	264,398	44,992	112,479	41,856	104,639

9.2.8 Strategy for Solid Wastes Management

(1) Wastes Generation

The ways in which source generation may be limited include: reduction of unnecessary or excessive packaging, development and use of products with

greater durability, use of reusable products instead of disposable ones, and increasing the recycled material content of products.

(2) Wastes Handling, Separation and Storage at Source

Separation at source is an important step as this is the best place to separate waste materials for reuse and recycling. Fortunately, this is already widely practiced in the study area.

On-site storage is of primary importance because of public health concerns and aesthetic considerations. The recommendations for storage of wastes at source are summarized below.

Type of Development	Recommended Storage Method
High Density Areas	- Household storage units for door to door collection (householder supplied – not standardized) - Large portable storage containers at collection points in areas with good access - Hand cart mounted containers at collection points for areas with difficult access
Low Density and Rural Areas	- Portable storage containers at collection points in areas with good access - Hand cart mounted containers at collection points for areas with difficult access
Commercial Areas	- Large portable storage containers at collection points in areas with good access

(3) Wastes Collection

The recommended methods for municipal solid wastes collection are summarized below.

Type of Development	Recommended Collection Method
High Density Areas	- Compactor trucks or hand carts for door to door collection - Collection and/or emptying of portable containers by trucks - Collection of waste bins by hand cart for areas with difficult access
Low Density and Rural Areas	- Collection and/or emptying of portable containers by trucks - Collection of waste bins by hand cart for areas with difficult access
Commercial Areas	- Collection of portable containers or skips by trucks

(4) Separation, Processing and Transformation of Solid Wastes

The source separation that is widely practiced in the study area is often done for direct financial gain and therefore systems used in developed countries, such as curb collection and drop-off centers, are not generally applicable. Buy-back

centers may be appropriate for materials that do not have an outlet at present. Processing of wastes that have been separated is carried by the private sector in the study area and there is no need at present to introduce materials recovery facilities as part of the municipal solid wastes management system.

Chemical and biological transformation processes can be used to reduce the volume and weight of waste requiring disposal and to recover conversion products. The most commonly used chemical transformation process is combustion (incineration). The most commonly used biological transformation process is aerobic composting.

(5) Transfer and Transport

Transfer and transport operations become a necessity when haul distances to available disposal sites increase and direct hauling is no longer economically feasible. The urban areas of Hong Gai, Bai Chay and Cam Pha each have their own disposal sites at present and this situation is likely to continue for the next 10 years. Thus, there is no need to establish transfer stations within the time frame of the EMP. However, they would become necessary in the longer term if, as proposed by Kampsax, there is one landfill site to serve all the urban areas in the EMP area.

(6) Disposal of Solid Wastes

Even if wastes recovery and transformation are practiced, there are residues which have to be disposed of. There are only two basic options, disposal on land and disposal at the bottom of the sea. Marine disposal has generally fallen out of favor due to environmental concerns and it cannot be recommended near Ha Long bay. Thus, the only realistic option is disposal on land.

(7) Education and Enforcement

No matter how good a municipal solid wastes collection and disposal is, it will not be completely successful in improving the environment unless the public are persuaded to dispose of their rubbish in a responsible manner. Public awareness

can be improved through education programs in schools and in the community as well as through advertising campaigns in the press, on radio, and on television. However, experience elsewhere has shown that education on its own is not always sufficient and it is generally necessary to enforce anti-littering legislation through prosecution or fines.

9.2.9 Targets for Domestic Solid Wastes Collection and Disposal

The basis of the conservation criteria adopted for the EMP is that there should be no increase in pollution loads. For domestic solid wastes, the pollution load can be equated to the quantity of uncollected solid wastes. The coverage rates required to maintain the same level of uncollected waste in 2010 are as follows.

Parameter	Hong Gai	Bai Chay	Cam Pha	Overall
Solid wastes collection potential (ton/year)	105,759	44,992	41,856	192,607
Amount uncollected (ton/year)	20,855	9,897	22,360	53,112
Amount to be collected (ton/year)	84,904	35,095	19,496	139,495
Percentage coverage (%)	80	78	47	72

The collection coverage required to meet the conservation criteria conditions is relatively modest for a long term target; particularly for Cam Pha, where the coverage is lower than HWSSP first stage program target. It is, therefore, recommended that the targets for 2010 should be as follows.

Parameter	Hong Gai	Bai Chay	Cam Pha	Overall
Target coverage (%)	85	85	80	84
Amount to be collected (ton/year)	89,895	38,243	33,485	161,623
Amount uncollected (ton/year)	15,864	6,749	8,371	30,984

9.2.10 Required Projects to Meet 2010 Solid Wastes Collection Target

(1) Collection

The collection target can be met by the methods proposed for the first stage program of HWSSP, but some changes will be required to the percentage coverage for each method. HWSSP program relies to a significant extent on collection point systems and, while these work well in high density development, they will be less effective in lower density areas where the householders will have to carry their waste greater distances. It therefore is necessary to make greater use

of door to door collection methods and this, in turn, will require greater use of mechanized compactor vehicles in order to cover the larger areas effectively. The capacity of the solid wastes collection equipment that will be provided in HWSSP first stage program is approximately 64,000 ton/year whereas the collection rate required in 2010 to meet the target is 162,000 ton/year. The estimated base cost for the additional equipment to increase the collection capacity by 98,000 ton/year is US$ 4,900,000.

(2) Domestic Solid Wastes Disposal

The quantity of solid wastes that will have to be disposed between 2000 and 2010 to meet the collection target is estimated to be 950,300 ton which, assuming a compaction factor of two, is equivalent to a compacted volume of 1,188,000 m^3. The volume available in the sanitary landfills to be provided under the HWSSP first stage program is 960,000 m^3. Thus, by 2010 there will be a shortfall in landfill capacity of 228,000 m^3. It is projected that the present landfills will be full in 2008 and thus it will be necessary to provide more landfill capacity by 2008 or to reduce the quantities for disposal by introducing a transformation method, such as incineration or composting. Three options to deal with the increased quantities are considered in the Supporting Report and the estimated costs of these options are as follows.

(Unit: US$ million)

Disposal/Transformation Method	Estimated Cost
Landfill	2.25
Incineration	15.00
Composting	4.00

The construction cost of the incinerator is so much higher than the other options that it need not be considered further. Composting is just under twice the cost of landfilling in terms of construction costs and therefore could be feasible if the value of the compost as a soil conditioner can be realized. However, the amount of agricultural land in the EMP area is limited (6%) and the use of compost for agriculture in the area is not common. It is doubtful whether a market exists for compost at an economic rate and so the additional investment required for composting facilities cannot be recommended at present. The recommended

option is therefore extension of the landfill capacity and, in line with the long-term aim to centralize landfill facilities, the extension should be at Quang Hanh.

(3) Hospital Clinical Wastes

Hospital clinical waste is a hazardous waste that should be collected and disposed of separately from municipal solid wastes. It is recommended that a suitable incinerator should be provided for all the hospital wastes generated in the EMP area. The estimated quantity of hospital clinical wastes in 2010 is 1,575 ton/year and an incinerator with a rating of 10 ton/d would be adequate to handle this quantity.

(4) Education and Public Awareness

As described earlier, it is recommended that an education program and advertising campaign be undertaken. An allowance of 5% of the overall construction costs has been included to cover the costs of this program.

9.2.11 Estimated Costs of the Recommended Program for Domestic Solid Wastes Facilities

The build up of the estimated costs of the domestic solid wastes management plan for both construction and running costs are shown in Table 9.2.3. The total construction cost is about US$ 10.0 million and the annual running cost in 2010 is US$ 0.8 million. The phased investment and running costs over the period 2000 to 2010 are shown in Table 9.2.4.

9.2.12 Development of Industrial Wastewater Management

(1) Design Criteria

1) Industrial wastewater flows

The industrial wastewater flows used in this section for new industries are based on information presented in Chapter 5. Flows for existing industries and any

expansion of those industries are based on the results of the field survey carried out in 1998.

2) Pollution loads discharged from factories

Pollution loads from existing industries have been based on the results of analyses carried out during the field survey. Pollution loads for new industries are based on the premise that it is a requirement for all new industry to pre-treat its wastewater to the Vietnamese Standard for industrial discharges to Class B receiving waters.

3) Effluent discharge standards

Vietnam Standard TCVN 5945-1995 specifies parameter limits and allowable concentrations of pollutants in industrial wastewater discharged into water bodies. The standard considers three classifications of water bodies: A, B, and C. Class B includes waters used for navigation, bathing, aquatic breeding and cultivation and is therefore the classification applicable to Bai Chay bay and the coastal areas of the study area. The most stringent effluent quality standard is for discharges to Class A waters, which are waters used as a source of drinking water. This classification does not apply strictly to Ha Long bay or Bai Chay bay. However, there are instances where a higher discharge standard than required for Class B waters could be necessary to meet the target conservation criteria. In such cases reference is made to the discharge standard for Class A waters.

9.2.13 Strategy for Industrial Wastewater Management Plan

(1) General

From the point of view of industrial wastewater management, Ha Long city is fortunate in that there is little industry in existing developed areas and the planned industries are to be located in industrial parks. Individual industries will have to treat their wastewater to the effluent standard for discharges to Class B waters. In addition to this, the industrial parks should have the infrastructure to collect effluent discharges from the individual factories and either provide further treatment to the wastewater or deliver the combined factory effluents to a suitable discharge location.

(2) Wastewater Treatment

1) Pre-treatment

The on-site pre-treatment methods used by individual factories will depend on the types of industries and the characteristics of the wastewaters. The alternative technologies that can be used for treatment of industrial wastewater, either individually or as an integrated system, are indicated in Figure 9.2.7.

The most significant existing industrial discharges are from the brewery and seafood processing factory in Hong Gai. Both factories are within the area for which an urgent collection and treatment system has been proposed and, since the pollution loads are relatively small it is acceptable to connect the discharges directly to the collection system when it is commissioned.

2) Centralized industrial wastewater treatment

Given adequate control of factory discharges, the combined wastewater flow should be treatable to the effluent standard for discharge to Class A waters by biological means. Oxidation ditches are the generally preferred method.

It is also possible to treat combined industrial wastewater flows in combination with domestic wastewater. Again, given adequate control of factory discharges, it is possible to use the same treatment processes recommended for domestic wastewater treatment and to produce effluents to Level 1 or 2 standards as required.

3) Discharge locations and effluent standards

The effluent standard required for a discharge to a receiving water will depend upon the target conservation criteria for that water. In general, the standards for industrial wastewater discharges to Class B waters will be adequate for discharges to Ha Long bay and Bai Tu Long bay. However, a higher level of treatment will be necessary in order to meet the target conservation criteria for the enclosed Bai Chay bay.

9.2.14 Main Industrial Development Areas

The main industrial development areas and the projected 2010 industrial wastewater flows and loads are shown below.

Area	Flow (m^3/day)	BOD_5 (kg/day)	T-N (kg/day)	T-P (kg/day)
Cai Lan Industrial Park	23,850	1,196	542	74
Hoanh Bo Industrial Park	27,550	1,382	627	86
Lang Bang (cement)	2,560	108	40	3
Quang Hanh (cement)	2,140	88	33	2
Cam Pha (cement)	2,140	88	33	2
Cua Ong (steel refinery)	2,400	168	163	18

The Quang Hanh, Cam Pha and Cua Ong factories discharge to Bai Tu Long bay and wastewater treatment to the standard for discharge to Class B waters is adequate. Since pre-treatment to this standard will be a prerequisite for these developments they are not considered further in the industrial wastewater management plans.

9.2.15 Options for Treatment and Discharge of Industrial Wastewater

(1) Cai Lan Industrial Park

Three options have been considered for reducing the pollution loads from this planned major industrial park. The options are shown in Figure 9.2.8.

- Option 1. The discharges from the individual factories would be collected and treated at a plant within the Industrial Park to effluent standard Class A prior to discharge to Bai Chay bay.
- Option 2. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and discharged to Ha Long bay near Don Dien. No further treatment beyond the prerequisite pre-treatment to Class B standard would be provided in this option.
- Option 3. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and delivered to the domestic wastewater treatment plant at Don Dien. The combined domestic and industrial wastewaters would then be treated to domestic Level 1 prior to discharge to Ha Long bay.

(2) Hoanh Bo Industrial Park

Four options have been considered for reducing the pollution loads from this industrial park, which is to be developed at a later date than the Cai Lan Industrial Park. The options are shown in Figure 9.2.9.

- Option 1. The discharges from the individual factories would be collected and treated at a plant within the Industrial Park to effluent standard Class A prior to discharge to Bai Chay bay.
- Option 2. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and discharged to Ha Long bay near Don Dien. No further treatment beyond the prerequisite pre-treatment to Class B standard would be provided in this option.
- Option 3. The discharges from the individual factories would be collected and delivered to the domestic wastewater treatment plant at Dong Dang. The combined domestic and industrial wastewaters would then be treated to domestic Level 2 before discharge to Bai Chay bay.
- Option 4. The discharges from the individual factories would be collected at a transfer pumping station in the Industrial Park and delivered to the domestic wastewater treatment plant at Don Dien. The combined domestic and industrial wastewaters would then be treated to domestic Level 1 before discharge to Ha Long bay.

(3) Lang Bang

The factories in this area are remote from Ha Long bay and from the domestic sewerage systems. The only feasible way to reduce the pollution loads from these factories is provide further treatment in the area prior to discharge to Bai Chay bay. It is recommended that the wastewater discharges from the two main factories be treated at a central treatment plant to Class A standard. The suggested arrangement is shown in Figure 9.2.9. The estimated construction cost for the recommended project is US$ 1.6 million including O&M cost from 2007 to 2010.

9.2.16 Basis of Cost Estimation Industrial Wastewater Management

(1) Collection Systems

Rates for main collection systems in industrial parks have been developed on a unit length basis for each park. The build up of the rates for each park is shown in Table 9.2.5.

(2) Wastewater Treatment

The cost estimates for treatment plants have therefore been derived by costing preliminary designs for each treatment plant. Details of the designs and cost estimates are included in the Supporting Report.

9.2.17 Development of Industrial Solid Wastes Management

(1) Design Criteria for Industrial Solid Wastes Management

1) Industrial solid wastes generation

Waste generation from new industry is difficult to forecast without knowledge of the exact types of industry to be established. However, the factories to be established in the various industrial parks are not expected to be of the type that generates large amounts of solid waste. Therefore the overall factory solid wastes generation is taken as 25% of domestic solid wastes generation.

2) Hazardous wastes generation

Hazardous or special wastes may be defined as all wastes that by their nature pose a threat to the environment and to human health. There are many substances that are potentially hazardous and the Supporting Report includes a generic listing. This list is a guide only and it does not follow that wastes containing substances listed are necessarily hazardous. Normally each case must be considered individually taking into account the quantity and concentration of potentially hazardous substances. A recommended assessment procedure is illustrated in Figure 9.2.10.

The Development Master Plan of Ha Long City for 1994-2000 includes fairly specific lists of the types of industries that should and should not be encouraged in future industrial development. If these guidelines are followed, the amounts of hazardous wastes generated by new industries should be relatively low and an allowance of 10% of the total industrial solid wastes generation would be adequate.

(2) Projected Industrial Solid Wastes Quantities

Based this design criteria, the projected 2010 total industrial solid wastes generation will be 34,500 ton per year of which 3,450 ton will be hazardous wastes.

9.2.18 Strategy for Solid Wastes Management Plan

(1) Industrial Wastes Generation

The ways in which source generation may be limited include: reduction of wastage of raw materials, use of wastes from one industry as a raw material for another industry, efficient use of materials to minimize resource requirements, and increasing the recycled material content of products.

(2) Collection of Industrial Solid Wastes

It is recommended that industry be responsible for all aspects of collection. The method of collection should be the choice of industry and could include the use of its own transport, the use of private sector contractors, or the use of public sector collection services at a commercial rate.

(3) Separation, Processing, and Transformation of Solid Wastes

Certain industries may be able to use part or all of the separated or processed wastes products of other particular industries. Every effort should be made to encourage these practices by siting such compatible industries together.

Incineration under closely controlled conditions can be used for the disposal of hazardous wastes. Modern cement kilns also have suitable characteristics for the safe incineration of certain hazardous wastes and the opportunity for mutually beneficial disposal of hazardous wastes in this manner in the EMP area should be investigated.

(4) Disposal of Solid Wastes Residues

There are only two basic options for disposal of residues, disposal on land and disposal at the bottom of the sea. Marine disposal cannot be recommended near Ha Long bay, so the only realistic option is disposal on land. In the case of industrial solid wastes this invariably means disposal to a landfill.

9.2.19 Required Projects to Meet Projected Industrial Solid Wastes Generation

(1) Collection

Additional collection equipment will be necessary to handle the projected industrial wastes generation. This equipment will essentially be funded by industry whether it purchases its own equipment, uses private sector contractors, or uses public sector services.

(2) Industrial Solid Wastes Disposal

The only economic option for the disposal of non-hazardous industrial wastes is to a landfill. Disposal must take place at authorized and controlled sites. Such sites could be those used for disposal of municipal solid waste, privately operated sites, or sites owned by particular industries. In any event, industry will have to fund the cost of creating sufficient landfill capacity. The required landfill capacity to accept the projected industrial solid wastes generation until the year 2010 is estimated to be 94,000 m^3.

(3) Hazardous Wastes Disposal

The methods that can be adopted for disposal hazardous wastes vary depending on the nature of the wastes and can include incineration, special landfill facilities, and long term containment or storage. All of these methods will be applicable to a greater or lesser extent in the EMP area. Burial in special landfill facilities is economic but is not suitable or desirable for all hazardous wastes. Long term containment is expensive but will be necessary for certain hazardous wastes such as radioactive materials. Incineration is suitable for a number of hazardous wastes provided that it takes place under carefully controlled conditions with provision to avoid harmful emissions. An incinerator capacity of 15 ton/day will be appropriate for the proportion of the projected 2010 hazardous wastes generation that is suitable for incineration.

9.2.20 Estimated Costs of the Recommended Program

The build up of the estimated costs of the industrial solid wastes management plan for both investment and running costs are shown in Table 9.2.6. The total investment cost is US$ 3.1 million and the annual running cost in 2010 is US$ 0.4 million.

The phased investment and running costs over the period 2000 to 2010 are shown in Table 9.2.7.

9.3 Environmental Measures for Mining

9.3.1 Existing Environmental Measures for Mining

(1) Regulations

The coal mining operation in Quang Ninh Province is generally subject to the following laws and related regulations:

- Law on Environmental Protection, 1994
- Mineral Law, 1996
- Forest Protection/Development Law, 1991

- Water Resources Law
- Land Law, 1993
- Decree No. 175/CP, Execution of the Law on Environmental Protection
- Decree No. 68/CP, Guidelines for the Implementation of Mineral Law
- Decree No. 26/CP, Guidelines for Administrative Violations of Environmental Protection Law
- Decision No. 2920/QD-MTg, Applying Vietnam Environmental Protection Standards
- Circular No. 2781 TT KCM of MOSTE, Guidelines for Environmental License
- Circular No. 291 TT/KCM of MOSTE, Guidelines on the Protection of Ha Long Bay Environment
- TCVN 5326-1991, Open Mining Technical and Operational Regulations
- TCVN 5945-1995, Industrial Wastewater Discharge Standard

As far as the overall regulatory frame is concerned, these laws and regulations appear to cover all essential aspects of environmental problems. However, because these laws and regulations are not necessarily specific, and because QNPC does not have the strong authority to enforce environmental regulations to the State-Owned-Enterprises (SOEs), the environmental laws and regulations are not strictly enforced.

To facilitate the environmental compliance by mining enterprises, the UNDP Project VIE/95/003 (UNDP, 1998) recently drafted the following documents.

- Model Agreement between Quang Ninh People Committee and VINACOAL
- Special Environmental Protection Standards for the Open-Pit Coal Mining Industry in Quang Ninh Province
- Special Rules for Assessment, Compensation and Restoration of Damage to the Environment for the Coal Industry in Quang Ninh Province

To our knowledge, these documents from the UNDP Project were accepted by the central government in general terms, and VINACOAL is reviewing the details.

(2) Environmental Impact Assessment

In 1997, 28 major coal mining enterprises in Quang Ninh Province submitted EIA reports in compliance with the Environmental Protection Law. The reports are being reviewed by MOSTE. This is a significant progress from the past as essentially no formal EIA had been carried out before. The EIA reports cover the environmental impacts and plans for mitigating measures including financial analysis. However, because VINACOAL and mining enterprises do not have clear future production plans, the analyses of the future environmental problems are weak. In addition, the quality of the reports varies from one enterprise to another. Further coordination among mining industries is strongly recommended. Aside from the EIA studies by mining enterprises, several environmental studies have been carried out by the national environmental experts.

(3) Environmental Fund

VINACOAL now sets aside a part of its revenue for environmental purposes, such as environmental measures and environmental compensation. The level of the allocation had long been debated among MOI, VINACOAL, and MOF since the mid-1990s. It is currently set at 1%, and some enterprises spend more than 1% of their revenues for environmental expenditures. To our knowledge, however, there has been no official order to legally-bind VINACOAL to this environmental fund, and it is on voluntary basis for now. According to VINACOAL officials, the current environmental fund amounts to roughly 30 billion VND/year. Fifty percent of the fund is used by each enterprise, and the rest is pooled for high-priority environmental projects in the region. VINACOAL also contributes to the Provincial environmental projects through this fund.

(4) Technical Measures

Coal mining enterprises have carried out a number of environmental projects in the past. Some of the major projects are listed in Table 9.3.1. Most of the environmental measures carried out in the past have not been well documented, and there have been no coordinated efforts to evaluate the environmental

effectiveness of such measures. Because the information about the historical and existing environmental measures is scarce, it was difficult to analyze the overall extent of these efforts. However, it is easy to speculate the following:

- Environmental measures in the past have been limited, and were not effective enough to control major environmental problems such as the sedimentation problems in rivers and irrigation systems, landslide in Cam Pha, saltwater intrusion, and siltation in Bai Tu Long Bay.
- Most of the existing measures are oriented toward fixing the immediate problems by dredging, installing erosion control dykes, or compensating for the inflicted damages.

According to DOSTE, the environmental performance of the coal enterprises improved considerably after the restructuring and consolidation of the industries to VINACOAL in mid-1990s, and most mining enterprises now have plans for environmental projects. In addition, UNDP Project VIE/95/003 (UNDP, 1998) formulated "Pilot Project on Land Reclamation", "Pilot Project in Dust Prevention", and "Pilot Project on Wastewater Treatment". These pilot projects were designed to be financed through VINACOAL's environmental fund. UNDP project also developed "Environmental Monitoring Plan in Quang Ninh" (UNDP, 1998), in which a plan for environmental monitoring is briefly outlined. Recently, rehabilitation of coal processing plants has attracted the attention of Japanese investment, which aims at recycling coal sludge for commercial (power generation) purposes.

9.3.2 Environmental Targets for Coal Mining Industries

To set specific targets for each environmental program and project, the following requirements are proposed:

(1) Compliance with Environmental Regulations

1) Environmental laws and regulations

As it was reviewed in Section 9.3.1, the coal mining operation in Quang Ninh province is generally subject to a series of environmental laws, regulations, and guidelines. All coal enterprises should comply with these laws, regulations, and guidelines.

2) Mining in environmentally-sensitive area

QNPC proposed to prohibit mining activities in the following areas (see Chapter 18 of the Supporting Report).

Areas of No Mining Activities

No.	Name	Reasons
I*	Yen Tu Relics	historical and religious significance
II*	East Dong Trieu Lake	source of irrigation water
III*	North Dong Trieu Lake	source of irrigation water
IV	Yen Lap Lake	source of irrigation water
V	Dong Ho Lake	water supply source
VI	Cao Van Lake	water supply source
VII	Dien Vong Water Supply Plant	water supply source

*: out side of the EMP area

It is recommended that mining activities in these areas be prohibited. In addition, overburden dumping, deforestation, and other disturbances of environmentally sensitive areas should be prohibited.

(2) Basin-Specific Environmental Targets

1) Non-point source pollution control/vegetation coverage

To ensure sustainable development of Ha Long bay and Bai Tu Long bay areas, the environmental conservation criteria set in Chapter 8 of this Supporting Report shall be followed. The mining area is vast, and it is difficult to directly monitor environmental conditions, such as the pollution loads. For this reason, the target criterion was set in terms of "size of denuded area" rather than the pollution loads at specific locations. The suggested environmental targets are summarized in the table below.

Target Size of Denuded Area in 2010

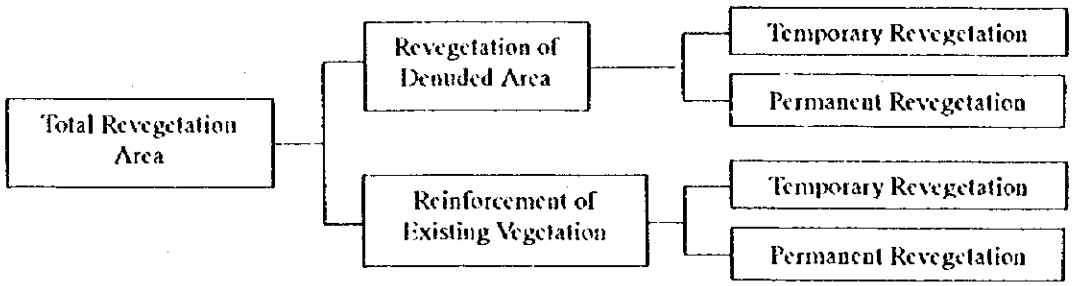
(Unit: ha)

No.	Basin Name	Present	Without Measure	With Measure
6	Dien Vong	1,709	2,694	1,720
7	Hong Gai North	195	333	200
8	Hong Gai South	3	5	5
9	Ha Tu	790	1,022	790
10	Cam Pha West	65	89	40
11	Cam Pha Central	376	458	36
12	Cam Pha East	213	213	53
13	Cua Ong	138	218	140
14	Mong Duong	1,876	2,488	1,890
Total		5,420	7,520	4,874

No mining is allowed in other basins.
No.: Catchment area number used in Chapter 8 of Main Report.

2) Revegetation

To meet the basin-specific environmental targets, the denuded areas have to be revegetated. In addition to the denuded area, vegetation in buffer area and area where existing vegetation is degraded may also have to be reinforced. Hence, the revegetation requirement shall be designed according to the following classification.



Classification of Revegetation Area

In total, 3,900 ha are to be revegetated, of which 2,736 ha is used to revegetate the denuded area, and remaining 1,164 ha is revegetated to reinforce existing vegetation as shown below.

Proposed Area for Revegetation

(Unit: ha)

No.	Basin Name	Total Revegetation Area	Revegetation of Denuded Area	Reinforcement of Existing Vegetation
6	Dien Vong	1,500	974	526
7	Hong Gai North	150	133	17
8	Hong Gai South	-	-	-
9	Ha Tu	400	232	168
10	Cam Pha West	50	49	1
11	Cam Pha Central	600	582	18
12	Cam Pha East	-	-	-
13	Cua Ong	110	78	32
14	Mong Duong	1,000	598	402
-	Processing Plant	90	90	-
Total		3,900	2,736	1,164

No. : Catchment area number used in Chapter 8 of Main Report.

3) Point-source pollution control

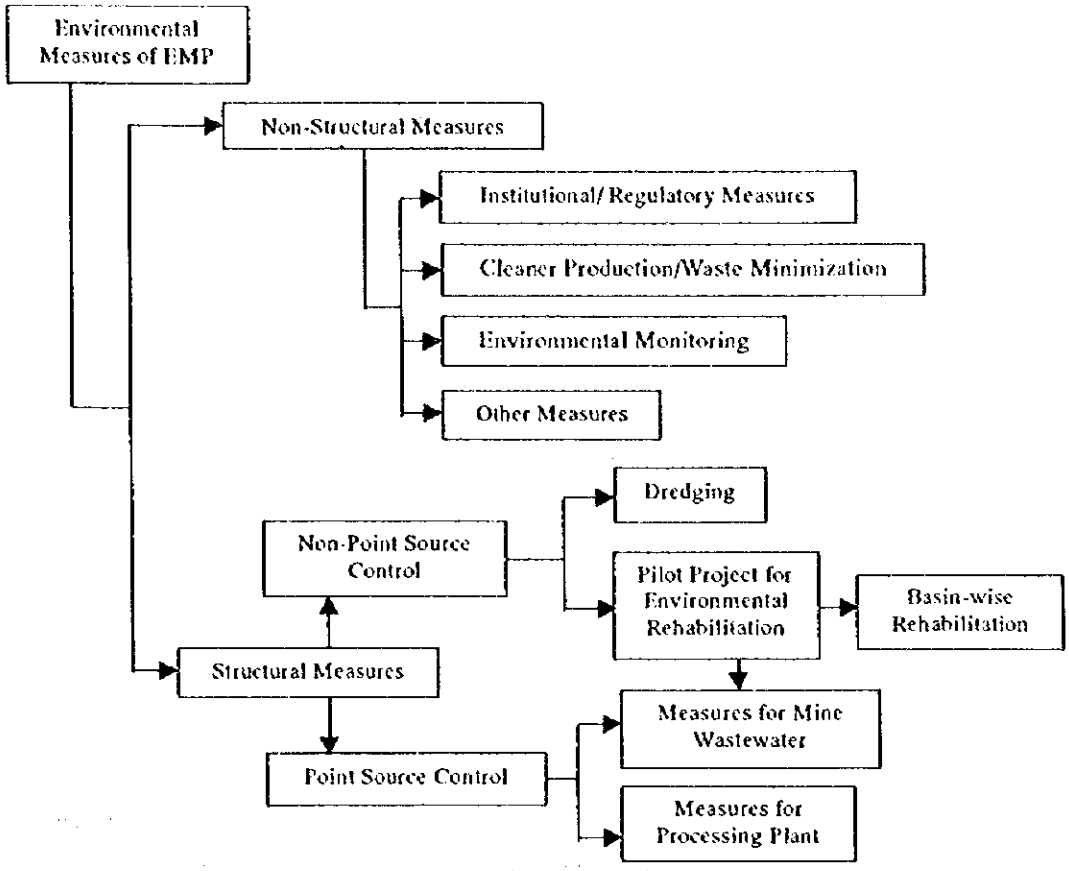
For point sources, the compliance with the Discharge Standard, TCVN 5945-1995, by 2010 is the target.

(3) Rehabilitation Requirement

According to an estimate by VINACOAL, the coal production in the EMP area is expected to reach a peak in the next 5 to 10 years, and will start to diminish after that (Table 9.3.2). Assuming that the production lasts 40 years from now, roughly 1/3 of the output will be produced by 2010. In principle, therefore, 1/3 of the cost for the mine land rehabilitation works, including the cost for operation/ maintenance works, shall be generated by 2010, and be invested on rehabilitation works or set aside for future rehabilitation works. Obviously, there is an urgent need to develop a comprehensive rehabilitation plan, and implement it. To meet the basin-specific rehabilitation targets, it is suggested that any mine land developed from now on has to be rehabilitated as soon as practically possible. For the development of area that cannot be rehabilitated soon, the mining industry should rehabilitate other mine land larger than the area to be developed so that the area to be rehabilitated does not increase anymore.

9.3.3 Suggested Environmental Programs and Projects

The environmental targets set in Section 9.3.4 should be achieved through an array of environmental measures. They are broadly classified into "structural measures" and "non-structural measures". The figure below schematically shows the overall organization of various environmental measures.



Organization of Proposed Environmental Measures

In total, 12 environmental measures were proposed. They are summarized below (see Fig. 9.3.1 for the locations of the project sites).

(1) Development of Environmental Plan

Good planning is a required part of environmental management, although developing a good environmental plan is not easy. Hence, the EMP adopts a 2-stage approach to develop environmental plans for coal industries. First, a model environmental plan is formulated for a representative mine in the EMP area. A suggested mine for this is East Coc Sau mine, where VINACOAL is currently

soliciting an international business partner for the development. In the following stage, all mines formulate their own environmental plans based on the model environmental plan, and VINACOAL prepares a comprehensive environmental plan for the region.

(2) Pilot Project on Environmental Rehabilitation

The lack of practical experiences is one of the important factors preventing the coal industries to design and implement effective environmental measures. Therefore, a pilot project is proposed to foster working experiences in designing and implementing environmental rehabilitation. The suggested project site is Mong Duong River basin. The design/construction stage of the project will last 3 years, followed by O&M. The table below summarizes of the project.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	150	
	Revegetation	ha	100	
	Drainage System	m	11,000	
	Wastewater Treatment	facility	1	
Target	Denuded Area	ha	125	50
	SS	10^3 tons/year	3.8	1.7
	Erosion	10^3 tons/year	50	21

(3) Environmental Measures for Mine Wastewater

This project will install water treatment system at 50 outlets of mine wastewater to keep the level of pollutants below the discharge standard (TCVN 5945-1995). The anticipated reduction in SS is estimated below.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	-	all mines	
Target	SS in 2010	10^3 tons/year	8.88	2.82

(4) Environmental Measures for Coal Processing Plants

There are two major processing plants in the EMP area: Cua Ong Coal Processing Plant and Nam Cau Trang Coal Processing Plant. Cua Ong plant uses a combination of wet and dry technologies, and Nam Cau Trang plant uses wet technology to process coal. Considering the environmental problems at these

plants, the following measures are suggested: 1) environmentally sound disposal of solid waste, 2) improvement of drainage system to intercept SS in runoff and floor washing wastewater, and 3) dust control.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	approx. 400 ha	
Target	Solid Waste	-	environmentally-sound disposal	
	SS in 2010	tons/year	4,400	880

Among these measures, this report mainly focuses on the improvement of drainage system, and dust control. The environmentally-sound disposal of solid waste requires a detailed feasibility study.

(5) South Deo Nai Dumping Site Rehabilitation Project

Among the 739 ha of mining land in Cam Pha Central and Cam Pha East basins, this project will mainly rehabilitate 600 ha of the steep slope area. The main components of the project include: terracing the western wall, installation of diversion channels and downdrains on the slopes, and revegetation of the denuded area. The project is expected to reduce the erosion rate to 1/6 of the present level (approximately 240,000 tons/year). The table below summarizes the project area, area to be rehabilitated, and anticipated pollution loads without and with the project.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	739	
	Revegetation	ha	600	
	Drainage	m	33,000	
Target	Denuded Area	ha	671	89
	SS	10^3 tons/year	7.30	1.46
	Erosion	10^3 tons/year	278	40

(6) Mong Duong River Basin Rehabilitation Project

Deo Nai – Coc Sau area in the southeast part of the basin is the most disturbed area in the EMP area, and is a main source of erosion. In addition, the contribution from the Cao Son area is increasing recently. Unless environmental measures are

taken, about 600 ha of land will be newly denuded by 2010. The main objective of the Mong Duong River Basin Rehabilitation Project is, therefore, to rehabilitate this area so that the denuded area in 2010 is reduced to 1,890 ha. Because "Pilot Study on Environmental Rehabilitation" rehabilitates a part of this basin, this project will rehabilitate the remaining part.

Project Size and Target*

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	3,250	
	Revegetation**	ha	900	
	Drainage	m	99,000	
Target	Denuded Area	ha	2,413	1,890
	SS	10^3 tons/year	27.7	23.6
	Erosion	10^3 tons/year	946	764

Note: * excluding the rehabilitation with "Pilot Study on Environmental Rehabilitation"
** including temporal rehabilitation site

(7) Dien Vong Basin Rehabilitation Project

This area is characterized by the existence of relatively new, small mines, such as Khe Tam, Nga Hai, and Ha Rang along the southwest tributary developed in the last 10 years. In addition, there are some mines, such as Suoi Lai, Cao Thang, and Ha Tu in the north of Ha Tu basin. Except Ha Tu mine area, mining activities are scattered, and the pollution loads per unit area are not high. However, due to the large size of the basin, and the anticipated rapid increase in denuded area in the future, this basin is going to contribute to 37% of the total SS from coal-mine related non-point sources by 2010. Hence, this project will mainly focus on establishing contemporaneous rehabilitation in the newly developed area.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	6,750	
	Revegetation*	ha	1,500	
	Drainage	m	165,000	
Target	Denuded Area	ha	2,694	1,720
	SS	10^3 tons/year	32	23
	Erosion	10^3 tons/year	769	508

Note: * including temporal rehabilitation site

(8) Ha Tu Basin Rehabilitation Project

Ha Tu basin is not as large as Mong Duong and Dien Vong basins. However, over 60% (790 ha) of the basin is already denuded, and the erosion rate is high. Therefore, the main objective of this project is to minimize denuded area as much as possible.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	1,275	
	Revegetation*	ha	400	
	Drainage	m	44,000	
Target	Denuded Area	ha	1,022	790
	SS	10^3 tons/year	11	9
	Erosion	10^3 tons/year	469	366

Note: * including temporal rehabilitation site

(9) Hong Gai North Basin Rehabilitation Project

Located in the north of the inhabited area of Hong Gai, this is one of the areas where people are exposed to the direct impact of mining activities. Considering the future expansion of the urban area, the conflict between mining industry and urban development will grow further. Therefore, this project aims at isolating the environmental impacts of coal mining activities to the urban area.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	1,275	
	Revegetation*	ha	150	
	Drainage	m	16,500	
Target	Denuded Area	ha	333	200
	SS	10^3 tons/year	4.4	2.9
	Erosion	10^3 tons/year	111	70

Note: * including temporal rehabilitation site

(10) Cam Pha West Basin Rehabilitation Project

This area is located north of Cam Pha town, and there is Tay Khe Sim mine in the basin. The mining activity is minor, and the environmental condition is much better than the one in the neighboring South Deo Nai dumping site. However, the south slope is steep and is prone to intense erosion once the surface vegetation is

denuded. For this area, this project focuses on revegetating the denuded area and buffer area. The target is to reduce the denuded area to 40 ha by 2010.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	125	
	Revegetation*	ha	50	
	Drainage	m	5,100	
Target	Denuded Area	ha	89	40
	SS	10^3 tons/year	1.1	0.4
	Erosion	10^3 tons/year	50	23

Note: * including temporal rehabilitation site

(11) Cua Ong Basin Rehabilitation Project

This area is characterized as a haul route of coal to processing plant and coal ports. In addition, the impact of mining activities in the Mong Duong river basin is reaching this basin. Therefore, dust control, revegetation of buffer area, and erosion control of dumping sites are the main components of this project.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	550	
	Revegetation*	ha	110	
	Drainage	m	12,100	
Target	Denuded Area	ha	218	140
	SS	10^3 tons/year	2.6	1.8
	Erosion	10^3 tons/year	84	56

Note: * including temporal rehabilitation site

(12) Dredging Project

According to our estimate, as much as 2 million tons of sediment is eroded every year. While not all of the 2 million tons is reaching the rivers and seas, a substantial amount is filling-up rivers, reservoirs, and irrigation systems, and there are occasional problems of limited landslides in the rainy season. Because denuded area is the main source of erosion, rehabilitation of denuded area, as proposed, will significantly reduce the erosion in the long run. However, it will take time before the proposed measures start to show a benefit. Meanwhile, the deposited sediment will have to be periodically dredged out from critical water courses, such as rivers and irrigation channels.

Project Size and Target

Item	Category	Unit	Without Project	With Project
Project Size	Project Area	ha	Affected Area	
Target	Dredging	tons/year	0.6-0.8 million	

9.3.4 Estimated Costs of Proposed Environmental Measures

The estimated costs for the proposed environmental measures are summarized below. They include the costs for design, construction, and O&M from 2000 to 2010.

Summary of Estimated Project Costs

No.	Projects	Cost ($\times 10^6$ US$)	%
1	Environmental Plans	0.9	2.6
2	Pilot Study on Rehabilitation	1.8	5.2
3	Measure for Mine Wastewater	2.2	6.3
4	Measures for Processing Plants	1.7	4.9
5	South Deo Nai Dumping Site	3.4	9.8
6	Mong Duong River Basin	4.4	12.6
7	Dien Vong River Basin	4.2	11.9
8	Ha Tu River Basin	1.8	5.2
9	Hong Gai North Basin	0.5	1.5
10	Cam Pha West Basin	0.1	0.4
11	Cua Ong Basin	0.5	1.5
12	Dredging	13.3	38.1
Total		34.8	100

Note: Implementation: Year 2000-2010, before adjustment of discount rate.

The total cost from 2000 to 2010 will be about US$ 35 million. The dredging project has the largest cost. Due to the large sizes of basins, Mong Duong River Basin Rehabilitation Project and Dien Vong River Basin Rehabilitation Project will cost more than the measures for other basins. The measures for point sources, i.e., Environmental Measures for Mine Wastewater and Environmental Measures for Processing Plants, will cost US$ 3.9 million or 11.2% of the total cost.

9.4 Environmental Measures for Tourism

9.4.1 Present and Future Environmental Problems

The existing environmental problems associated with tourism are limited mainly because the number of the tourists is still relatively small (about 300,000 tourists/year in the EMP area). The most serious problem is the unsanitary

condition of Bai Chay Beach area, which is polluted by discharge of untreated sewage from the hotel district. With the significant increase in tourism, however, the environmental problems will intensify in the future. The anticipated major environmental issues include:

(1) Solid Wastes

The issues of solid wastes generated from the inland sources, such as hotels and entertainment facilities, have been discussed in Section 9.2. Therefore, this section focuses on the solid wastes in the sea area. There are two major sources of solid wastes associated with tourism activities in the sea area: tourism boats and tourism islands.

Currently solid wastes generated on a tourism boat is collected by the boat operators, and is brought to a garbage bin at a wharf. However, a large amount of garbage is also discarded to the sea. The solid wastes released on tourism islands are collected by HLMB, and brought back to the land for disposal by sanitation company. HLMB also dedicates three boats to collect floating garbage on the sea.

The estimated peak solid wastes generations on tourism boats and islands are given below, assuming that tourists spend three hours on boats and three hours on islands. Because, they spend approximately the same time on the islands and on the boats, approximately the same amounts of solid wastes are generated at these sources.

Generation of Solid Wastes on Tourism Boat & Island

Parameter	Unit	Present	2010
per capita generation	kg/tourist/site	0.11	0.14
peak number of tourists	tourist/day	750	9,500
total load (boat)	kg/day	75	1,330
total load (island)	kg/day	75	1,330

(2) Wastewater

According to the local regulation, tourism boats are supposed to have holding tanks for wastewater. However, because there is no place to discharge wastewater in an environmentally-sound manner, the wastewater is dumped directly to the sea. On major tourism islands, such as Dao Go and Ti Top, HLMB already placed

toilets, and wastewater is managed by HLMB. However, the number of the facilities is limited, and many islands do not have proper sanitation facilities. The estimated peak loads of wastewater from tourism boats and islands are as follows:

Generation of Wastewater on Tourism Boat & Island

Parameter		Unit	Present	2010
peak tourists/day		tourist/day	750	9,500
boat	per capita generation	m^3/tourist	0.01	0.01
	total generation	m^3/day	7.5	95
island	per capita generation	m^3/tourist	0.025	0.025
	total generation	m^3/day	19	240

(3) Other Environmental Problems

In addition to the sanitation problems in tourism spots, the direct impacts of tourist activities to environmental resources, which is protected under the local environmental regulation, have been noted. Other environmental problems include uncontrolled development and over-development of tourism area. Because the tourism development in the area is still limited, these problems are minor. However, in the future, tourism development needs careful control.

9.4.2 Environmental Targets for Tourism

Considering the existing environmental regulations, existing levels of environmental measures, and the anticipated increase in tourism activities, the following targets are considered for the environmental measures for tourism.

Environmental Measures for Tourism : Goals

Category	Target
Planning	Development of Tourism Management Plan
Solid Wastes	Essentially 100% collection and disposal of solid waste from tourism boats & islands
Wastewater	Essentially 100% collection and disposal of wastewater from tourism boats & islands
Natural Resource Protection	Doubling patrolling capacity

9.4.3 Suggested Environmental Program and Projects

(1) Development of Environmental Management Plans for Tourism

Tourism is in the early stage of development, and good planning is the most effective tool to achieve sustainable tourism. The proposed program will develop

environmental management plans for tourism, which shall be built into the comprehensive tourism management for sustainable tourism.

Land Use: Special attention should be paid to unauthorized reclamation of coastal area for tourism development, development without proper sanitary measures, and development of tourism spots in the World Heritage area. Detailed siting plan for tourism enterprises have to be developed jointly by the Department of Tourism, Department of Construction, the Department of Planning and Investment, Ha Long Bay Management Board, DOSTE, and other relevant organizations.

Sanitation: All newly constructed tourism facilities shall have properly constructed and maintained drainage to the public sewer system. If the facility is constructed at a place far from the existing sewer system, the facility shall be connected to the local wastewater treatment system or install in-house water treatment system.

Natural Resources: Education is a key approach to prevent further destruction of natural resources by tourists and tourism industries. It is recommended that a good education/public awareness program is developed and implemented as a part of the environmental management plan for tourism.

Monitoring: In tourism, environmental quality is ultimately judged by the subjective standards of the tourists, tourism operators, and local residents. Therefore, to make sure that tourists are satisfied with the environmental condition, related organizations are urged to monitor the tourists' impression about the regional environment. Such data will help identify potential problems that prevent the development of sustainable tourism. The monitoring may be carried out as a part of the general tourism management activities. Nevertheless, environmental experts from DOSTE shall help the Department of Tourism, the Department of Culture and Information, HLMB, and other related organization to develop tourism monitoring plan that can capture the tourists' perception of the environmental quality. The results of the sustainable tourism monitoring will also help formulate an integrated strategy for environmental administration.

(2) Improvement of Sanitary Condition on Tourism Boats and Islands - Phase I

Lack of sanitation is the main environmental problem associated with tourism activities, in both inland and sea area. Therefore, the sanitary conditions in the tourism areas have to be improved as soon as possible. Because the improvement of sanitation conditions in the inland area has already been discussed in Section 9.2, this section proposes measures to improve sanitary condition in the sea area, i.e., tourism boats and tourism islands. The overall goal of the project is essentially 100% collections of solid waste and wastewater from tourism boats and islands by 2010. The estimated peak requirements in 2010 are:

Estimated Peak Loads of Solid Wastes and Wastewater in 2010

	Unit	Tourism Boat	Island
Solid Wastes	tons/day	1,330	1,330
Wastewater	m^3/day	95	240

This should be achieved in two phases, so that the project can deal with the demand of waste collection and disposal in a flexible manner.

Wastewater Collection from Tourism Boats: Wastewater generated on tourism boats shall be collected at mobile and stationary service stations placed strategically at convenient places.

Mobile Service Station: By 2002, four boats equipped with pumps and holding tanks will be procured for wastewater collection services. The collection boats shall be placed at major wharves, floating gas stations, and other convenient places. The collected wastewater shall be pumped up to the domestic sewer line from the stationary service stations.

Stationary Service Station: By 2003, two wastewater collection systems equipped with pump shall be installed at major wharves for stationary collection of wastewater. The collected wastewater shall be pumped to the domestic wastewater sewer line.

Waste Oil Collection: Containers to collect waste oil generated from tourism boats shall be placed at all mobile and stationary service stations for easy disposal of waste oil.

Wastewater Collection from Islands: Eight toilets are constructed throughout the popular tourism islands. The suggested locations include Sung Sot Cave, Soi Scam Beach, Me Cung Sea Park, Trang Luoi Liem Beach, Ngoc Vung Beach, and other areas where toilets are needed (see Figure 9.4.1). As far as the treatment of wastewater is concerned, sequencing batch reactor is preferable. However, considering the requirements for electricity and maintenance, septic tank with filter was considered as an alternative for islands with no beaches. The septic tank has to be properly maintained and emptied regularly with a boat dedicated for this task. The effluent needs to be disinfected. If it is difficult to construct a facility, or if there is a concern for contamination of bathing beach, portable toilets may be placed instead.

Solid Wastes Collection from Tourism Boats: It is the responsibility of boat operators to collect all garbage generated on their boats. The collected wastes shall be put into a garbage collection bin strategically placed at all wharves. Garbage collection service by the Sanitation Company shall be provided everyday.

Solid Wastes Collection from Islands and Sea: HLMB has 3 boats dedicated to collect solid wastes from the World Heritage area. However, HLMB is facing the limitation of current operation of solid wastes collection due to the lack of staff and resources. The most important approach may be to educate and encourage the tourists to bring back their waste. In addition, the solid wastes collection capability of HLMB has to be reinforced. In Phase 1, two boats with reasonable mobility shall be purchased to collect solid wastes from tourism spots in the World Heritage area (including floating solid waste). The collected solid wastes shall be brought to a designated solid wastes disposal site (possibly a designated port or island such as Hong Doc Island) and disposed of by the Sanitation Company.

(3) Improvement of Sanitary Condition on Tourism Boats and Islands - Phase 2

Phase 2 of the "Improvement of Sanitary Condition on Tourism Boats & Islands" is the continuation of Phase 1 to meet the waste collection targets set for 2010 (see Section on Phase 1 project for the targets). The proposed measures are essentially

the same as the ones in Phase 1. Additionally 3 mobile stations and 2 stationary stations for wastewater collection from tourism boats, 1 boat for wastewater collection from islands, 2 boats for solid waste collection from islands, and 12 toilets will be constructed from 2005 to 2010.

(4) Reinforcement of Patrolling Capability

HLMB has 3 patrol boats and staffs to control activities in the World Heritage area. With the several-fold increase in tourism numbers, however, it is likely that the existing patrol capability will be overpowered by the demand in the future. To reinforce the patrolling capabilities, 6 high-speed boats will be procured during 2000 and 2010, and a team of 5 will be staffed for each boat. The staff will be engaged in activities to protect environmental condition of Ha Long by area, by controlling damages to environmental resources such as corals and stalactite, trashing, wastewater dumping, and unsafe activities.

9.4.4 Estimated Costs of Proposed Environmental Measures

The estimated costs of the proposed environmental measures are summarized below. They include the costs for planning, design, construction, and O&M from 2000 to 2010. Full assessment of the long-term costs with varying discount rate is provided in Chapter 13.

Summary of Proposed Environmental Measures and Estimated Costs

No.	Project	Description	Cost	
			$\times 10^6$ US$	%
1	Environmental Planning for Tourism	Development of Environmental Plans for Tourism	0.1	2.6
2	Improvement of Sanitation Condition - Phase 1	Collection of wastewater from tourism boats and islands	1.5	39.5
3	Improvement of Sanitation Condition - Phase 2	Collection of wastewater from tourism boats and islands	1.2	31.6
4	Reinforcement of Patrolling Capability	reinforcement with 6 boats and 30 staff members by 2010	1.0	26.3
Total			3.8	100

Note: Implementation: Year 2000-2010, before adjustment of discount rate.

The total project cost during 2000-2010 is US$ 3.8 million.

9.5 Environmental Measures for Environmental Resources

9.5.1 Environmental Measures for Natural Environment

(1) Target Management Items

Forests, tidal flats, mangrove swamps, and coral reefs are selected as the target items for natural environment management considering their important roles in maintaining natural environment in the EMP area. In addition to them, fish and shellfish have economic values as fishery resources.

(2) Strategies

The following three strategies were proposed for management of the natural environment.

1) Conservation of existing resources

Conserving the existing natural resources and their habitat conditions are the primary strategies for natural environment management.

2) Rehabilitation of deteriorated resources

The forest coverage in the EMP area is supposed to be higher than the average of Quang Ninh province, but there are about 800 ha of bare area at present except for denuded areas by coal mining activities. And also, in the future it is predicted that about 2,000 ha of bare area except for denuded areas by coal mining activities will be made by 2010 because of the planned development projects and related land use changes. Therefore, reforestation is the important measures for forest management including greening.

Mangrove swamps near Cua On, Cam Pha, and Hung Thang have been lost because of land reclamation. It is recommended to make up such a large loss of mangrove swamps by reforestation.

3) Reinforcement of on-going management activities

For conservation of natural environment, it is important to support and strengthen the ongoing management activities that have been carried out by each sector in charge. The following ongoing activities should be supported and strengthened continuously.

Ongoing Management Activities for Natural Environment

Target Items	Ongoing Management Activities	Sector in Charge
Forests	Conservation of the protected forests	Forest Protection Agency (FPA), Department of Agriculture and Rural Development (DARD)
Coral reefs	Prohibition of collection of coral reefs, Dynamite fishing in the area of coral reefs	Department of Fishery (DOF)
Fish and Shellfish	Regulation for fishing method, fishing gears	Department of Fishery (DOF)

(3) Projects and Programs

In order to manage natural environment, it is proposed to conduct the following two projects and one program. As for coral reefs, management of them should be carried out by water quality management as well as fishing activity management.

- Reforestation in bare areas
- Rehabilitation of mangrove swamps
- Fishing activity management program

1) Reforestation in bare areas

In the EMP area, there is about 800 ha of bare areas at present, and additionally 2,000 ha of bare land will be formed by land use changes by 2010. Among the bare areas, the Troi river basin has relatively large bare areas at present, and Man river basin, the Dien Vong river basin and the Mong Duong basin are predicted to have large bare areas in the future. Therefore, those areas should have priority of reforestation. In order to achieve the target conservation criteria, 2,700 ha should be covered by trees or greened by 2010. While denuded areas by coal mining activities are to be re-vegetated as measures for mining.

The Forest Protection Agency (FPA) and the Department of Agriculture and Rural Development (DARD) are in charge of forest management in bare areas except for denuded areas by coal mining activities. It is recommended that, three will be

staffed additionally in FPA for management of reforestation with increase in work volume.

The estimated costs of reforestation in bare areas from 2001 to 2010 are shown in the next table. Necessary design, bed preparation, and reforestation are assumed to entrust to consultants or contractors. It is proposed that this project should be commenced in 2001.

Estimated Costs for Reforestation in Bare Area (Year 2001-2010)

Type	Work	Estimated Cost (US$x10^3)
Construction	Design	32
	Bed Preparation	694
	Tree Planting	655
O&M	Vegetation, Staff of FPA	86
Total		1,467

2) Rehabilitation of mangrove swamps

Reforestation project should be carried out in the area where large areas of mangroves have been lost by reclamation, such as Cua On, Cam Pha, and Hung Thang. In order to achieve the target conservation criteria, mangrove swamps rehabilitation by mangrove planting of 1,320 ha should be carried out by 2010. For tree planting, local or native species in the EMP area are recommended, such as *Aegiceras corniulatum, Kandelia candel, Avecinnia lanata,* and *Rhizopher stylosa.*

The proposed Tidal Flat Management Unit (TFMU) is expected to be in charge of the mangrove swamps rehabilitation. Considering expected work volume including total management of tidal flats and monitoring, five staff will be required.

The overall estimated costs of rehabilitation of mangrove swamps are as shown in the next table. Necessary design, bed preparation, and reforestation are assumed to entrust to the consultants or contractors. It is proposed that this project should be commenced in 2000.

Estimated Costs for Rehabilitation of Mangrove Swamps (Year 2000-2010)

Type	Work	Cost (US$x10^3)
Construction	Design/Plan	25
	Bed Preparation	319
	Tree Planting	572
O&M	Vegetation, Staff of TFMU	105
Total		1,021

3) Fishing activity management program

This program is mainly to reinforce ongoing management activities by the Department of Fisheries (DOF).

- Reinforcement of patrolling capability of fishing activities
- Promotion of environmental education to fishermen
- Collection of fishermen's data (Fishermen data survey)

It is necessary to conduct strict control for prohibited fishing methods and gears to conserve fishery resources. To implement the management of fishery resources, fishermen's understanding for conservation of fishery resources is needed. Thus, environmental education should be provided for fishermen in subjects such as habitat conditions of fish and shellfish, necessity of the control of fishing activity and appropriate use of natural resources.

In addition, in order to manage fish and shellfish, it is necessary to understand the current condition and the changes of fishery production in the bays. For the collection of fishery production data, a fishermen data survey is proposed. This survey is to collect the data about kinds of fishing activities, amount and seasonal changes of fishery production, location of fishing grounds and their conditions by asking fishermen to write the daily fishing records in a journal. The sample number of fishermen is about 50. This survey should be carried out every year.

A team of three will be staffed for patrolling fishing activities. They use an additional boat for the proposed patrol. For the promotion of environmental education and fishermen data survey, two and three staff will be allocated respectively. The estimated costs of the fishing activities' management are as below. It is proposed that this program will be commenced in 2001 and then be carried out continuously every year.

Estimated Costs for Fishing Activity Management Program (Year 2001-2010)

Type	Work	Cost(US$x10^3)
Reinforcement patrolling capability for fishing activity	Boat	32
	O&M (Personnel)	35
Promotion of environmental education	O&M (Personnel)	11
Fishermen data survey	O&M (Personnel)	19
Total		97

9.5.2 Environmental Measures for Landscape

(1) Target Management Items

In the EMP area, the landscape of the World Heritage area should be given the highest priority to be managed for absolute protection. The value of landscape of the World Heritage area depends on the following landscape elements and they should be considered as the target items of landscape management.

- Shape and surface of islands,
- Color and clearness of seawater
- View of natural resources, and
- Natural scenery

(2) Strategies

1) Enforcement for ongoing management activities

HLMB has carried out many management activities in the World Heritage area such as patrol and collection of floating garbage and regulation of illegal activities. It is important to enforce these ongoing management activities.

2) Landscape management guideline

The value of landscape of the World Heritage area depends on the various landscape elements such as shape of islands, water color, water clearness, condition of natural resources, condition of surface of islands and natural impression without artificial landscape. It is important to conserve these landscape elements and their combination in good condition. It is necessary to coordinate measures relating to each landscape element. Therefore, a comprehensive guideline for landscape management is required.

3) Restriction of anchored area and route of cargo ships

In order to conserve the natural impression in the World Heritage area, the route and anchored area of cargo ships should be controlled by the regulation.

(3) Projects and Programs

1) Preparation of guideline management for landscape

The proposed guideline for landscape is to be used by not only agencies but also by the private sector such as shipping companies and tourism. The guideline should be in consistent with the proposed environmental plan for tourism, and also involve the results of landscape value survey which is to be implemented as part of the monitoring. Although the main target of landscape management is the World Heritage area, the proposed guideline should include notes and directions from an aesthetic viewpoint in AMZ and DZ. The future development projects should follow this guideline in view of shape, coloring of buildings, and greening.

The estimated cost for preparation of the guideline for landscape is shown below. It is necessary to conduct pre-investigation of landscape and entrust preparation of guideline to the consultants.

Estimated Cost for Preparation of guideline for Landscape (2000-2007)

Type	Works	Cost (US$x10^3)
Guideline preparation	Pre-investigation, Preparation	75
Total		75

2) Reinforcement of patrolling capability for shipping activities

Major impact that may affect the natural impression in the World Heritage area is anchored and sailing cargo ships. Popular tourism spots are mainly distributed in the west of the World Heritage area. This area is close to the anchored area near Hon Net Floating Port (HNFP). HNFP is scheduled to move to the east area of the bays. Thus, the number of anchored ships near the popular tourism area and sailing boats deviated from the defined courses should be controlled strictly.

To control shipping activity, it is necessary to reinforce patrolling capability of HLMB. One additional high-speed boat will be required, and a team of 3 will be staffed for patrol. The estimated costs of the reinforcement of patrolling capability

for shipping activities are as shown below. It is proposed that this program should be commenced in 2003 and then carried out continuously to 2010.

Estimated Costs for Reinforcement of Patrolling Capability (Year 2003-2010)

Type	Works	Cost (US$x10^3)
Reioforcement of Patrolling Capability for shipping activities	Personnel	23
	Boat	32
	O&M (Boat)	15
Total		0

TABLES

Table 9.2.1 Advantages and Disadvantages of Competitive Treatment Processes

Treatment Processes	Advantages	Disadvantages
1. Wastes Stabilization Ponds	· Low construction cost · No energy required · Simple operation with low maintenance requirement · Minimal electrical and mechanical plant · Small quantity of digested sludge produced	· Very large land requirement · Performance deteriorates at low temperature · Possible odor and mosquito problems · Algae growth can affect effluent quality of unfiltered samples
2. Oxidation Ditches	· Robust process with good resistance to shock loads · Relatively simple operation and maintenance compared to other mechanized processes · The sludge produced is stable · Nitrogen reduction is readily achievable at appropriate loading rates · No odor problems from ditches or sludge	· High energy requirement · Relatively high land requirement
3. Sequencing Batch Reactors	· Small land area required · Flexible operation allows nitrogen and phosphorus removal at appropriate loading rates · No odor problems from the reactors	· Relatively sophisticated mechanical and electrical components require maintenance · Skill needed to modify operating cycle · Sludge from higher rate (Level 1) processes requires further treatment and is a potential source of odor

Table 9.2.2 Build Up of Main Collector Rates for Domestic Wastewater

System	DWF (cu m/d)	Design Flow[1] (ℓ/s)	Main Collector Dia[2] (mm)	Typical PS Rating[3] (kW)	Pumping Main Dia[4] (mm)	Collector Cost (US$/m)	PS Unit Cost (US$)	Pumping Main Cost (US$/m)	System Rate[5] (US$/km)
Don Dien	3,600	83	400	25	300	60	124,346	90	128,000
Dong Dang (main collectors)	10,824	251	600	61	400	100	206,815	125	208,000
Dong Dang (transfer system)	10,824	251	-	276	500	-	479,671	170	-
Deo Sen	20,000	463	800	136	500	150	322,468	170	315,000
Bach Dang	7,200	125	500	37	300	80	155,580	90	160,000
Cam Pha	5,400	125	500	37	300	80	155,580	90	160,000

Note: 1. Peak flows vary from 1.5 DWF to 2.0 DWF.
2. Collector diameters based on minimum gradient of 1 in pipe diameter in mm.
3. Collector pumping stations based on a head of 10 m and 2 duty plus 1 standby pump. Transfer pumping station based on head of 45 m.
4. Pumping main diameters selected to give a velocity of approx. 1.5 m/s.
5. Collection system costs per km based on 800m collector sewer, 200m pumping main plus a pumping station every 2 km.

Table 9.2.3 Cost Estimate for Domestic Solid Wastes

Investment Costs

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Collection				
Collection vehicles and equipment	ton/yr	98,000	50.0	4,900,000
Landfill				
Extension of Quang Hanh landfill	cu m	450,000	5.0	2,250,000
Hospital Wastes				
Clinical wastes incinerator	ton/day	10	75,000	750,000
Base construction cost				7,900,000
Engineering and supervision costs		10%		790,000
Institutional strengthening and pubic awareness		5%		435,000
Contingencies		10%		913,000
Total Investment Cost	-	-	-	10,038,000

Annual O&M Costs in 2010

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Collection				
Collection vehicles and equipment	ton/yr	98,000	4.25	417,000
Landfill				
Extension of Quang Hanh landfill	ton/yr	98,000	3.5	343,000
Hospital Wastes				
Clinical wastes incinerator	ton/yr	1,575	25.0	39,000
Total Annual O&M Cost in 2010	-	-	-	799,000

Table 9.2.4 Investment and O&M Costs for Domestic Solid Wastes Management

(Unit: US$×10^3)

Year	Investment Costs	Wastes Collected (×10^3 ton /year)	Clinical Wastes (×10^3 ton /year)	O&M Costs			Total Investment + O&M Costs
				Collection	Landfill	Clinical	
2000	0			0	0	0	0
2001	407			0	0	0	407
2002	500			0	0	0	500
2003	1,801		0.8	0	0	29	1,830
2004	2,524	64	0.9	165	135	32	2,856
2005	801	74	1.0	192	158	35	1,186
2006	801	87	1.1	224	185	38	1,248
2007	801	102	1.2	262	216	39	1,318
2008	801	119	1.3	306	252	39	1,398
2009	801	139	1.4	357	294	39	1,491
2010	801	162	1.6	417	343	39	1,600
Total	10,038			1,923	1,583	290	13,834

Table 9.2.5 Build Up of Rates for Collector Systems for Industrial Wastewater

System	DWF (cu m/d)	Design Flow[1] (l/s)	Main Collector Dia[2] (mm)	Typical PS Rating[3] (kW)	Pumping Main Dia[4] (mm)	Collector Cost (US$/m)	PS Unit Cost (US$)	Pumping Main Cost (US$/m)	System Rate[5] (US$/km)
Cai Lan Industrial Park									
Collection system	23,850	414	700	102	600	125	273,612	240	285,000
Transfer system	23,850	414		406	600		595,678	240	
Hoanh Bo Industrial Park									
Collection system	27,550	478	800	117	600	150	296,566	240	316,000
Transfer system	27,550	478		586	600		733,005	240	
Lang Bang	2,560	89	500	26	300	80	128,855	90	146,000

Notes:
1. Peak flows for industrial parks are 1.5 DWF.
   Peak flows for major industries are 3 DWF.
2. Collector diameters based on minimum gradient of 1 in pipe diameter in mm.
3. Collection pumping stations based on a head of 10m and 2 duty plus 1 standby pump.
   Cai Lan transfer pumping station (PS) based on 40m head
   Hoanh Bo transfer pumping station based on 50m head
4. Pumping main diameters selected to give a velocity of approx. 1.5 m/s.
5. System costs per km for industrial parks based on 800m collector sewer, 200m pumping main plus a pumping station every 2 km.
   System costs for major industries include gravity sewers only.

Table 9.2.6 Cost Estimates for Industrial Solid Wastes

Investment Costs

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Collection				
Collection vehicles and equipment	ton/yr	34,500	25.0	863,000
Landfill				
Extension of landfill capacity	cu m	94,000	5.0	470,000
Hazardous Wastes				
Hazardous wastes incinerator	ton/day	15	75,000	1,125,000
Base construction cost				2,458,000
Engineering and supervision costs		10%		246,000
Institutional strengthening		5%		135,000
Contingencies		10%		284,000
Total Investment Cost				3,123,000

Annual O&M Costs in 2010

Component	Unit	Quantity	Rate (US$)	Amount (US$)
Collection				
Collection vehicles and equipment	ton/yr	34,500	3.75	129,000
Landfill				
Extension of landfill capacity	ton/yr	34,500	3.5	121,000
Hazardous Wastes				
Hazardous wastes incinerator	ton/yr	3,450	50.0	173,000
Total Annual O&M Cost in 2010				423,000

Table 9.2.7 Investment and O&M Costs for Industrial Solid Wastes Management

(Unit: 10^3 US$)

Year	Investment Costs	Ind. Wastes Collected ($\times 10^3$ ton /year)	Hazardous Wastes ($\times 10^3$ ton /year)	O&M Costs			Total Investment + O&M Costs
				Collection	Landfill	Hazardous	
2000	0			0	0	0	0
2001	270			0	0	0	270
2002	300			0	0	0	300
2003	616	4.8		18	17	0	681
2004	1,107	6.2		23	22	0	1,152
2005	0	8.3	1.0	31	29	51	111
2006	0	11.0	1.3	41	39	65	145
2007	400	14.7	1.7	55	52	83	590
2008	400	19.5	2.1	81	76	106	663
2009	0	26.0	2.9	120	112	146	378
2010	0	34.5	3.5	129	121	173	423
Total	3,123			498	468	624	4,713

Table 9.3.1 Selected Existing and Planned Pollution Control Programs

Category	Location	Problem	Measure	Year	Cost	Source	
Erosion & Water Pollution	Mong Duong River	increased risk of flooding due to excessive sedimentation	94,000 m^3 sediment removed in 1997. Further dredging and construction of dyke planned	1997-1998	0.9 billion VND in 1997; 2 billion VND in 1998	1	DOSTE, VINACOAL
	Cau Hai stream	excessive erosion/sedimentation problem	construction of erosion control dam (capacity 2.5 million m^3)	proposed (1999-2000)	0.9 billion VND	2	VINACOAL
	Deo Nai mine	excessive erosion/sedimentation problem	leveling of stairs at overburden dump	proposed (1998-2019)	27 billion VND	2	VINACOAL
	Deo Nai mine	excessive erosion/sedimentation problem	construction of 3 dykes	1970's -	over 10 billion VND	2	VINACOAL
	East Cao Son dump site	excessive erosion/sedimentation problem	construction of erosion control dyke (60,000 m^3)	proposed (1998-2020)	11 billion VND	3	VINACOAL
	Cao Son mine	excessive erosion/sedimentation problem	dredging of drainage system in mine	proposed (1998-2020)	3.4 billion VND	3	VINACOAL
	Dien Vong Reservoir (drinking water supply)	water supply capacity decreased from 25,000 m^3/day to 15,000 m^3/day. Significant decrease in water quality	new reservoir in Cao Van (capacity 60,000 m^3/day) proposed, rehabilitation of Dien Vong plant	ongoing	26 billion VND for water mains from Cao Van to Dien Vong and for rehabilitation of Dien Vong plant	4	-
	Dong Ho intake (drinking water supply)	deterioration of water quality	installation of new sedimentation tank to treat water	1997	13 billion VND	4	
	BaTone, Cua Ong and Mong Duong irrigation/drainage system	sedimentation problem	dredging of Ba Tone system has been proposed	proposed	2.3 billion VND (Ba Tone only)	5	VINACOAL, DOA
	Three Lakes in Dong Trieu District	excessive sedimentation problem	7.0 million m^3 to be dredged	proposed	5 billion VND	5	VINACOAL, DOA
	Noi Hoang Lake	excessive sedimentation problem	dredging	1997-1998	3 billion VND	1	VINACOAL
	3 Processing Plants	lack of solid waste and sludge management	installation of re-screen/refill system, sludge recovery pond	proposed	175 billion VND	7	VINACOAL
Land Use	Cao Son mine	erosion, lack of reclamation	reforestation	proposed (1998-2020)	3.8 billion VND	3	VINACOAL
	Quang Ninh Province	deforestation and related erosion problem	reforestation, over 3,000 ha/year during 1996-1998	1998-	unknown	5	DOA, central government assistance
	Quang Ninh Province	deforestation and related erosion problem	reforestation, development of forestry for use by VINACOAL (300 ha in 1997)	1997-	unknown	5	VINACOAL
	dump sites (1,500 hectare) and buffer zones (3,400 hectare)	deforestation and related erosion problem	reforestation	proposed	40 billion VND	7	VINACOAL
Dust	truck road in Cao Son mine	dust problem	watering	proposed (1998-2020)	2.4 billion VND	3	VINACOAL
	truck road in Deo Nai mine	dust problem	watering	proposed (1998-2019)	35 billion VND	2	VINACOAL
	Nam Cau Trang Coal Processing Company	dust problem	watering (trucks, spray system)	proposed (1998-)	0.6 billion VND for trucks and spray system, 0.13 billion/year for running cost	6	VINACOAL
	11 underground mines, 6 open-pit mines, and 3 processing plants	dust problem	installation of ventilation system, water sprayers, dust filters, etc.	proposed	150 billion VND	7	VINACOAL

Sources:
1: VINACOAL, 1998 (hearing)
2: Deo Nai Mine EIA Report, 1997
3: Coc Sau Mine EIA Report, 1997
4: Water Supply Company, 1998 (hearing) and Carl Bro, 1995
5: QN Dept. Agr. & Rural Develop., 1998 (hearing)
6: Hong Gai Coal Processing Company EIA Report, 1997
7: EVS, 1996

Table 9.3.2 Anticipated Production, Overburden, and Mine Wastewater

(Unit: $\times 10^3$ tons/year)

Production

Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Cam Pha	8,544	8,639	8,734	8,830	8,925	9,020	8,879	8,738	8,597	8,456	8,315	95,677
Hong Gai	2,905	3,024	3,143	3,262	3,381	3,500	3,487	3,474	3,461	3,448	3,435	36,520
Uong Bi	3,277	3,421	3,564	3,708	3,851	3,995	4,152	4,309	4,466	4,623	4,780	44,146
Total	14,726	15,084	15,442	15,799	16,157	16,515	16,518	16,521	16,524	16,527	16,530	176,343
Study Area	11,449	11,663	11,877	12,092	12,306	12,520	12,366	12,212	12,058	11,904	11,750	132,197

(Unit: $\times 10^3$ m^3/year)

Overburden

Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Cam Pha	34,225	34,050	33,875	33,700	33,525	33,350	31,972	30,594	29,216	27,838	26,460	348,805
Hong Gai	9,200	9,885	10,570	11,255	11,940	12,625	11,975	11,325	10,675	10,025	9,375	118,850
Uong Bi	6,554	6,841	7,128	7,416	7,703	7,990	8,304	8,618	8,932	9,246	9,560	88,292
Total	49,979	50,776	51,573	52,371	53,168	53,965	52,251	50,537	48,823	47,109	45,395	555,947
Study Area	40,779	40,891	41,003	41,116	41,228	41,340	40,276	39,212	38,148	37,084	36,020	437,097

(Unit: $\times 10^3$ m^3/year)

Mine Wastewater

Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Cam Pha	20,506	20,734	20,963	21,191	21,420	21,648	21,310	20,971	20,633	20,294	19,956	229,625
Hong Gai	6,972	7,258	7,543	7,829	8,114	8,400	8,369	8,338	8,306	8,275	8,244	87,648
Uong Bi	9,831	10,262	10,693	11,123	11,554	11,985	12,456	12,927	13,398	13,869	14,340	132,438
Total	37,309	38,253	39,198	40,143	41,088	42,033	42,134	42,236	42,337	42,439	42,540	449,711
Study Area	27,478	27,992	28,506	29,020	29,534	30,048	29,678	29,309	28,939	28,570	28,200	317,273

Based on IMSAT, 1999

Note: Study area is the sum of Cam Pha and Hong Gai.
Values for 2001-2004 and 2006-2009 were linear-interporated from the estimates for 2000, 2005, and 2010.
2.0 m^3 overburden/ton coal was assumed for overburden in Uong Bi.
2.4 m^3 wastewater/ton coal was assumed for wastewater in Cam Pha and Hong Gai.
3.0 m^3 wastewater/ton coal was assumed for wastewater in Uong Bi.

FIGURES

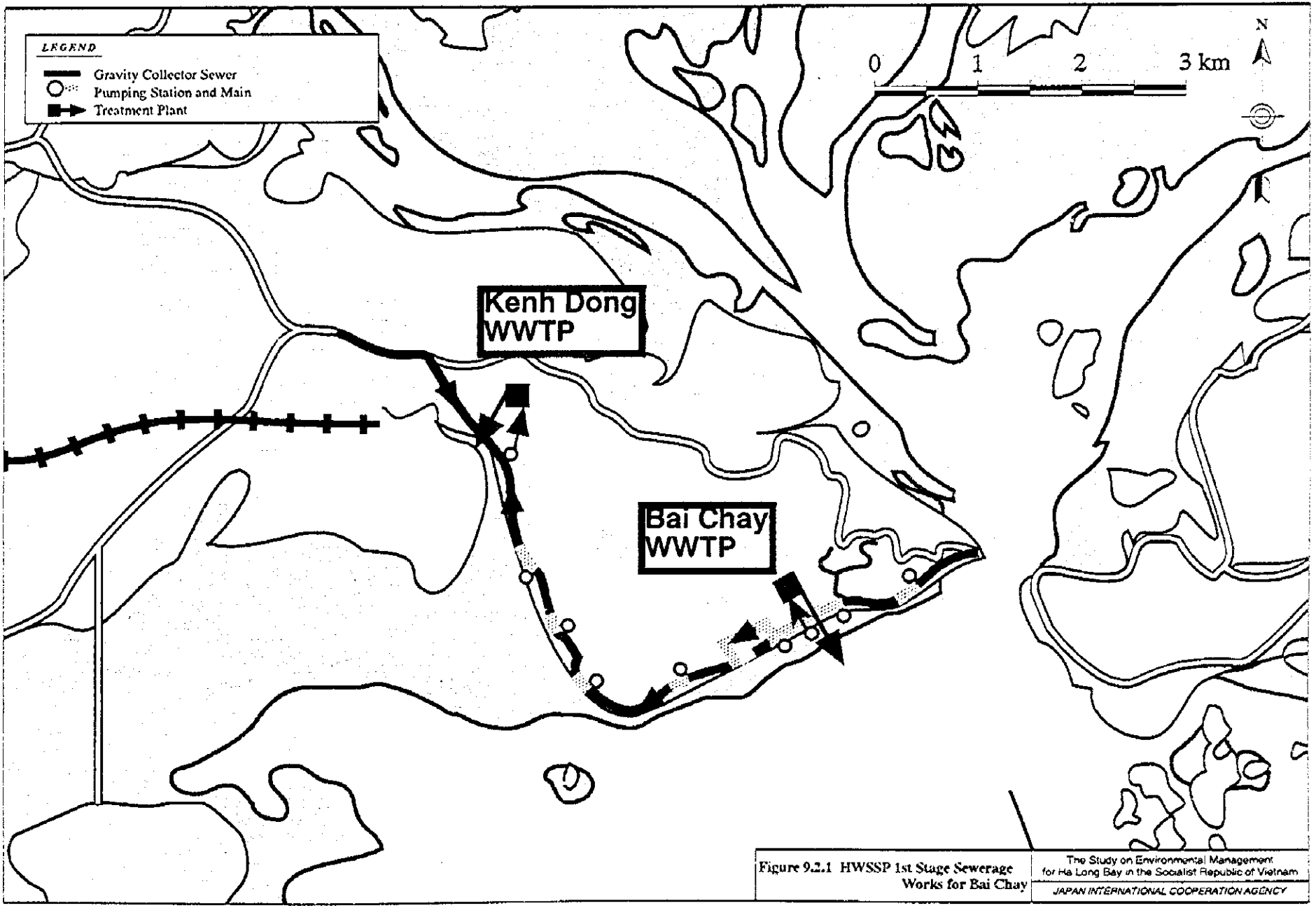
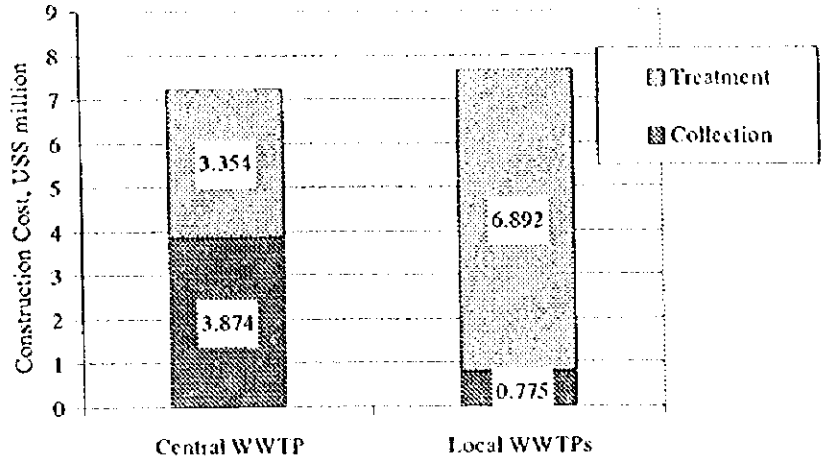


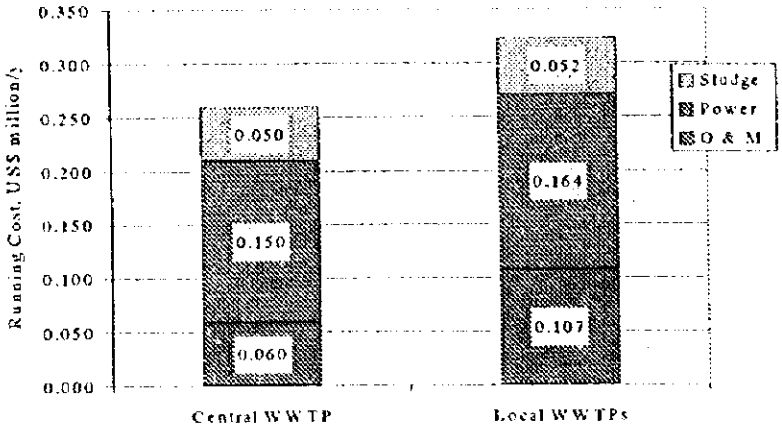
Figure 9.2.1 HWSSP 1st Stage Sewerage Works for Bai Chay

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

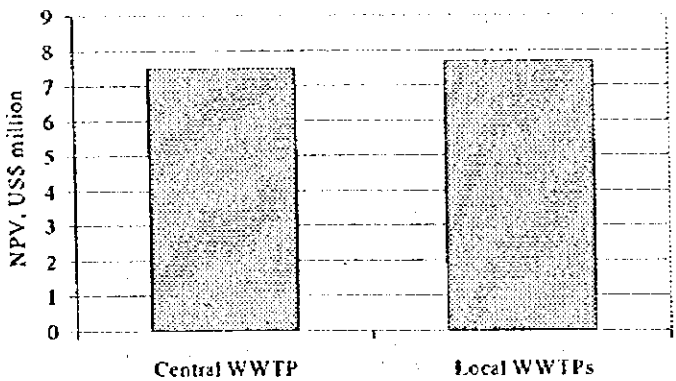
JAPAN INTERNATIONAL COOPERATION AGENCY



Construction Costs (Excluding Common Components)



Running Costs



Net Present Value @ 6% Discount Rate

Figure 9.2.2 Cost Comparison of Central versus Local Treatment Schemes

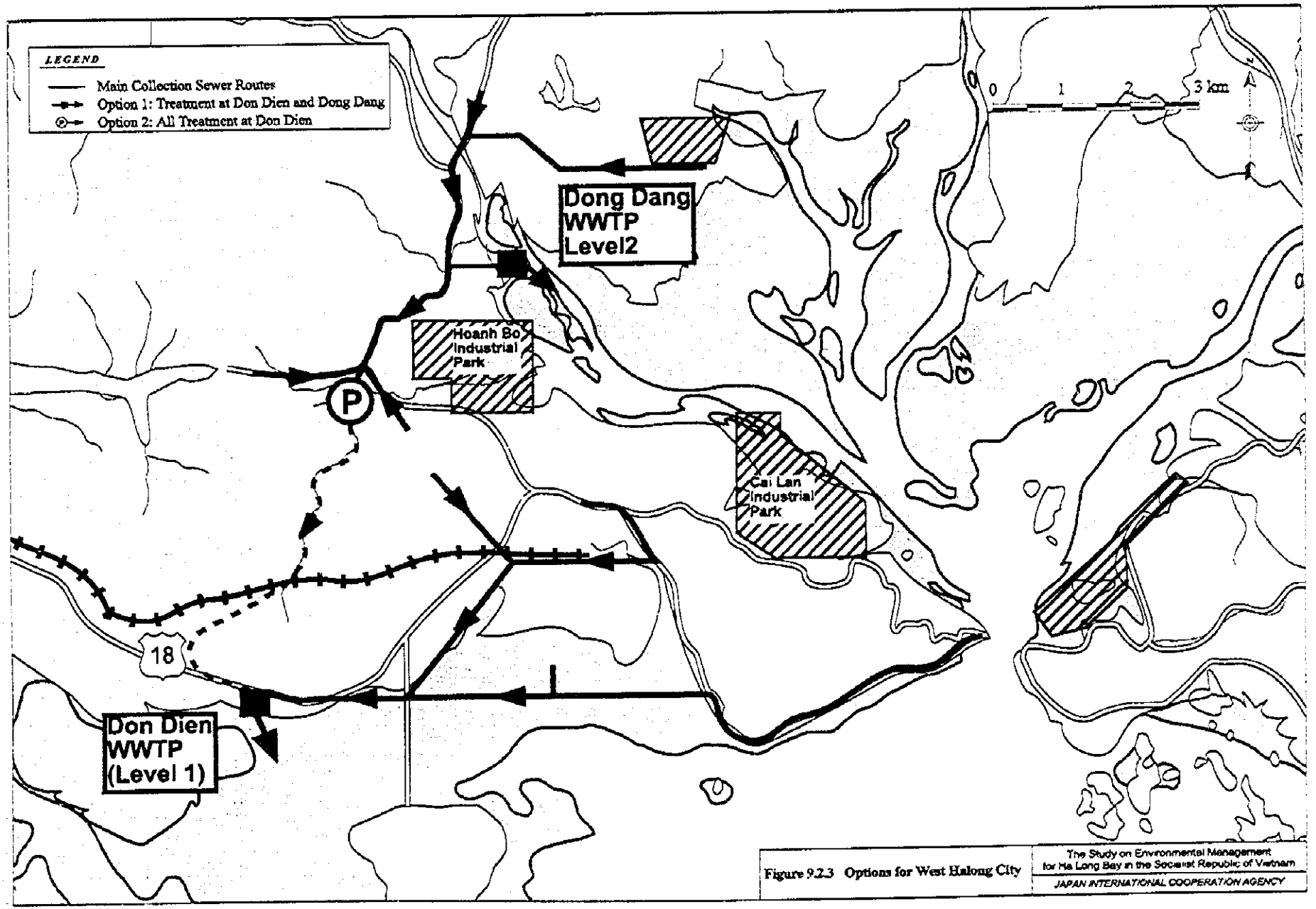


Figure 9.2.3 Options for West Halong City

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

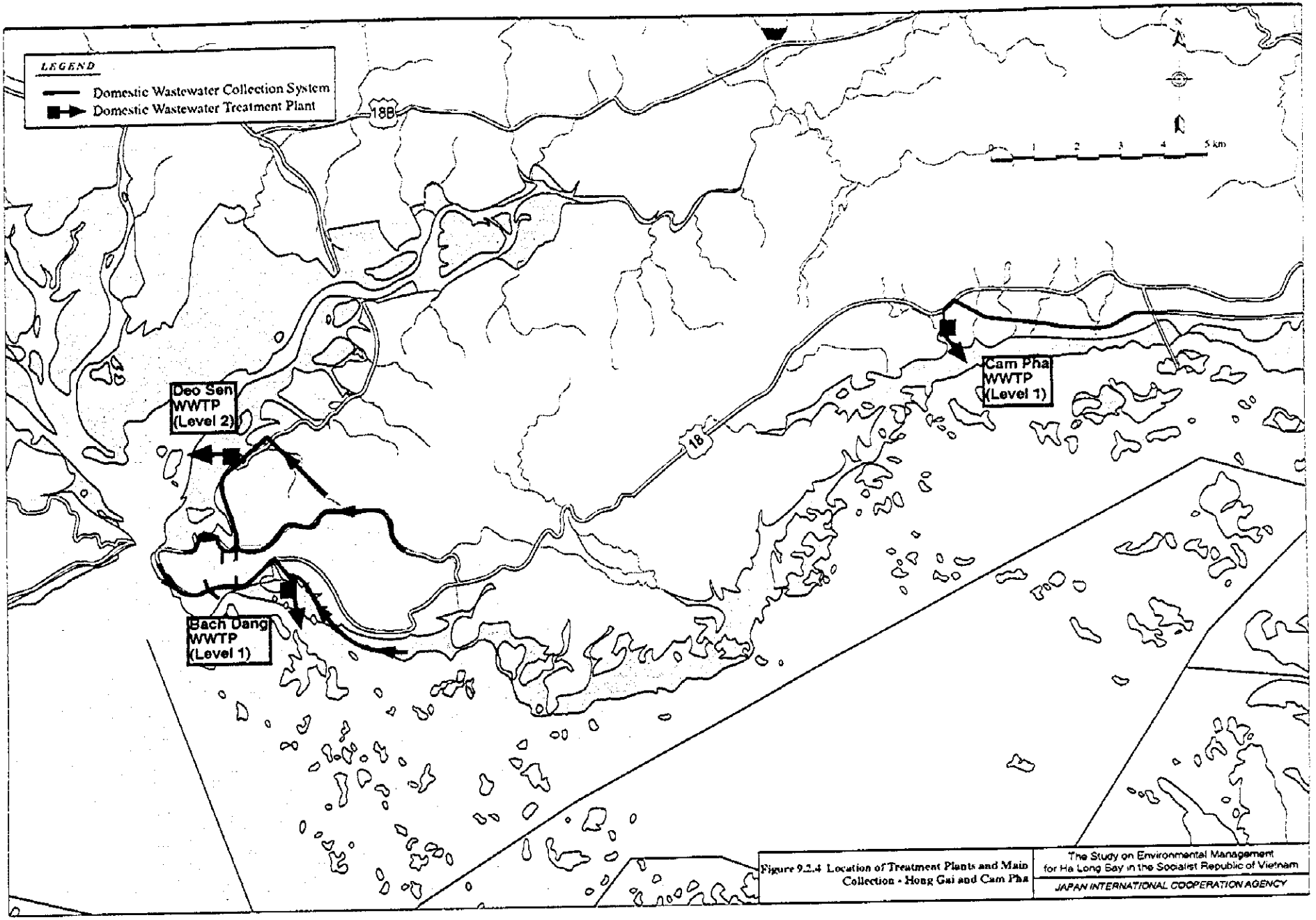


Figure 9.2.4 Location of Treatment Plants and Main Collection - Hong Gai and Cam Pha

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

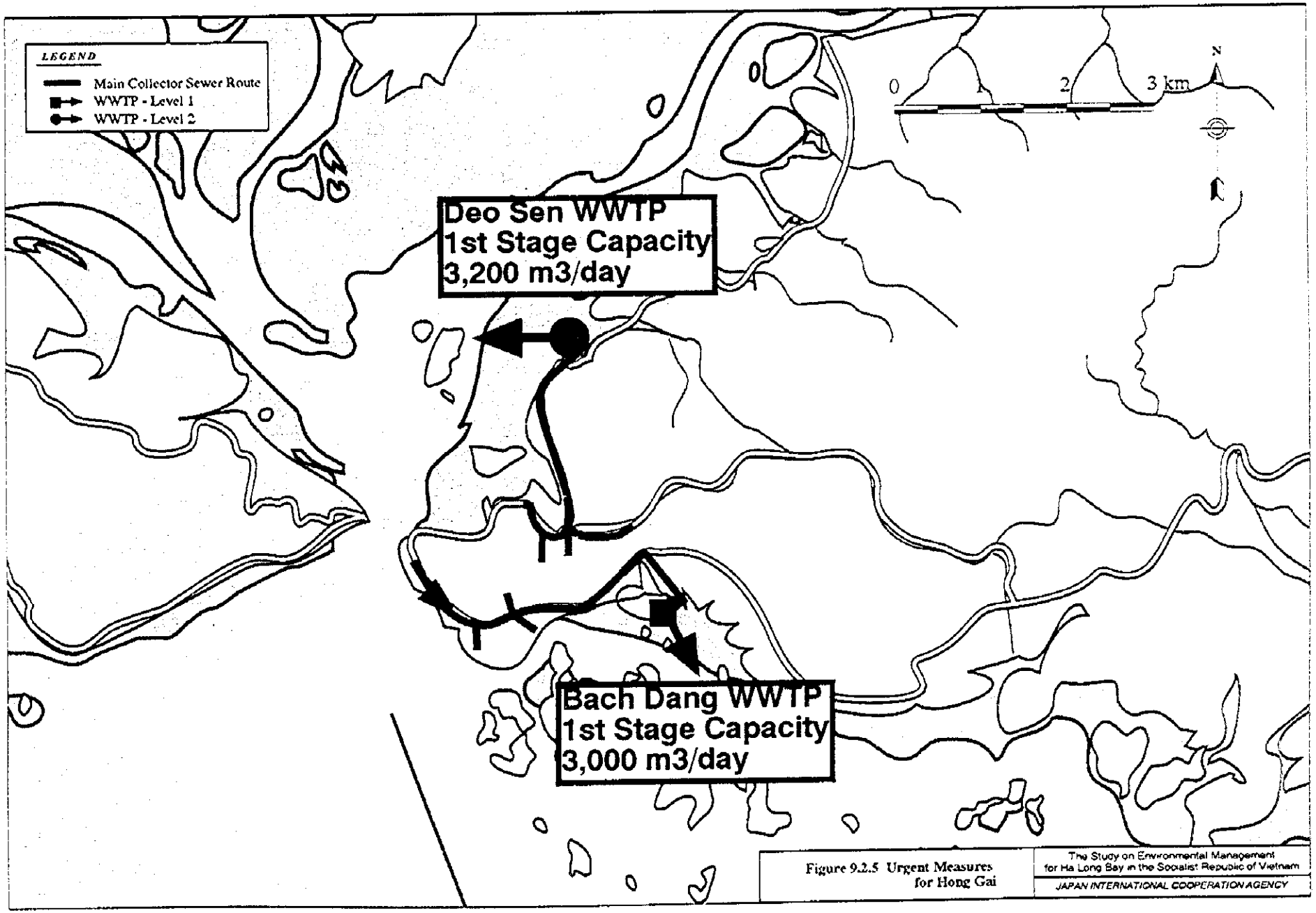


Figure 9.2.5 Urgent Measures for Hong Gai

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

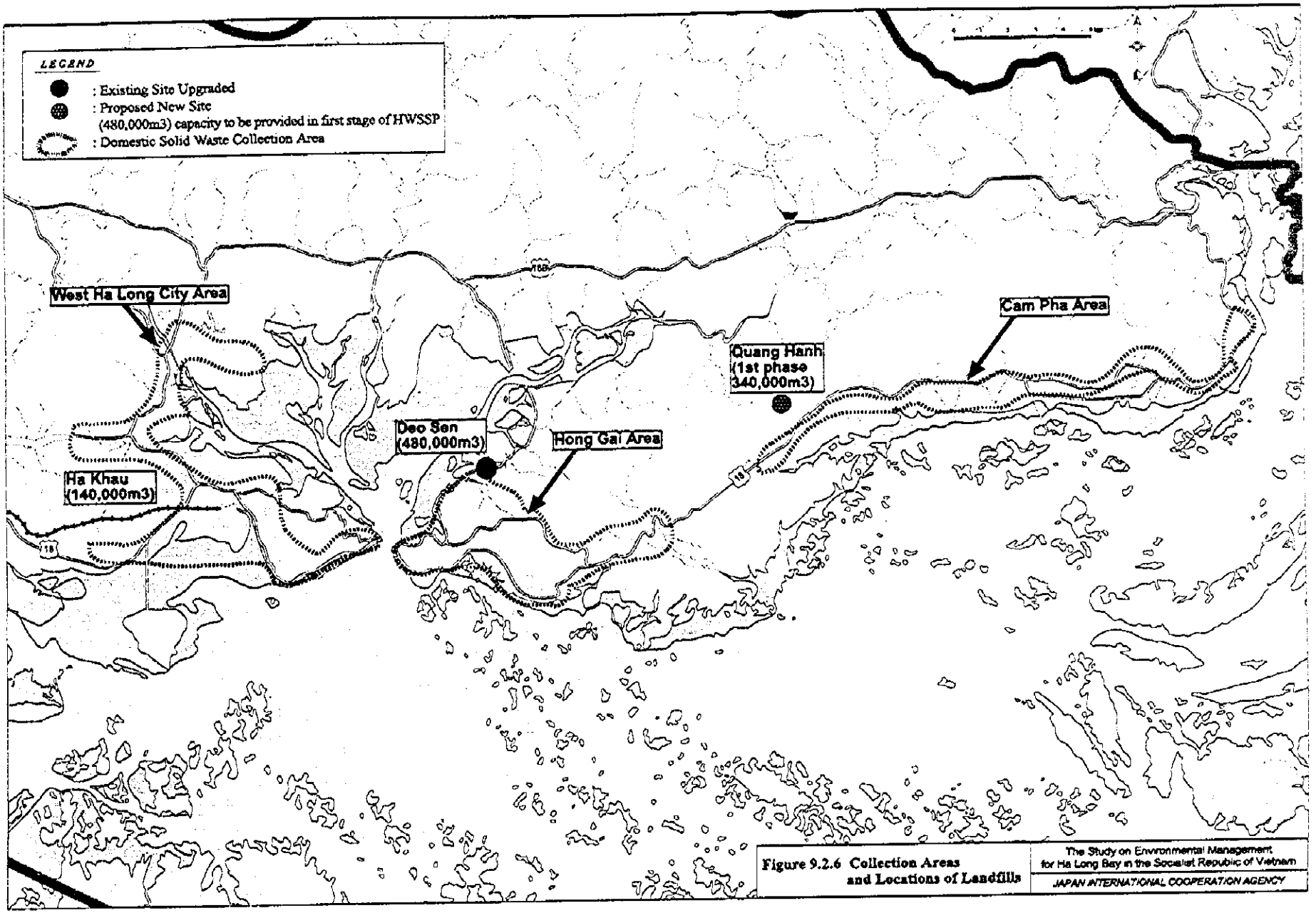


Figure 9.2.6 Collection Areas and Locations of Landfills

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

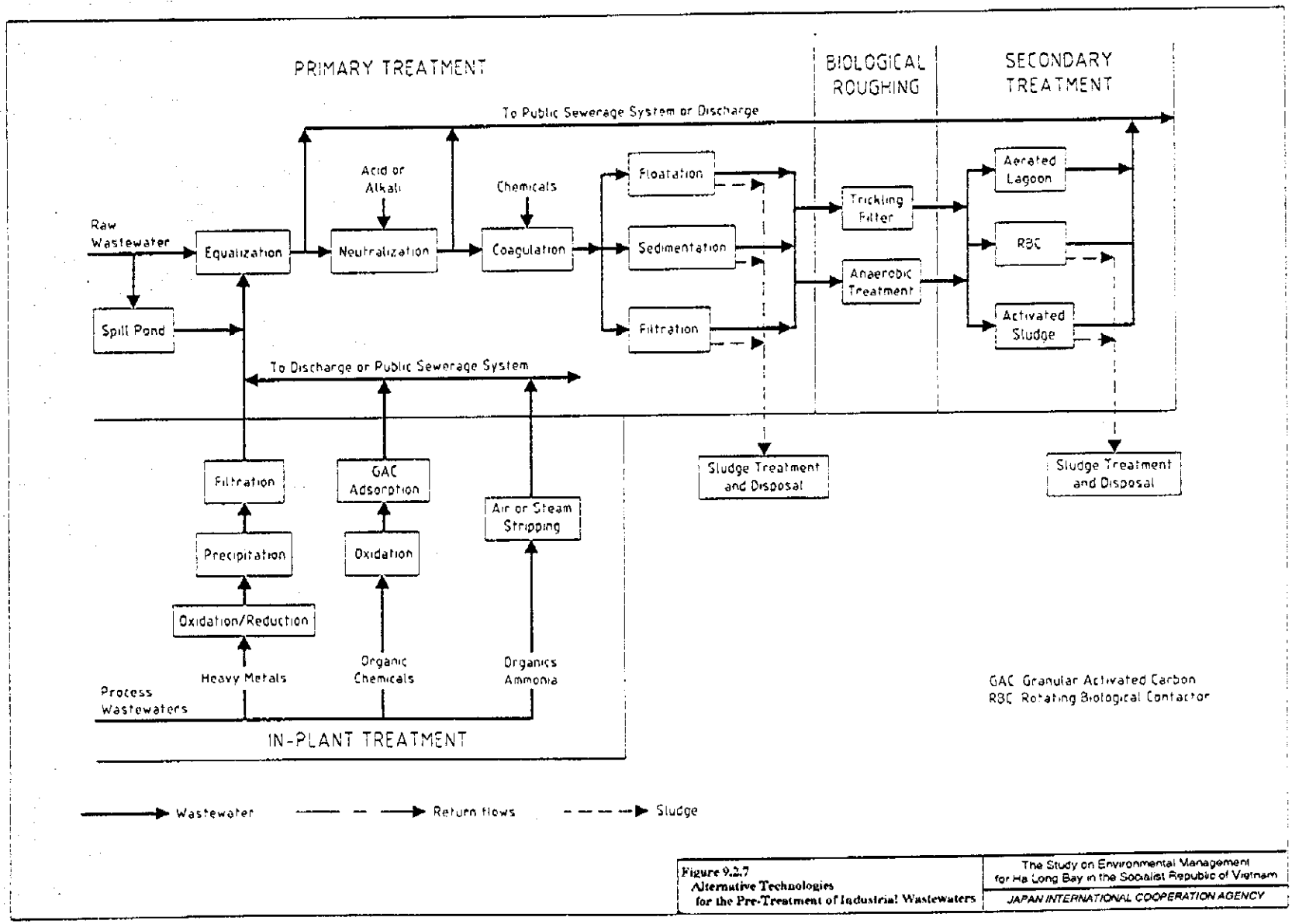


Figure 9.2.7
Alternative Technologies for the Pre-Treatment of Industrial Wastewaters

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam
JAPAN INTERNATIONAL COOPERATION AGENCY

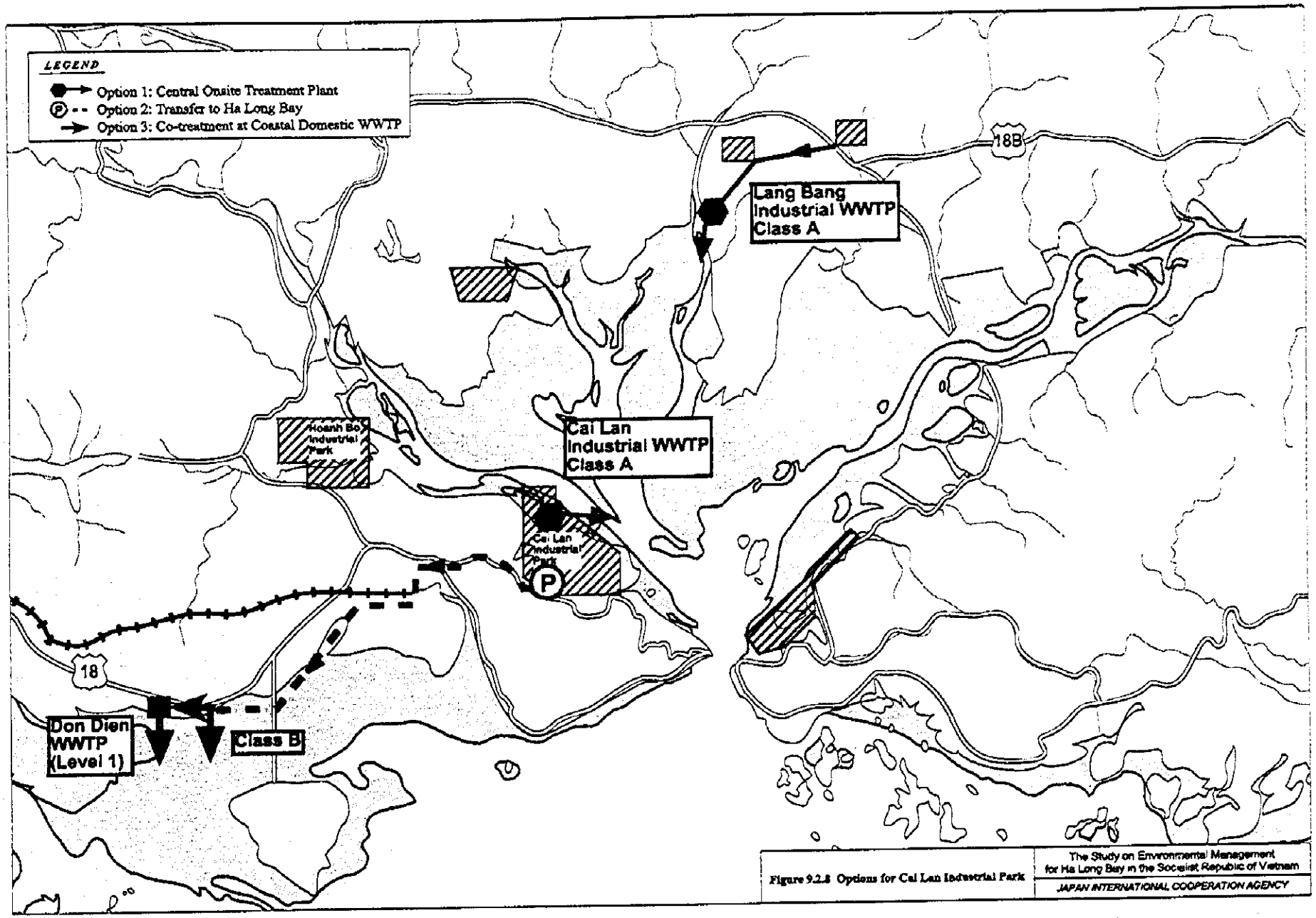


Figure 9.2.8 Options for Cai Lan Industrial Park

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY

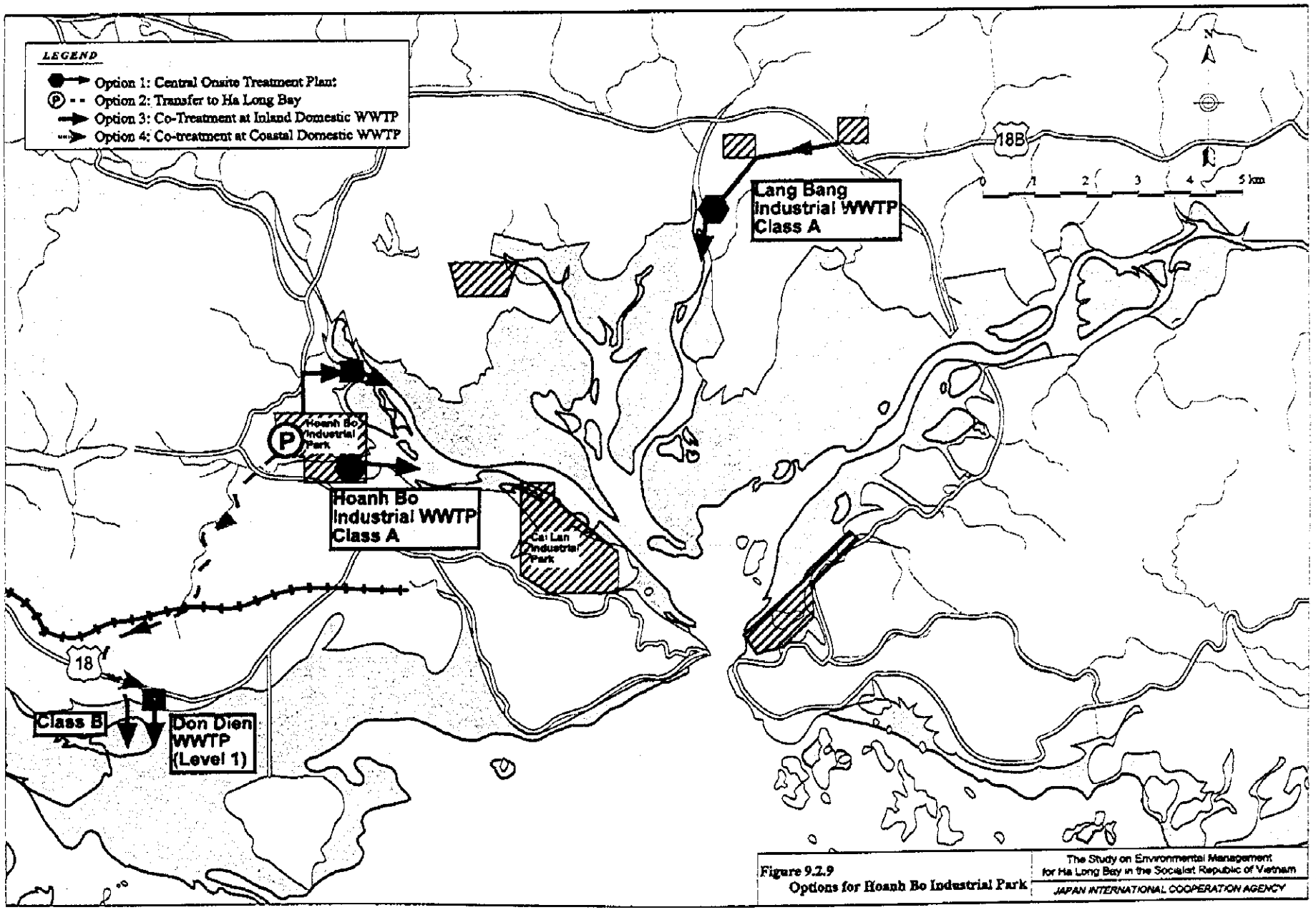


Figure 9.2.9
Options for Hoanh Bo Industrial Park

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam
JAPAN INTERNATIONAL COOPERATION AGENCY

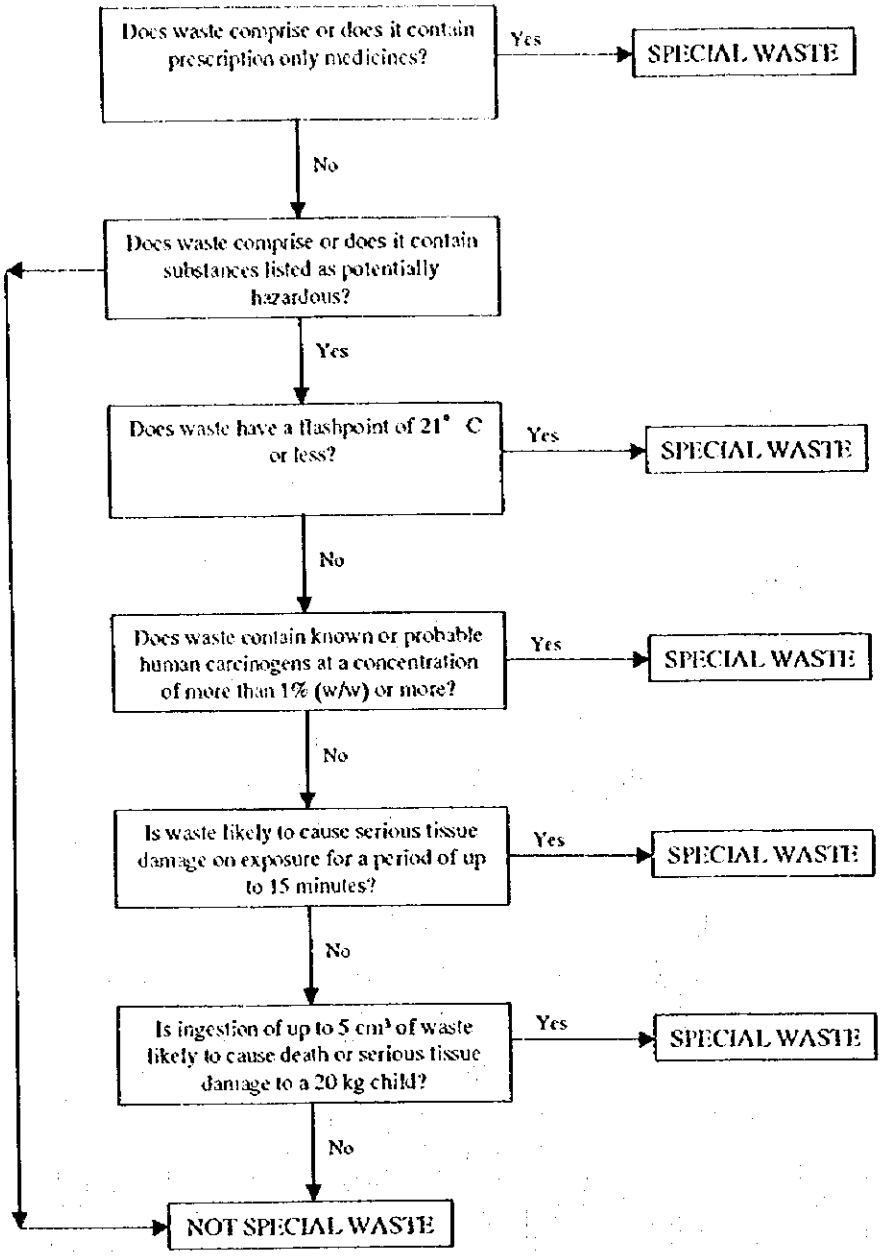


Figure 9.2.10 Special Wastes Assessment Procedure Diagram

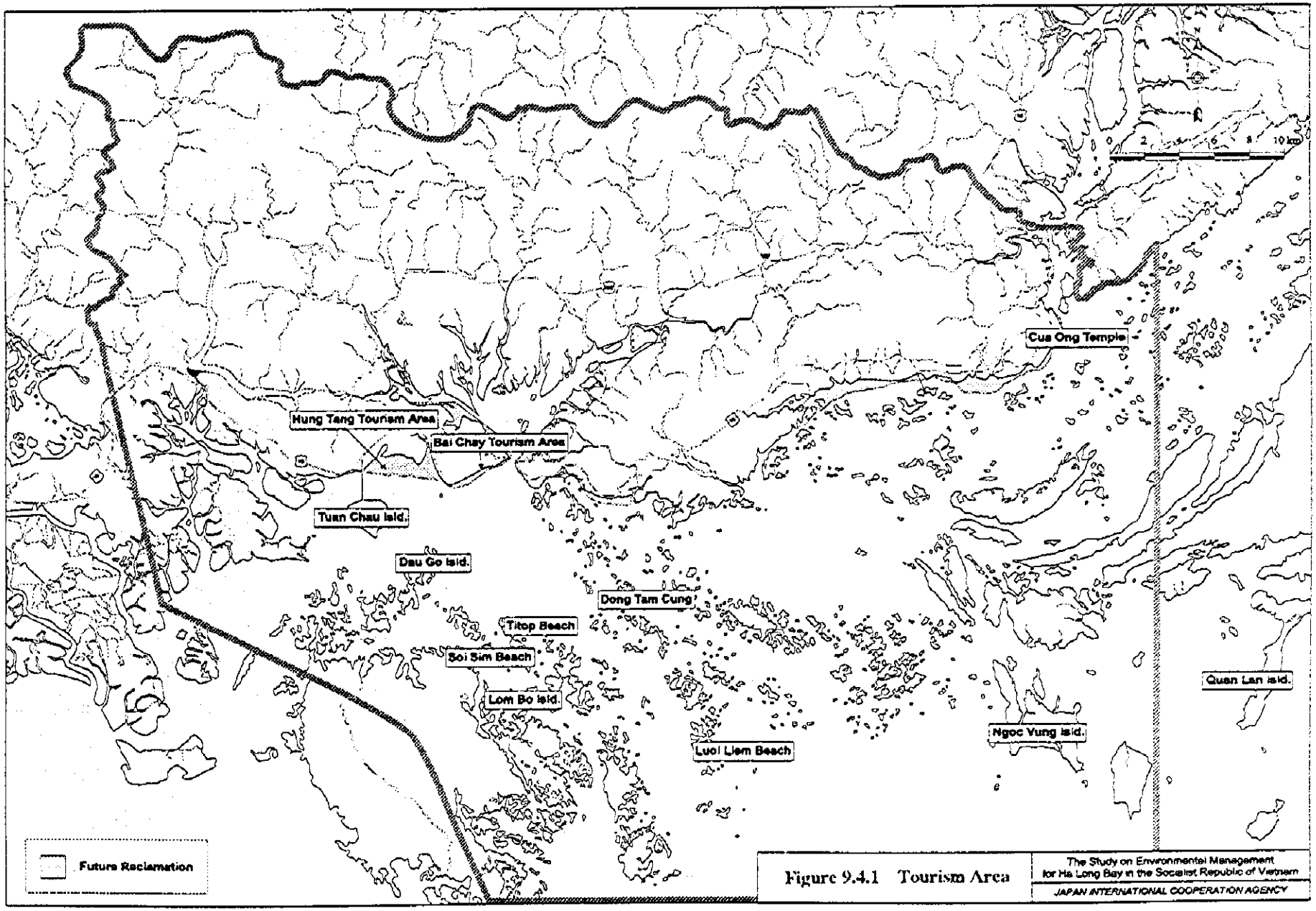


Figure 9.4.1 Tourism Area

The Study on Environmental Management for Ha Long Bay in the Socialist Republic of Vietnam

JAPAN INTERNATIONAL COOPERATION AGENCY