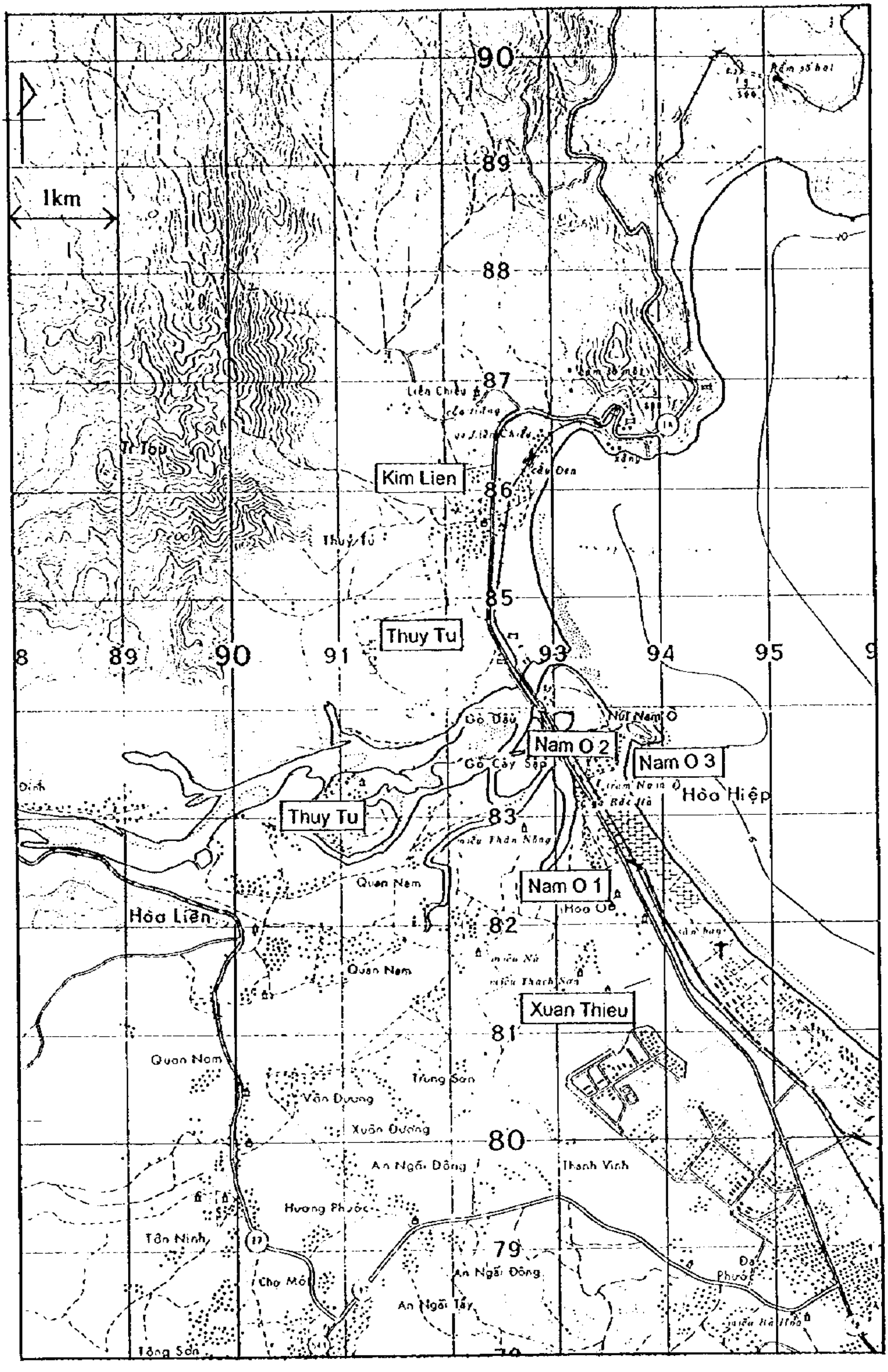

Figure 15.2.1 Map of Lien Chieu District and Communes in Danang City

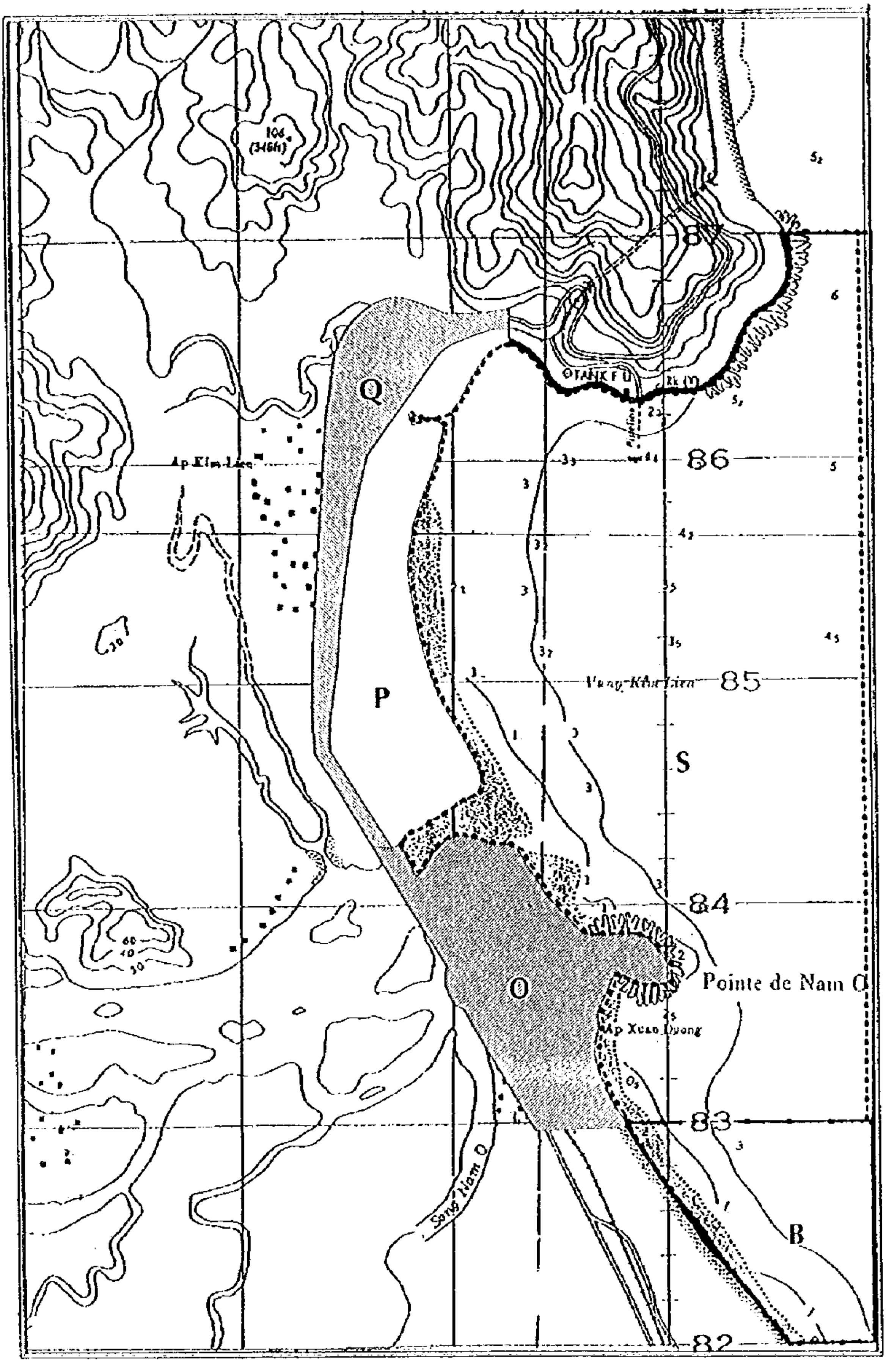

Figure 15.2.2 Study Area and Sub-areas in Lien Chieu

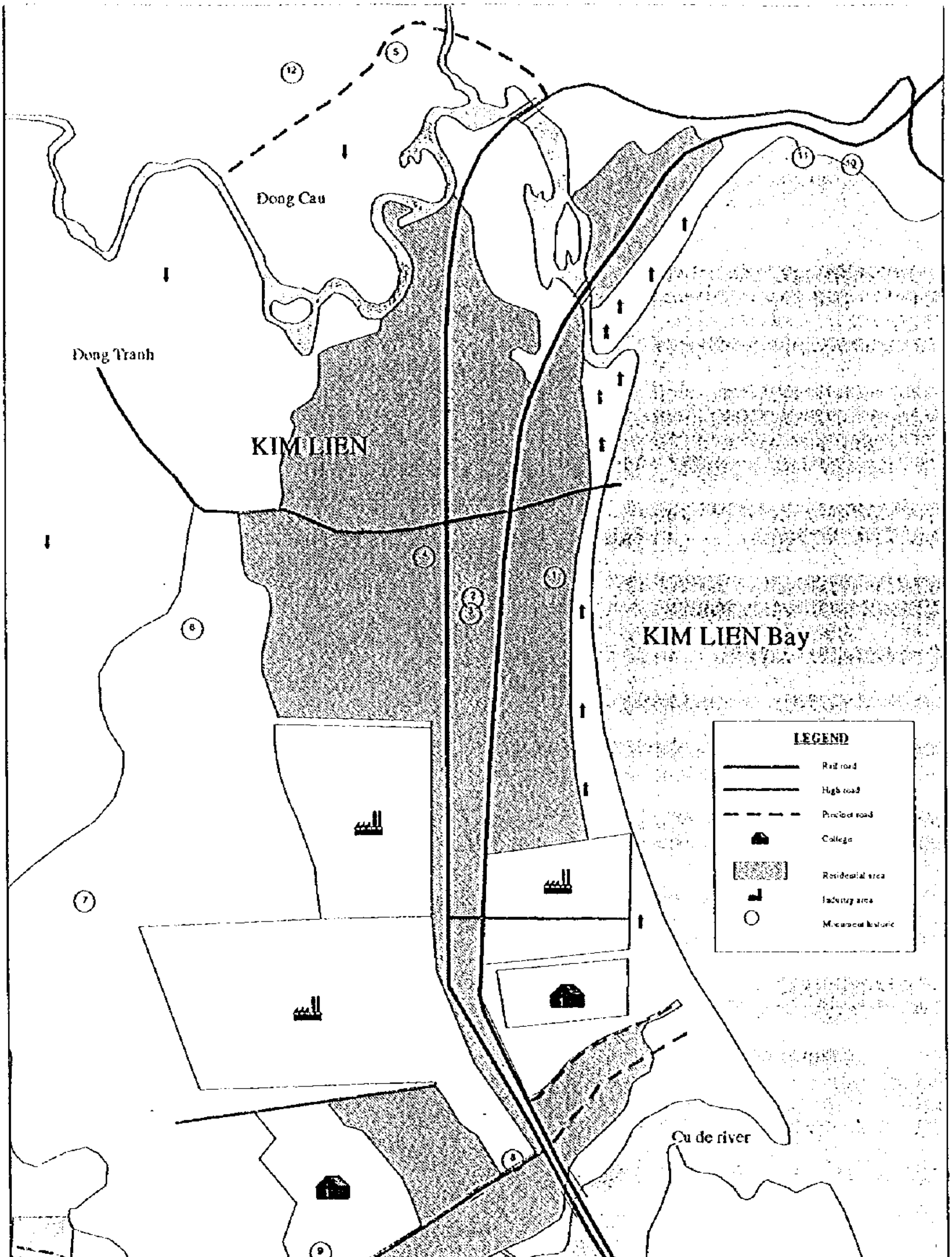

Figure 15.2.3 (1) Locations of Historical Relics in Kim Lien

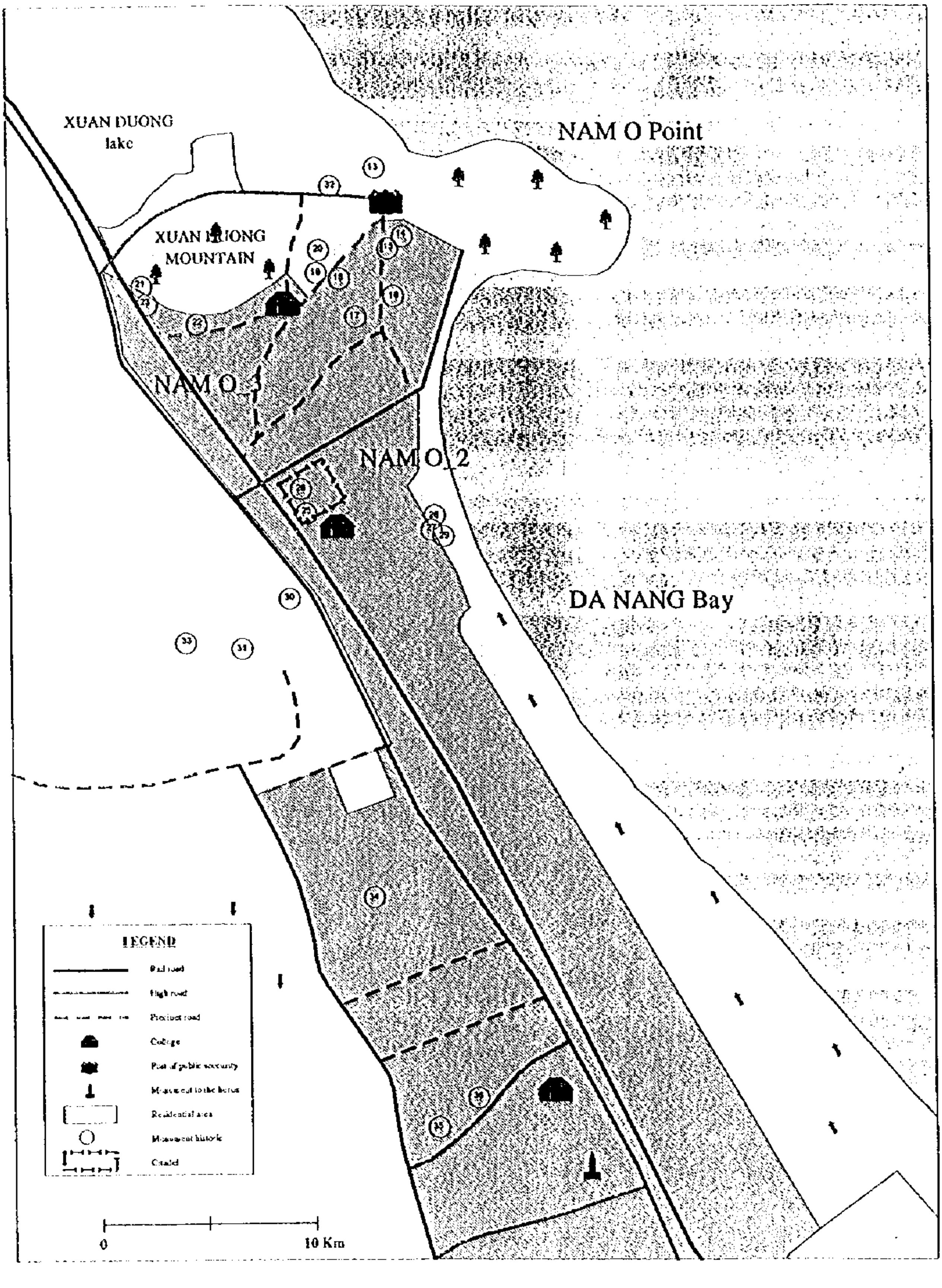

Figure 15.2.3 (2) Locations of Historical Relics in Nam O

15.3 IEE Checklist

The law on Environmental Protection was passed by the National Assembly of Vietnam in December 1993 and came into force in 1994. Consequently, most of large projects such as the development of Chan May are subject to EIA studies. The law requires the investors, project managers or directors of the offices to conduct the assessment of environmental impact (Article 9). Article 11 of the law defines that the EIA shall be conducted in two phases, namely preliminary and detailed. Appraising power is given to the Ministry of Science, Technology and Environment (MOSTE) for large projects and to the provincial Department of Science, Technology and Environment for others. In case of the development of ports, all projects which may handle more than 500,000 m3 per year need to be appraised by MOSTE.

Major sources of adverse effects of port development can be categorized into three types: (a) location of port; (b) construction; and (c) port operation, including ship traffic and discharges, cargo handling and storage, and land transport. Location of port connotes the existence of structures or landfills, and the position of the development site. Construction implies construction activities in the sea and on land, dredging, disposal of dredged materials, and transport of construction materials. Port operation includes ship-related factors such as vessel traffic, ship discharges and emissions, spills and leakage from ships; and cargo-related factors such as cargo handling and storage, handling equipment, hazardous materials, waterfront industry discharges, and land transport to and from the port.

Environmental facets to be considered in relation to the development of the new port of Lien Chieu are categorized into nine groups: (a) water quality; (b) coastal hydrology; (c) bottom contamination; (d) marine and coastal ecology; (e) air quality; (f) noise and vibration; (g) waste management; (h) visual quality; and (i) socio-cultural impacts.

Checklists of adverse effects of port development for IEE have been compiled by several organizations including the World Bank, the Asian Development Bank, the International Association of Ports and Harbors and Japan International Cooperation Agency. Based on the these checklists potential adverse effects are checked as listed in Table 14.3.1.

TABLE 15.3.1 Initial Environmental Examination Check List (Lien Chieu)

Factors	Impacts
(1) WATER-RELATED ITEMS	
a. Dredging 1) Toxic, harmful substances in water column; Sunlight penetration; Smothering bottom biota	Dredging will stir up bottom muds/sands. This will temporarily reduce sunlight penetration and smother some of the local bottom biota, but bottom habitat of particular high value/importance have not been detected.
2) Influence on tidal flows; Accelerated natural sediment deposition; Attraction of desirable or undesirable fisheries; Altered bottom biota	Dredging will alter bottom biota locally and may result in loss of fishery in the limited area of Danang Bay. Influence on tidal flow and sediment deposition to be studied in EIA
3) Change in current patterns; Shorezone and beach erosion; Accelerated sediment deposition shoaling	Impact of the reclamation and submersed structures to be studied in EIA
4) Loss of bottom habitat, shellfisheries, fishery food resources	Bottom habitat of particular high value/importance have not been detected.
5) Salt water intrusion; Accelerated groundwater flow to estuary	No dredging planned in river area
b. Dredged Material Disposal 1) Selection of appropriate disposal site; Methods of dredging and dredged material transfer and related disposal impacts	Dumping site located offshore well away from known fishing areas and coral reefs.
2) Characteristics of dredged material	Sand and sandy silt
3) Disposal methods (Potential or requirements for capping; Alteration of current patterns; Accelerated shoaling)	Dredged material will be used for land reclamation as much as possible. Limited volume of marine dumping will take place at offshore disposal site carefully selected.
c. Landfills and Construction of Breakwaters 1) Loss or displacement of shellfisheries, fishery food resources lost or displaced	Although there will be adverse effects on coral reefs at Lien Chieu, these reefs which are generally in bad condition are unlikely to be important/valuable shellfisheries or fishery food resources.

2) Desirable, undesirable species formed by structures (especially pilings and breakwaters)	Not detected in the past
3) Alter currents; Sediment deposition accelerated; Change required in harbor maintenance dredging practices	Changes in currents to be simulated.
4) Dispersal of suspended sediments	Areas likely to be adversely affected by dispersal of suspended sediments from landfills and breakwater construction do not contain any habitat or fisheries of particularly high value/importance, although these sediments are likely to adversely affect corals at Lien Chieu.
d. Alteration of Harbor/Port Ship Traffic Patterns	
1) Relocation of navigation markers, moorings	Not required
e. Ship Discharges, Oily Ballast; Bilge Water; Sewage	
1) Regulations controlling cleaning procedures; Limitations on release of cargo and machinery space residues (Discharge limitations); Need for facilities to receive waste from ships; Means of storage and ultimate disposal of residual wastes	Potential impacts will be mitigated by developing site-specific waste management procedures to be employed at each site for collection, handling, treatment and disposal of cleaning wastes, including wash-waters and residues.
2) Importance to fishery resources; Water quality of rivers, bays, harbors	Monitoring is ongoing. Change in Water quality to be studied
3) Shore facilities for receiving ship generated sewage and garbage waste; Sanitary treatment facilities (Connection to special or municipal systems); Transfer and pumping facilities	Port Design will include on-shore sewage and garbage waste handling, storage and disposal facilities for ship-board wastes.
f. Detection and Clean-up of Spills	
1) Type of spills (oils, lubricants, hydraulic oils, fuels, liquid and solid chemicals); Frequent spill sources	Potential types of spills and assessment of spill risk will be identified during detailed port design phase.

2) Spill clean-up measures (regulations, clean-up equipment available); Spill detection routines; Contingency plan	Oil berth to be equipped with oil fences. Site-specific spill clean-up measures will be developed, including management procedures, equipment requirements, spill detection system and emergency response procedures as part of the site contingency plan.
3) Dry cargo releases (fugitive emissions, dust control, smoke density and effects)	Bulk (mining products, coal, clinker and others) operations will have little dust emission. Site-specific dust control measures will be adopted during detailed port design phase.
g. Waterfront Industry Discharges	
1) Sanitary wastes (sources, volumes, special contaminants) - Sanitary treatment facilities (existing, planned, proposed, capacity of each locations, discharge water quality, ability to handle shipping)	Direct discharges of sanitary wastes into port waters are not planned in Lien Chieu. Sanitary treatment facilities and appropriate mitigation to be designed in the construction stage of waterfront industry.
2) Non-sanitary wastes (sources, volumes, toxins) - Discharge/treatment procedures (capacities, discharge points, limitations, residuals) - Discharges reaching harbor/river waters; Dispersion; Settling tendencies	Any requirements for non-sanitary waste discharge treatment facilities will be addressed in the site-specific design stage.
- Non-sanitary spillage from non-ship related activities (types of spills, frequency, volumes, how handled, retention/recovery systems)	Risk of non-sanitary spillage from non-ship related activities to be assessed during site-specific study
3) Heated process water discharges (electricity generation, industrial processes, LNG condensation)	Heated water discharges not detected
(2) LAND-RELATED ITEMS	
h. Excavation for Fill 1) Shore sand/gravel excavation; Dust (fugitive emissions); Blasting	Gravel extraction areas and potential impacts associated with gravel extraction process and appropriate mitigation methods for these will be identified in the site-specific study.

2) Transportation to construction site	Potential environmental impacts from the transportation of fill materials will be identified and addressed with appropriate mitigation measures in the site-specific study.
i. Wetland Damage and Filling	
1) Ecological value of wetlands (use by domestic animals, use by other fauna, unique vegetation, irrigation water source, damage to flora)	Wetland is located along the Cu De River. Although no mangrove has been identified, influence on the river flow would need detailed study during the site-specific investigations.
2) Runoff from ports and harbor facilities, Existing contamination input	Runoff collection and control measures will be designed at the detailed design stage with a view to minimizing the risk of future contamination of port and harbor waters.
j. Loss of Usable Uplands	
1) Types of land areas likely lost to waterfront use (residential areas, market centers, commercial areas)	The areas likely to be lost to waterfront use are currently low value, low populated land with few commercial activities.
2) Residential relocation; Replacement farmlands; Other replacement/relocation needs	Residential relocation of a few low quality houses and garden/farm land will be required at Lien Chieu.
k. Noise from ports and harborside industry:	
1) Location of noise sources; Background noise level	Noise from port activities is limited. Port related traffic which would be sources of noise needs further study to plan impact mitigation along the main transportation routes.
l. Dust and Other Airborne Emissions	
1) Sources (industrial, construction), Raw material storage	Sources of dust and other airborne emissions will be identified and appropriate mitigation measures planned on a site-specific basis.
2) Smoke and other combustion products (ships, traffic, industry)	Port activities in Lien Chieu area will generate no significant volume of smoke and other combustion products. Smoke from ship will be seen temporarily.

m. Traffic related items	
1) Existing traffic load (roadway network, traffic load, accident data)	Route No.1 is the major existing road and port-related traffic load will be studied in the site-specific investigation.
2) Projected traffic increases (roadway additions/improvements, important routes)	Port related road traffic will be identified and impact mitigation planned in the site-specific study.
n. Handling and Disposal of Solid Shore Generated Wastes	
1) Important sources (ships, waterfront industrial areas, residential areas)	Collection, handling and disposal of solid wastes generated from ships and port activities will be managed by port authorities and municipal agencies.
2) Means of transport/transfer (ship-to-shore, onshore)	Ship to shore transfer of ship generated wastes and onshore transport of these to treatment/disposal sites in an environmentally safe and secure manner will be carried out in accordance with the direction of port authority.
3) Disposal methods (incineration, landfills)	To be carried out in accordance with the direction of municipal agencies.
o. Runoff from Raw Material Storage	
1) Nature of materials (salt, sulfur, metal ores, refined concentrates)	Bulk cargo would be a potential runoff source. Preventive measures will be designed in the site-specific design stage.
2) Typical storage conditions, locations, storage time, health menace to workforce)	Storage of raw materials will be designed in the site-specific design stage with a view to reducing health menace to port workers.
p. Visual impacts	
Structure; Painting; Lighting; Attempts to blend with surroundings	Visual impact mitigation measures will be incorporated into the site development plans where this is practicable and warranted.

(3) AIR-RELATED ITEMS	
q. Background information	
1) Meteorological data (prevailing winds, seasonal weather patterns, storm tracks, frequency and severity, rainfall records, wind rose data)	Available in this report
2) Identify sensitive areas	None detected in Lien Chieu area
r. Gases, Smoke, and Fumes	
1) Sources, components, controls (industrial contributions, ships, residential background, vehicle emissions, background from other areas)	Impact of the emission from ships and port-related vehicles will be examined in the site-specific study.
(4) HAZARDOUS MATERIALS/CARGOES	
s. Categories Gases, Liquids, Solids	
1) How stored; Location of storage areas; Shipping and handling procedures; Disposal of any hazardous wastes generated	Site-specific hazardous materials/cargoes management practices, including location and design of storage areas, handling procedures and collection/treatment/disposal of any hazardous wastes will be developed in the site-specific detailed design stage. These cargoes will be handled in a restricted area of the Port.
(5) SOCIO-CULTURAL ITEMS	
Tribal, cultural, ethnic, historical, religious aspects likely impacted by changes, including consequences of modernisation and industrialisation Preserving traditions with minimum loss and disturbance; Removal of graveyards, churches, etc.	Socio-cultural situation of Lien Chieu area were studied and information is available in Chapter 15.2 of this report. Population to be relocated will be identified and assessed in the site-specific study.

15.4 Assessment of Environmental Impacts

15.4.1 Dredging and Dredged Material Disposal

Reclamation and dredging have the most potentially adverse effects. The development of Lien Chieu Port is designed within the water area between Cu De River and Lien Chieu Cape. A total of 95 ha landfill is proposed in the Master Plan and the total volume of dredging will be 8 million m^3.

(1) Dispersion of Suspended Solid (SS)

Deposition of rubble mound, dredging, pile driving and other construction works in water cause resuspension of sediments and turbid water. Resuspension of sediments in water leads to an increase in the level of suspended solids (SS) and in the concentration of organic matter, possibly to toxic or harmful levels. It also reduces sunlight penetration.

Disposal of dredged material has also potential adverse effects on the level of SS. Dredging volume is estimated at about 8 million for the Master Plan and at 3 million for the Initial Stage Development Plan (short-term development plan). Part of the dredged materials can be reclaimed in the landfill of planned wharves, but the remaining volume of dredged materials are disposed in the sea.

Two dumping sites are provisionally supposed at offshore of Son Tra Peninsula. Area A is located at N16°10' E108°16' (15 km from Lien Chieu) and area B is at N16°10' E108°13' (10 km from Lien Chieu). (see Figure 15.4.1)

As dumping generates a much larger volume of SS than dredging, a possible area of turbid water dispersion is assessed by the diffusion simulation of suspended solids.

(2) Simulation model of Suapended Solid

SS load caused by the dumping

SS load caused by the dumping is estimated using a method proposed by the Ministry of Transport of Japan (Environmental assessment manual for maritime constructions, 1984). The SS load caused by the dumping will be calculated by the following equation;

$$W = W_0(R/R_0)Q \quad \cdots\cdots\cdots\cdots \quad (1),$$

where,

W	:SS load caused by the dumping (ton),
W_0	:loading rate which is defined as a ratio of SS load to dumping volume(ton/m^3),
R	:percentage of sediment that contributes to resuspension at the dumping site(%),
R_0	:percentage of sediment whose diameter is less than 0.075mm where the loading rate was investigated(%),
Q	:dumping volume(m^3).

Dumping volume(Q); 3240m^3/one dumping ship.

Percentage of sediment that contributes to resuspension at the dumping site(R);

The percentage of sediment that contributes to resuspension depends on the flow velocity at the dumping site. The representative flow velocity at the dumping site obtained during the site survey is about 20 cm/s. Under these conditions, the diameter of the suspended sediment is less than 0.8mm according to the Camp equation that is presented as follows;

$$V_c=1.86\{(\rho_s-\rho)gd/\rho\}^{0.5},$$

where,

V_c	:flow velocity at dumping site(cm/s),
ρ_s	:sediment density(g/cm^3),
ρ	:water density(g/cm^3),
g	:acceleration of gravity(cm/s^2),
d	:diameter of sediment(cm).

According to the particle size tests of sediment, the portion of sediment less than 0.8mm is 97-99%, so we use R=100%.

Loading rate defined as a ratio of SS load to dumping volume (W_0);

The loading rate of dumping is set to W_0=11.63(kg/m^3) based on the previously mentioned assessment manual of the ministry of transport of Japan.

Percentage of sediment whose diameter is less than 0.075mm where the loading rate was investigated(R_0);

This value is set to R_0=96.7% from the manual.

SS load caused by the dumping (W,ton);

Substituting the above values into the equation(1), we obtain a SS load caused by the dumping, W=39ton/one dumping.

Dumping Site and Volume

The number of dumping times in a day is planned to be 2 times using one dumping ship. So, the total volume of dumping is 3240×2=6,480m^3/day, and the total SS load in a day is 39×2=78 ton/day. Settling velocity of suspended solid is an important parameter in the simulation. This parameter is set using the Stokes equation from the medium diameter of the sediment. The Stokes equation is as follows;

$$V=(1/18)g(\rho_s-\rho)d^2/\mu,$$

where,

V :settling velocity(cm/s)

ρ_s :sediment density(g/cm^3),

ρ :water density(g/cm^3),

g :acceleration of gravity(cm/s^2),

d :diameter of sediment(cm),

μ :viscosity of water(g/cm/s).

Given ρ_s=2.65, ρ=1.0, g=980, μ=0.0115(at a water temperature of 15℃), and substituting a medium diameter of 0.015mm into the equation based on the data of sediment size tests, we obtain a settling velocity of 0.018cm/s. This value is used in the simulation.

Other conditions such as the time step etc. are the same as previously mentioned ones regarding the COD simulation except for lateral diffusion coefficient and initial condition that is set as follows:.

Lateral diffusion coefficient:6.8×10^4 cm^2/sec,

Initial conditions: 0.0mg/l.

These conditions are shown in Table-15.4.1 .

Table-15.4.1 Conditions for suspended solid simulation

Items	Setting values etc.
Time step	90 seconds
Integration time	720 hours(30 days)
Lateral diffusion coefficient	6.8×10^4 cm^2/s
Location of dumping sites	Figure-5.1.4
SS load	78 ton/day (39ton/one dumping×2 times)
Initial value	0.0 mg/l
Boundary conditions	dilution method dilution ratio = 1.0

(3) Current Flow Simulation for SS Dispersion

To assess turbid water dispersion, tidal flow is identified in Danang Bay including outer area of the bay by computer simulation. Simulation results are shown in Figures A15.4.1 - A 15.4.3. The residual current is characterized by the outgoing anti-clockwise flow from the river mouth toward the mouth of the Danang Bay. The tidal current flows from the the mouth of Han river towards the bay mouth along the west coast. In the bay mouth, the incoming flow is seen in the northern part of the area while the outgoing flow is seen in the southern part. Results of this simulation on residual current (see Figure A15.4.3) are utilized to assess turbid water dispersion.

(4) Turbid water dispersion

Turbid water dispersion caused by disposal of dredged material at each dumping site is calculated as shown in Figure A15.4.4 -A15.4.7 using a dispersion equation. SS load caused by the disposition of dredged material is estimated at 78 ton. This estimation is carried out on the assumption that dredged material is disposed twice a day, 39ton at 7 a.m. and 39ton at 3 p.m.

Dumping Site B

Distribution pattern of daily mean concentration of suspended solid dumping and its maximum value at dumping site B are shown in Figure-A15.4.4 and A15.5.5. These figures show the overall tendency of the spread of high SS concentration area along the main stream of residual current (on the east side of the dumping site). Maximum SS concentration at site B is 0.9mg/l while the simulation shows no area in which SS concentration exceeds 1mg/l. Therefore it can be said that the effects of disposition of dredged material give little impact on daily mean SS concentration.

Daily maximum concentration of suspended solid is 12.8mg/l at the loading point or dumping site while the simulation shows daily maximum concentration of 1mg/l or more are seen in the area within 800m east of the loading point. The effects of dredged material disposal is limited to the area adjacent to the loading point.

Dumping site A

Distribution pattern of daily mean concentration of suspended solid dumping and its maximum value at dumping site A are shown in Figure-15.4.6 and A15.5.7. These figures show the overall tendency of the spread of high SS concentration area along the main stream of residual current (on the east side of the loading point or dumping site). SS concentration level is still relatively low. Maximum SS concentration at site 2 is 0.6mg/l, lower than at dumping site1. More active seawater exchange is supposed to pull down SS level. It can be said that there is no substantial adverse effects of disposal of dredged material on SS level at dumping site A. Daily maximum concentration of suspended solid is 10.6mg/l at the loading point or dumping site while the simulation shows daily maximum concentration of 1mg/l or more are seen in the area within 800m east of the loading point. The effects of dredged material disposal is limited to the area adjacent to the loading point.

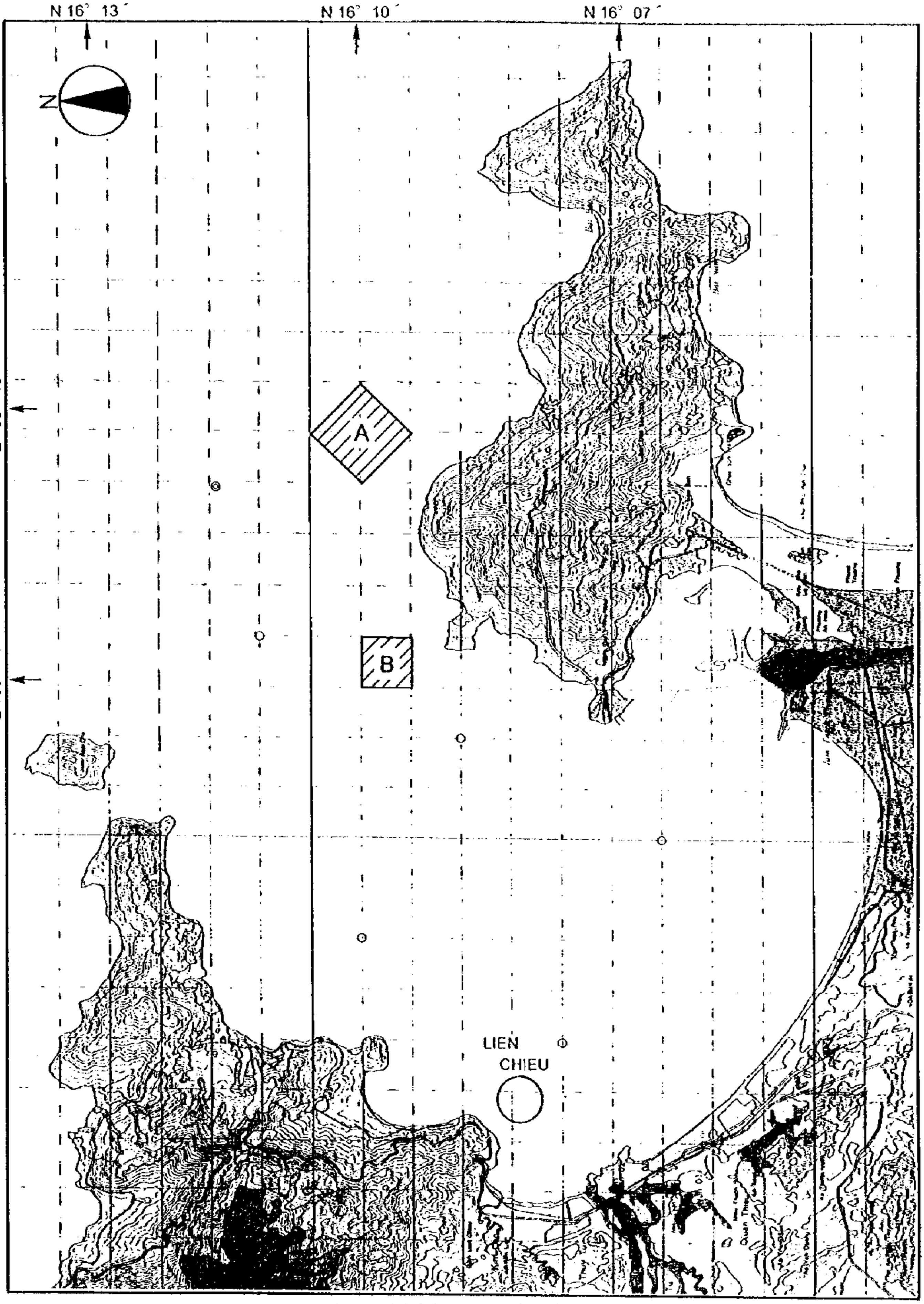

Figure 15.4.1 Dumping Sites

15.4.2 Current Flow

To assess the impact of the port development in the ISP (short-term development plan) and master plan, tidal currents are identified by means of computer simulation.

(1) Simulation Model

Depth-averaged two-dimensional hydrodynamic equations can be obtained by integrating the original three-dimensional equations from the bottom to the surface. Using the hydrostatic approximation, the momentum and continuity equations are obtained as follows;

Continuity equation ; $\frac{\partial \zeta}{\partial t}+\frac{\partial}{\partial x}\left[(\zeta+D)u\right]+\frac{\partial}{\partial y}\left[(\zeta+D)v\right]=0$

Momentum equations ;

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=fv-g\frac{\partial \zeta}{\partial x}+A_h\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)-\gamma_b^2\frac{u\sqrt{u^2+v^2}}{(\zeta+D)}+\frac{\rho_a}{\rho}\gamma_a^2\frac{W_x\sqrt{W_x^2+W_y^2}}{(\zeta+D)}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-fu-g\frac{\partial \zeta}{\partial y}+A_h\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)-\gamma_b^2\frac{v\sqrt{u^2+v^2}}{(\zeta+D)}+\frac{\rho_a}{\rho}\gamma_a^2\frac{W_y\sqrt{W_x^2+W_y^2}}{(\zeta+D)}$$

where,

x, y	:	A rectangular coordinate system is x-eastward ,y-northward
u, v	:	Depth-averaged velocity components in the x- and y-directions ,respectively
t	:	Time
ζ	:	Elevation of water surface measured from the mean sea level positive upward
D	:	Water depth below the mean sea level
f	:	Coriolis parameter
g	:	Gravitational acceleration
γ_a^2	:	Sea surface friction coefficient
γ_b^2	:	Bottom friction coefficient
A_h	:	Lateral eddy viscosity coefficient
ρ_a, ρ	:	Air and water density, respectively
W_x, W_y	:	Wind velocity components in the x- and y-direction, respectively

Diffusion model for passive materials can be obtained separately after the computation of current by a hydrodynamic model. The depth-averaged two-dimensional mass conservation equation for passive materials can be obtained by vertical integration similar to a hydrodynamic model. The equation is obtained as follows;

$$\frac{\partial S(\zeta+D)}{\partial t}=-\frac{\partial}{\partial x}[Su(\zeta+D)]-\frac{\partial}{\partial y}[Sv(\zeta+D)]$$

$$+\frac{\partial}{\partial x}\left[K(\zeta+D)\frac{\partial S}{\partial x}\right]+\frac{\partial}{\partial y}\left[K(\zeta+D)\frac{\partial S}{\partial y}\right]+L_S$$

where,

S	:	Depth-averaged concentration for the material
x,y	:	A rectangular coordinate system is x-eastward ,y-northward
u,v	:	Depth-averaged velocity components in the x- and y-directions ,respectively
t	:	Time
ζ	:	Elevation of water surface measured from the mean sea level positive upward
D	:	Water depth below the mean sea level
K	:	Lateral eddy diffusivity coefficient
L_S	:	Input load of the material

In a depth-averaged two-dimensional diffusion model for suspended solid, sinking term of suspended solid is incorporated in the equation. It can be obtained by vertical integration similar to the hydrodynamic model. The equation is obtained as follows;

$$\frac{\partial S(\zeta+D)}{\partial t}=-\frac{\partial}{\partial x}[Su(\zeta+D)]-\frac{\partial}{\partial y}[Sv(\zeta+D)]$$

$$+\frac{\partial}{\partial x}\left[K(\zeta+D)\frac{\partial S}{\partial x}\right]+\frac{\partial}{\partial y}\left[K(\zeta+D)\frac{\partial S}{\partial y}\right]+L_S-W_0S$$

where,

S	:	Depth-averaged concentration for the suspended solids
x,y	:	A rectangular coordinate system is x-eastward ,y-northward
u,v	:	Depth-averaged velocity components in the x- and y-directions ,respectively
t	:	Time
ζ	:	Elevation of water surface measured from the mean sea level positive upward
D	:	Water depth below the mean sea level
K	:	Lateral eddy diffusivity coefficient
W_0	:	Settling speed
L_S	:	Input load of the suspended solids

The influence on current velocity field by the construction of port is estimated using a depth-averaged 2-dimensional sea flow simulation model. The prediction is executed for the intermediate and final development stage.

(2) Prerequisites for Simulation

In order to execute the flow simulation, we necessarily set conditions such as simulation domain, grid system, water depth at each grid, boundary conditions, parameters required in the simulation and inflows from river to sea and so on. These conditions are set as shown in Table-15.4.2 based on the development plans and the observation data etc. In the observation of the sea flow, it is considered that the K1 constituent in the tidal current is representative, so the boundary condition is set to be 24 hours in the period.

TABLE 15.4.2 Prerequisites for flow simulation

Items		Setting values etc.
Simulation area		Figure-A15.4.8
Grid length		200m
Water depth		Chart
Boundary conditions		Figure-A15.4.8, Table-15.4.3
Time step		60 seconds
Integration time		96 hours(4 tides)
Wind condition	Wind speed	3.0 m/sec
	Wind direction	NE(45°)
Lateral eddy viscosity coefficient		2.7×10^4 cm^2/sec
Sea surface friction coefficient		0.0016
Bottom friction coefficient		0.0026
Inflows from rivers		Figure-A15.4.8, Table-15.4.4
Coliolis parameter		$f = 2\omega \sin\varphi$ $\omega = 2\pi / (24 \times 3600)$ rad/sec $\varphi = 16.15°$

Table-15.4.3 Boundary conditions

Point	Amplitude(cm)	Phase(degree)
A	19.7	0.0
B	19.7	0.0
C	19.7	1.0

Table-15.4.4 Inflows from rivers

	Flow(m^3/sec)
Han river	400
Cude river	200

(3) Simulation Results

Comparison of current ellipse

Comparison between observed current ellipse of K_1 component and its calculated current ellipse is shown in Figure-A15.4.9 and A15.4.10.

TC1 - TC2 (15 days observation) shows diurnal changes in current direction. TC3 - TC5 (24 hours observation) shows no clear reversing current. It is assumed that the wind affected the result of survey on current pattern since the observation also found daily changes in wind direction. Observed current ellipse at survey sites is not so consistent with its calculated current ellipse at TC1-TC4. However observed pattern is relatively in good agreement with its calculated pattern at TC 5.

In computer simulation, predominant wind direction and wind velocity are taken into consideration. However diurnal changes in wind pattern were not utilized in the calculation. That may be one of the reasons why calculated values are inconsistent with observed values. In order to project and examine environmental effects such as water contamination, it is important to accurately simulate residual current which gives great impact on dispersion of materials. Thus this comparison between calculated and observed pattern of current ellipse is provided as a reference of which accuracy of reproduction will be later examined based on the observation of residual current.

Comparison between observed residual current and its calculated value

Residual current pattern and its calculated value at each survey site are shown in Figure-A15.4.11. The distribution pattern of residual current pattern is summarized as follows:

- The tidal current from the mouth of the Han river flows to the north along the north coast while the clockwise current appears flowing from the estuary along the west coast.
- The tidal current from the mouth of the Cu De river generally flows to NE or toward the bay mouth along the east coast.
- There is a tidal current from the north and partly the clockwise counter current in the mouth of the bay.
- Around the planned construction site, there is a relatively small tidal current from the north to south, which meet the outgoing flow of Cu De river.
- The observation found counter clockwise current patterns flowing from the river into the southern part of the bay mouth. The same pattern is also seen in computer simulation.

Therefore it is considered that calculated values are in good agreement with observed values. Calculated tidal current pattern during ebb tide and flood tide based on the result of computer simulation are shown in Figure-A15.4.12 and A15.4.13. During ebb tide, there is a tidal current from the back of the bay toward the bay along the north coast. During the flood tide, velocity of the tidal current flowing from the Han river along the north coast is smaller compared with that during the ebb tide since the outgoing current offsets the inward tidal current.

(4) Current Changes by Short-term Port Development

Projection is made for the changes in geographic features in the planned site of short term development of Lien Chieu Port. Calculated tidal pattern during ebb tide and flood tide and for tidal residual current are shown in Figure A15.4.14 - A15.4.16. Calculated tidal current patterns are generally consistent with observed patterns.

To quantitatively estimate the change in the direction of tidal current which the short term development plan may cause, calculated values for survey sites were subtracted from those in the short term development plan and results are shown Figure A15.4.17 - A15.4.19.

The construction of training jetty in short term development plan in Lien Chieu port is expected to change velocity of the tidal current near the mouth of the Cu De river. The result of the calculation during ebb tide and flood tide and for residual current are summarized as follows:

During ebb time

Increase in current velocity is seen near the mouth of the Cu De river. Current velocity is projected to increased by 1 cm/s or more in the area which extends to approximately 1,800 m from the estuary. Current velocity is predicted to increase by 8 cm/s at maximum. Near the training jetty, current velocity is expected to decrease by 3 - 4cm/s since the flow from the mouth of the bay is blocked in the north side of the training jetty. Although the current velocity is predicted to decrease by approximately 1cm/s near the reclaimed land in the port, the effect will be seen only in small area.

During flood tide

Changes in current velocity are expected in the same pattern as those seen during the ebb tide. The increase in current velocity, 8cm/s of increase at maximum, is expected at sites near the mouth of the Cu De river while 3 - 4cm/s of decrease in current velocity is predicted in the northern side of the training jetty since it blocks the flow from the river. Around 1cm/s of changes in current velocity are expected at a number of points compared with those during ebb tide.

Changes in the residual current

The same pattern of changes in current velocity as those seen during the ebb and flood tide is expected. Maximum of 8cm/s increase in current velocity is projected near the mouth of the Cu De river while 3 - 4cm/s of decrease is expected in the northern side of the training jetty. There is around 1cm/s of decrease in speed in the vicinity of the reclaimed land.

(5) Current Changes by Master Plan (Long term development plan)

Projection is made for the changes in geographic features in the planned site of the long term development plan of Lien Chieu Port. Calculated tidal pattern during ebb tide and flood tide and for tidal residual current are shown in Figure A15.4.20 - A15.4.22. Calculated current patterns are generally in good agreement with the observed patterns at the survey sites.

To quantitatively predict the changes in the tidal current, calculated values in the planned site are subtracted from those in long term development plan to see the difference which is presented in Figure A15.4.23 - A15.4.25.

Changes in current velocity are seen near the mouth of the Cu De river due to the planned training jetty in the estuary. These are the same kind of changes as those forecasted in the short term development plan. To summarize the projection during ebb tide and flood tide and for tidal residual current, predicted changes which are peculiar to the long term development plans are presented as follows.

During the ebb tide, a decrease of 1cm/s in current velocity is seen in the back of the reclaimed land in the port. During the flood tide, the same tendency as the short term development is expected, namely, 1cm/s of decrease in current velocity is seen in the back of the reclaimed land and near the reclaimed land on the east side of the port. 1cm/s of increase is predicted at sites off the coast of the reclaimed land.

As for tidal residual current, approximately 1cm/s of decrease in current velocity is seen off the bottom of reclaimed land in the port while 1 cm/s of increase in current velocity is predicted off the coast of the reclaimed land.

15.4.3 Water Quality

Water quality is mainly measured by five elements: (a) general features such as temperature, salinity, pH, colour, transparency, oil and grease, and organic material concentration measured by chemical oxygen demand (COD) or biochemical oxygen demand (BOD); (b) turbidity measured by suspended solids (SS); (c) eutrophication-related factors measured by dissolved oxygen (DO), nitrogen (N) and phosphorus (P); (d) harmful or toxic substances including heavy metals such as mercury, cadmium, lead, and pesticides; and (e) sanitation-related factors determined by measuring the amount of coliform bacteria.

(1) Simulation Model

COD is usually used for an indicator of the dispersion of water pollution in the sea, water quality is assessed by COD dispersion model on tidal currents. The influence on sea water quality to be caused by the construction of port is estimated using a depth-averaged 2-dimensional mass conservation simulation model. Chemical oxygen demand (COD) is selected for the index of organic pollution in the sea. The prediction is executed for the final development stage.

(2) Prerequisites for Simulation

In order to execute the water quality simulation, it is necessary to set initial conditions, boundary conditions, parameters required in the simulation and inflows from river to sea in addition to the conditions set in the flow simulation such as the grid system. These conditions are set as shown in Table 15.4.5 based on the observation data.

Table 15.4.5 Conditions for water quality simulation

Items		Setting values etc.	
Time step		90 seconds	
Integration time		720 hours (30 days)	
Lateral diffusion coefficient		$2.7\times10^4 cm^2/s$	
COD load from rivers	Case1	Han river	1600 g/s
		Cu De river	300 g/s
	Case2	Han river	1990 g/s
		Cu De river	373 g/s
Initial value		1.5 mg/l	
Boundary conditions		Dilution method Dilution ratio = 1.0	

(3) Verification of the result of computer simulation

There is not enough data to verify the result of COD simulation due to the fact that the observed COD data are limited and did not indicate an average concentration. Periodic monitoring is necessary for the calibration of COD simulation. Therefore, this simulation is used for identifying the difference between the present and future geological features.

Figure A15.4.26 shows the daily mean concentration of COD in the present condition which indicates that the load from the Han river spreads in Danang Bay. Concentration of COD is relatively high in the area from the mouth of the Han river along the west coast. It also suggests that COD concentration is inversely proportional to the distance from the mouth of the river. Daily mean concentration of COD is estimated at 1.5-1.6mg/l in the northern area of Danang Bay.

(4) Future Level of COD concentration

Future daily mean concentration of COD is estimated on the assumption that the proposed plan has the same amount of COD load as the one in the present condition. Distribution pattern is similar to the one calculated in the present condition however it tends to slightly expand offshore from the mouth of the Han river. Difference of COD level between the present and future geological features is shown in Figure A15.4.27.

Maximum increase in COD concentration is estimated at 0.5mg/l in the water area between two rivers. An increase of 0.1mg/l or more is seen in a broad area from Cu De river to Han river. A little change in clockwise current in the bay is considered to give slight impact on current velocity and COD concentration.

In case that future load of COD will increase at the rate of population increase, daily mean concentration of COD is assessed as shown in Figure A15.4.28. The estimation indicates that COD load from the Han river tends to spread offshore in the bay. COD concentration will increase by 26 % to 4.8mg/l at the mouth of the Han river and to 1.6~1.8mg/l in the vicinity of Lien Chieu port. Increase in COD concentration is estimated at about 1.0 mg/l at maximum in this case. Changes of 0.1mg/s or more are seen in a broad area from the Cu De river to Son Tra peninsula (see Figure A15.4.29). It is considered that increase in the amount of COD load from the river is more dominant over that caused by changes in geographic features.

15.4.4 Shoreline Change

Marine structures or land reclamation usually cause changes in currents and wave movements, which may result in changes in the shoreline configuration (e.g. beach erosion or accretion). Erosion and accretion take place alternately due to the change of onshore-offshore littoral transport and longshore littoral drifts.

The beach at the back of Danang bay has a total length of of 14,500 m, of which 12,500 m lies between the Han river and the Cu De river and 2,000 m is between Cu De river and Kim Lien. Since the beach is located in a bay, littoral drift is limited in the bay and a large volume of beach erosion or sand accretion is not likely at the beach.

Littoral drift survey by float movements showed that littoral current flows from the north to south, i.e. from Kim Lien to the mouth of Cu De river. This is confirmed by the fact that the construction of the pier of Hai Van Cement caused sand accumulation in the north of the jetty and small scale of erosion in the south of the pier. Shoreline changes in the Danang bay beach is assessed by a numeric simulation model which calculate the balance of sand drifts along the coast.

(1) Simulation Model

Volume of sand drift can be obtained by calculating the balance of inflow and outflow of sand at a section of the beach within a certain time period. Balance equation is expressed as follows.

Continuity equation ; $\frac{\partial X}{\partial t} + \frac{1}{D_h}\left(\frac{\partial Q}{\partial y} - q\right) = 0$

Where

X:	Distance of the shoreline from the base line
t:	Time
y:	Length along the shoreline
D_h	Width of surf zone
Q:	Quantity of longshore sand drift (along the shoreline)
Q:	Qunatity of onshore-offshore sand drift (perpendicular to the shoreline)

Quantity of sand drift along the shoreline is calculated by using the along shore component of the incoming wave energy. The predominant wave direction is ENE, so the shoreline in the Lien Chieu to Nam O area is perpendicular to this wave direction. As shown in the simulation of tidal current in the Danang bay, the counter clock-wise flow appears in the offshore of Lien Chieu area. Littoral drift therefore moves from the north to south in the offshore of the development site and Nam O area.

Result of numerical simulation is as shown in the Figure A4.7.3. Sand accumulation and erosion will take place between the mouth of Cu De river and Nam O Headland. Distance between Cu De river and Nam O headland is about 900 m, where the width of onshore-offshore shoreline change will be less than 50 m. Less change may take place in the south coast of Nam O headland.

The beach at the back of Danang Bay forms a pocket beach between Nam O headland and the mouth of Han river, and another pocket beach between Nam O headland and Lien Chieu Cape (Kim Lien), which are stable in general. Taking into account the numerical simulation of sand drift and the actual change caused by the construction of Hai Van Cement Pier, the Master Plan of Lien Chieu development will not induce serious beach erosion nor sand accumulation. However, it will be necessary to prevent a sand drift from north to Cu De river mouth by a groin extended from the left bank of the river mouth. The length of the proposed groin shall be carefully decided in the course of construction.

15.4.5 Port Traffic

Volume of port traffic is estimated using the standard formula of traffic volume originated from and destined to a port.

Design Traffic Volume (vehicles/hour)

$$= \text{Annual handled cargo volume (freight tons/year)} \times \alpha / W \times \beta / 12 \times \gamma / 30 \times (1+\delta) / \varepsilon \times \sigma$$

where,

- α : Share by vehicles = Transport volume by vehicles/transport volume by all traffic means
- β : Monthly variation = Cargo volume of peak month/cargo volume of average month
- γ : Daily variation = Cargo volume of peak day/cargo volume of average day
- W: Truck real loadage (freight tons/unit) Cargo transport volume per load truck (to be determined by surveys or in reference to results of other ports
- ε : Real load rate = Number of loaded trucks/number of all trucks
- δ : Related vehicle rate = Number of vehicles related to traffic of trucks /number of all trucks
- σ : Hourly variation = Peak hourly traffic volume/daily traffic volume

Daily traffic from/to the Lien Chieu area is estimated at about 6,000 in the year 2010 and at about 15,000 in 2020. Peak hour traffic is about 800 and 2,000 respectively. Breakdowns in vehicle types are shown in the Table 15.4.6. Port layout plan proposes two access roads with four lanes, i.e. one from R1 passing near the Lien Chieu Station and the other from Lien Chieu industrial zone crossing the R1. Therefore, peak hour traffic volume will be well in the capacity of access roads.

TABLE 15.4.6 Traffic Volume Estimates

	2010		2020	
Vehicle type	Hour	Day	Hour	Day
Container Trailers	81	578	263	1,877
Trucks	468	3,343	1,117	7,983
Passenger Cars	274	1,960	690	4,930
Total	823	5,881	2,071	14,790

15.4.6 Marine and Coastal Ecology

The proposed port development area at Lien Chieu contains for ecosystems that are normally noted for their particular sensitivity to environmental impacts. These are:

1. the coral reef communities;
2. the seagrass meadows;
3. the river estuaries, and;
4. the coastal wetlands.

<u>Coral reef communities</u>

Coral reef communities are particularly susceptible to the environmental impacts, which may arise during the construction of marine developments. These impacts may occur through:

- Direct physical damage caused by physical impact, dislocation, abrasion or smothering with construction materials or equipment, or as a result of pressure waves from rock blasting;
- Direct physical damage caused by dislocation and disturbance of the coral reefs and communities during channel dredging activities;
- Direct physical dislocation and smothering of the coral communities that are close to site operations by the silts and heavier sediments derived from construction activities along the shore and in the near-shore coastal waters, from dredging and dredge spoil dumping operations;
- Disruption to the growth and other vital metabolic processes of the coral reefs and communities (including the symbiotic algal components associated with corals) by increased light attenuation and the choking effect on respiratory and feeding apparatus caused by the finer sediments derived from these construction, dredging and dredge spoil dumping activities. These finer sediments are capable of being transported, by inshore currents and turbulence, much further from their source than the heavier silts. Consequently this effect, although not so immediate as the preceding effects, tends to be more pervasive, being longer lasting (as these finer materials remain suspended in the water column for much longer) and more widespread in their effects;

The presence and operations of a major seaport in the vicinity of coral reef communities can also have long-term effects on the health and viability of these ecosystems;

- Long-term disruption to the coastal ecosystem, of which these communities are an integral part. This disruption is frequently caused by changes to the inshore current patterns resulting from the construction of breakwaters and other submersed structures, and from dredging and channel clearance activities which change sedimentation patterns and the flow of nutrients and microscopic food organisms upon which these coral reef communities depend;
- Long-term displacement of coral reef communities through the eutrophication (nutrient enrichment) of the coastal waters from port sewage outfalls (most treated sewage effluent still contains high concentrations of nitrate and phosphate nutrients in the discharge) and increased surface runoff that promote the growth of other competing benthic communities at the expense of coral reefs which are adapted to a low-nutrient environment;
- Coral reef communities are particularly susceptible to sediment laden discharges, discharges of a high organic or toxic nature, and oil films and emulsions in the water column, Such discharges are frequently generated in the course of normal operations of a large seaport, and unless effective containment and treatment measures are implemented, these discharges will inevitably result in significant damage to the reef communities.

The development area at Lien Chieu contains two coral reef communities, at Ham So Mot at the northern end of the area, and Nam O cape at the southern end of the area. However, as has been described in Chapter 15.1.4, these reefs have already suffered severe stress resulting in 95% of the coral reefs at both locations having a living coral cover of less than 25%. Under these circumstances, unless immediate and effective action is taken to reverse this trend, the long-term viability of these two coral reefs is very low. As such a reversal in unlikely to be achieved given present economic constrains and the priorities of development, the additional burden of port derived impacts is much less significant on a regional scale than would otherwise be the case.

The coral reefs around the Ham So Mot rock outcrop are almost certainly likely to suffer further significant damage during the construction of breakwaters at Lien Chieu as the preliminary designs show a major breakwater running from this outcrop across the front of Kim Lien bay. Inevitably the construction of this breakwater will generate major impacts on these corals which are in the immediate vicinity.

The coral reefs around Nam O rock outcrop are also fairly close (approximately within 1 km) to a proposed breakwater construction site on the south-western side of Kim Lien bay, and are also likely to suffer further significant impacts such as these caused by sediment laden water and possibly direct physical damage.

As these coral reefs are already in very poor condition, further environmental stress may well result in the loss of the coral reef, particularly the reef at Ham So Mot. However, as noted above, the loss may not be significant at the regional level in terms of biodiversity value and fisheries values due to their already existing poor condition. Furthermore, although such a loss may have an effect on the local biodiversity value of this area, this can reasonably be regarded as inevitable given the nature and scale of the proposed development and should be balanced against the socio-economic benefits that the development will bring to the area.

Seagrass meadows

Seagrass meadows are common on shallow, exposed platforms, especially on the middle and back zones of reef flats. These meadows are highly productive and provide important habitats for herbivorous, carnivorous and detritus-feeding fish and shellfish, and their larvae, which feed and shelter within these dense meadows of marine grasses. The juveniles of some reef and offshore fishes use seagrass meadows as secure nursery grounds, and their ecological importance extends beyond their immediate vicinity.

Like other benthic (seabed) communities, seagrass meadows are affected by any activities or developments that affect the dynamics of current flows, sediment transport and deposition and the nutrient status of the water. They are also susceptible to sediment-laden discharges, discharges of a high organic or toxic nature, and oil films and emulsions in the water column. They are dependent upon, and will be affected by any changes to:

1. tidal currents and moderate wave action that flushes sediment and detritus (including dead plants and detached thalli (leaves) from the meadows;
2. protection from severe wave action, hence their occurrence mainly on the exposed flats behind the coral reefs;
3. adequate salinities that afford the seagrasses a competitive advantage over other benthic communities which are less tolerant of marine water;
4. nutrient replenishment from land-based sources (river discharges and surface runoff);
5. substrate hardness, stability, and depth that influence that ability of seagrasses to

attach and form firm root anchorages;

6. water clarity and light attenuation.

Several of these factors will be affected by the port development at Lien Chieu, and several of these effects will have an adverse impact on the seagrass meadows in the area unless effective measures to limit these impacts are taken. Of particular concern will be:

1. direct physical damage, dislocation and smothering;
2. increased turbidity and light attenuation from elevated concentrations of suspended silts and muds in the water column;
3. changes to the velocity and volume of current flows which will alter the patterns of sediment deposition and scouring, and the flow (import) of nutrients;
4. changes to sea-bed substrates as a results of changes to sediment deposition patterns and the composition of sediments;
5. changes to river discharge flow patterns which could affect salinity profiles and nutrient replenishment patterns.

Direct physical damage, dislocation and smothering can occur during construction and associated activities such as dredging. The construction program and the techniques employed will need to include effective measures to minimise the intensity of the impacts generated at source and the dissemination of the impacts through the waters of the bay, particularly in regard to suspended silts and muds generated during construction and dredging activities. This is discussed more fully later in this section.

However, some of these effects will not be capable of complete mitigation. There will inevitably be some changes to local inshore current patterns, river discharge flow patterns, and sediment deposition and scouring patterns. To some extent these can be mitigated by appropriate compensatory measures, such as the enhancement of suitable seagrass meadow sites in other, unaffected, parts of the bay. Despite such actions, there will inevitably be some residual impacts remaining which will have adverse effects on local seagrass meadow communities, but this should be balanced against the socio-economic benefits that the proposed port will bring to the area, and the people of Lien Chieu.

Seagrass meadows, like coral reef communities, are particularly susceptible to sediment-laden discharges, discharges of a high organic or toxic nature, and oil films and emulsions in the water column. Effective measures to control these with containment devices and treatment systems will have to be incorporated into the design and operating systems of the new port if longer-term impacts are to be avoided. It should be noted that such devices and systems are only as effective as the day-to-day operational management of them allows.

River estuaries

The estuary of the Cu De river is an important local fishing area, which reflects the high productivity characteristic of estuarine environments. This high productivity arises from the high nutrient loads carried by the river, which mixing with the marine waters, generates a fertile and diverse environment for plankton and benthic species, and consequently a rich feeding area for the larger invertebrates (particularly shellfish such as crabs and prawns) and fish.

Estuaries are also vital gateway for many marine species that migrate during their life cycle between the inland and coastal waters. Obstruction of such gateways, either directly through physical obstruction resulting from artificial barriers or siltation of the river mouth, or indirectly through adverse changes to the estuarine environment which prevent the passage of the more sensitive species, such as deterioration in the water quality or changes to the benthic substrate, can have a profound effect on the migratory marine species. This will affect not only the ecology of the estuary, but also the ecology of the river upstream and the ecology of the adjacent coastal waters. Such disturbances to the ecological balance of the area will inevitably affect the value of fisheries, not only in the estuary, but also the river and coastal water fisheries.

Consideration should be given in the detailed design phase of port development to maintaining the open, and as far as possible unaffected, passage of migratory species through the estuary if such adverse changes are to be avoided or minimised. The port layout design should, as far as possible, avoid or minimise changes to the depth, flow and tidal reach within the estuary, and avoid siting any discharges of waste material, drainage or stormwaters into the estuary.

Coastal wetlands

Tidal wetlands occur on the Cu De river directly upstream of the National Highway No.1 bridge. These wetlands are not only and important ecological resource, providing feeding, spawning and nursery areas for many migratory species of marine and aquatic life, but are also a locally important fishery and aquatic cultivation area.

Such wetlands are characteristically among the most productive of coastal ecosystems as they receive high nutrient inflows from tributary catchments and provide a diverse range of habitat niches in the daily tidal transition from marine to fresh environments. They provide a natural filtration system for the nutrient-rich sediments carried down to the coast by the river waters as the diversity of habitat niches provides opportunities for a wide variety of species to exploit this richness, removing waste materials in the water and recycling the nutrients through highly productive plant communities. These include both macrophytes (lager plants) and phytoplankton which provide a wide variety and abundance of habitat and feeding niches that supports a diverse and abundant range of planktonic and lager fauna. It is this diversity and abundance that provides such a favourable environment for feeding, spawning and nursery areas for many migratory species of marine and aquatic life, as well as local fishery and aquatic cultivation opportunities.

The development of a port at Lien Chieu could, through its effects on estuarine tidal flows and morphology, have adverse effects on the viability and dynamic balance of this important ecosystem. Consideration should be given in the detailed design phase of port development to minimising or avoiding any disturbance, either directly or indirectly, to the tidal dynamics and morphology of these wetland areas.

Impact mitigation

The marine and coastal environments at Kim Lien bay already show signs of adverse environmental impacts and stress which are not unusual in partially enclosed, highly developed, coastal areas such as Da Nang bay. The levels of environmental stress observed and recorded during these environmental investigations implies that in a regional context the bay's environmental values have already been significantly compromised, and further development in this area may be regarded as preferable, from an ecological point of view, to initiating development in a more pristine environment where the ecological values potentially at risk are much greater.

However, this does not preclude the need to apply effective environmental impact mitigation measures to any future developments in the area. Unless such measures are put in place at the commencement of development there is the potential risk that the levels of impact, particularly of a large-scale coastal development such as this proposed seaport, may result in such severe disruption and damage to the local ecosystems that an irreversible decline in environmental quality occurs which affects the important natural and socio-economic resources of the Da Nang coastal area.

Although it is unlikely that further significant damage to local coral and other benthic communities can be prevented during the construction phase of the port development, it can be reduced by minimising the spread of waterborne sediments from onshore construction activities. Runoff from on-shore construction sites can be intercepted by perimeter drains around the sites, and reticulated to small settlement ponds or baffle screen tanks to facilitate settlement of sediments prior to discharge to the sea, or river (e.g. the Cu De river, which discharges within the proposed development area). Runoff from workshop areas can likewise be treated, with the addition of oil interceptor traps.

Effective management controls on the storage, handling, use and disposal of all hazardous materials, including oils, fuels, paints, resins, chemical additives and surfactants, will minimise the risk that these potential contaminants will be entrained in the site run-off and so escape to the river or sea. However, it is most likely that some residual sediments, particularly the slower setting finer sediments, will escape in the runoff that is discharged to the river or sea, and these will have some impact on the coral communities, and other benthic communities in the coastal area, particularly in the relatively confined bay of Kim Lien.

With regard to sediments that are generated within the sea during construction of offshore structures and facilities, and dredging operations, there is not much that can be done apart from minimising the amount of sediment generated through the application of careful management controls, particularly on the sites selected for dredge spoil dumping, and the use of low-impact construction techniques for offshore / submerged structures. In inland water bodies, some success has been achieved using silt curtains to contain the spread of silts and heavier sediments. However, these are critically dependent on operating within a fairly static, low-turbulence water column, and are thus less likely to be effective in the inshore and coastal water at Lien Chieu.

Consideration will also need to be given to avoiding or minimising potential impacts during the operation of the port, post-construction. Detailed environmental monitoring and management plans, including waste management plans, will need to be drawn up, covering the various operations of the port, and its associated infrastructure. These plans must be rigorously and effectively implemented by the port management, with clear lines of responsibility, and a system of performance control and enforcement in the event of non-compliance.

15.4.7 Relocation of Residents

Here, assessment is made based on ISP and Master Plan as well as the regulations of Da Nang City on the July 1st, 1997. The regulation is on the classification of land in Lien Chieu district, including Hoa Hiep, price of each type of land and levels of compensation applied in both development and investment projects.

First, it is supposed that the relocation area in the future will be all the sub-area P in Figure 4.2.2. Second, the area will be limited only to access roads defined by the Master Plan.

On the other hand, due to the lack of detail information on items for compensation, cost estimation is limited in compensation costs for residential houses and land, and relocation costs only.

(1) Economic Activities in Sub-area P

The size of the hinter area is nearly 180 ha, of which around 98 ha in sub-area P, 36 ha in sub-area Q and 45 ha in sub-area O. The structure of land area in sub-area P is given in the table below.

Table 15.4.7 Composition of Land Area in Sub-area P

(ha)

Type of Usage	Residential	Agriculture	Water surface for aquaculture	Forestry	Structure for public utilities	River/ Spring	Un-inhabited	Cemetery
Area	1.18	0.07	0.15	8.27	16.58	21.51	32.08	0.16

With the effect of port development, assuming that the project requires the clearing of all P sub-area, the land area under production will decrease insignificantly, including 0.07 ha of agriculture land, 8.27 ha of forestry, 0.15 ha of aquaculture and 0.35 ha of prawn breeder farm. The land under agriculture and aquaculture production is compensated at 6,000 VND/m^2, and the loss for compensation is calculated equivalently to the average yield of one season. The land under forestry is compensated at 3,500 VND/m^2 and the loss is calculated equivalently to the earnings of two years. The price of compensation of other types of land such as land under structure for public utilities, residential and so on varies depending on the class and type of land, from 98,000 VND to 160,000 VND/m2. For simplification, the average price (13,000 VND or roughly 11 USD/m2) is taken to calculate compensation costs for land. The book value of prawn breeder farm of about 1.5 to 2.0 billion VND, and the book value of the Transport and Communication Training School about 5.0 billion VND are also calculated as compensation costs for relocation of these units.

In total, the compensation costs for all types of land, except residential, cemetery and the loss of production are 63,560 million VND. Adding to this sum the value of two other economic units (farm and school), the compensation costs for economic activity area are roughly 70,560 million VND.

(2) Compensation for Relocation and Resettlement of Residents in Sub-area P

Structure

In the total of 706 households in sub-area P, 522 households have brick houses of 50 m2/each on the average. The remaining houses are made form cheap materials. The compensation for these types of houses is given in detail in the Regulation on compensation of Da Nang City. Again, for simplification of estimation, the price will be taken on the average of most typical types of houses in the sub-area with the assumption that the average size of a house is 30 m2. The price for residential land is also 130,000 VND/m2. The compensation for grave is 400.000/grave and the price for land under cemetery if 50,000 VND m2. As results, an amount of 37,380 million VND is the compensation costs for related to residential land.

Relocation

According to the Regulation, a relocation fee is paid for three months to relocatees with 210,000 VND/month/capita for people in working age and 120,000 VND/month/capita for people out of working age. In total, with the population of 3,505 people, of which 1615 are in working age in P sub-area, relocation fee will be around 1,700 million VND.

There are also other subsidy to relocatees such as an amount of 400.000 VND per household is given to households living in state-own flats, or incentives are provided to households which move in time as scheduled at 10,000,000 VND/hhold on the average. However, it is not easy to estimate such costs due to the lack of detail information.

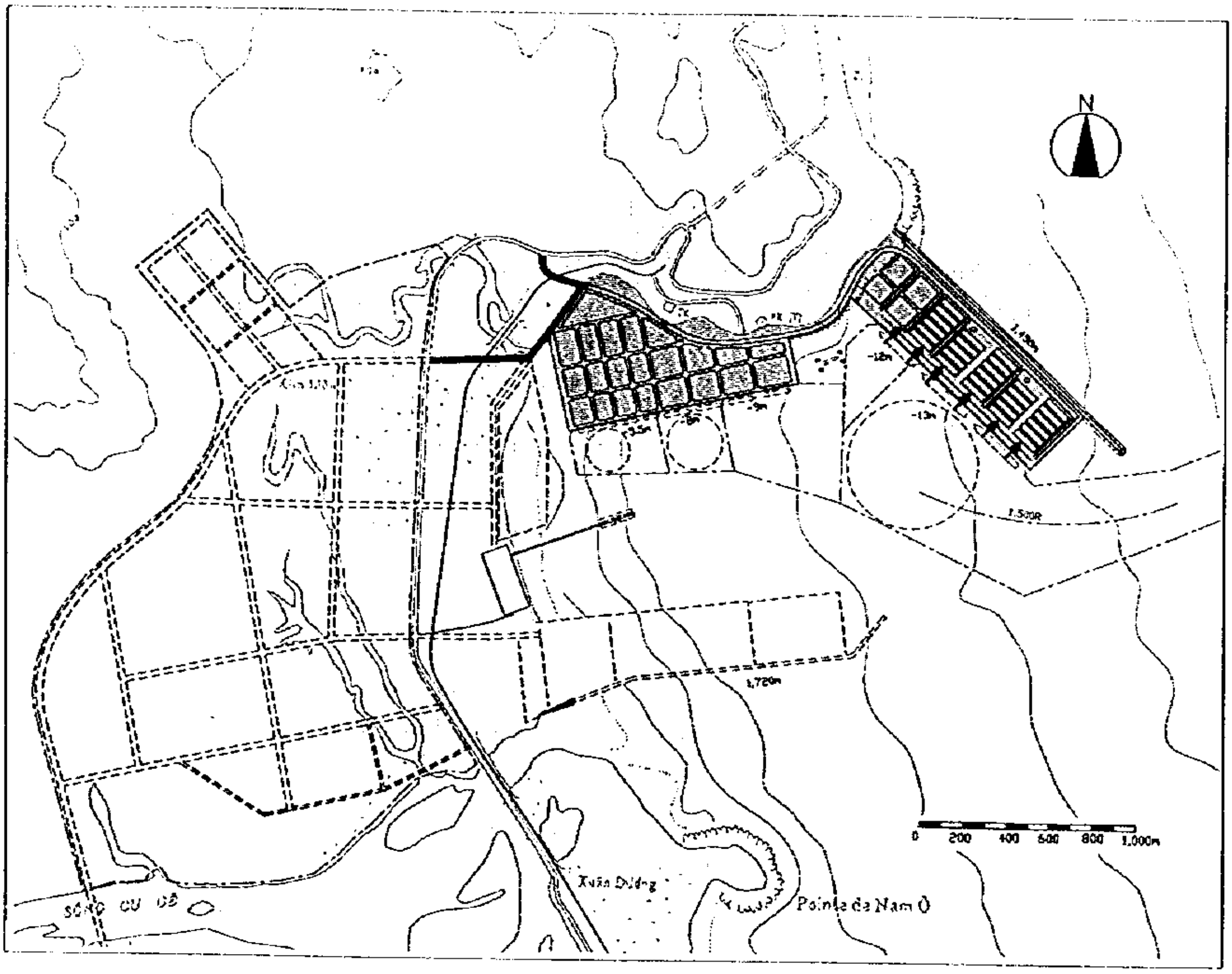

Figure 15.4.2 Access Roads related to Relocation of Residents in Master Plan

15.5 Guideline for Offshore Dumping

It is a general environmental tender of dredging that as far as possible the dredged material should be reused, either at the construction site or as land-fill at some other location, providing this does not present a significant environmental risk. Use at the construction site is constrained by the quality of material, not all of which may be suitable for use in construction purposes. In this event, the unsuitable material would then be deposited as landfill at a site where the environmental risks were assessed to be insignificant.

Although it is intended to use some of the dredged material at Lien Cheiu in the construction program, not all the material will be suitable and the volume of material removed will exceed the volume that can be used. Ground surveys carried out by the project team in the area were unable to identify any suitable areas that could accommodate this material in an environmentally secure manner. Thus there will be a need to carry out offshore dumping as part of the dredging program.

In selection a site for offshore dumping dredge wastes, consideration must be given to the dispersion of the materials plume and the effect of this on the marine ecology and benthic communities in the dumping area. The site should provide for fairly rapid dispersion of the plume and dilution of the material in order to reduce the concentrations of suspended material and turbidity as rapidly as possible, and hence minimise the extent of environmental impacts on the marine life in the area. This requires the selection of deep water sites that provide a high volume dilution coefficient, and preferably sites at which large current flows can enhance the dilution further. Areas of particular ecological sensitivity or value should be avoided, and wherever possible, dumping should be restricted to sea-bed areas of low ecological value where final settlement of the material will have minimal ecological impact.

The results of investigations into marine currents and circulation patterns around Da Nang bay revealed a counter-clockwise circulation from Lien Chieu around Da Nang bay to the Tien Sa headland from where the current flowed in a northerly direction out into the open sea.

Approximately 5 km north of Tien Sa headland, sea-bed sediment sampling has revealed a deep water area of sea-bed which is composed of moderately consolidated hard mud at which the benthic biological community is likely to be only poorly populated due to the inhospitable nature of the sea floor in this area

The depth of water and the current flows in this area will provide considerable dilution of the materials plume in its passage through the water column. The ecological impact of residual settlement materials on the sea floor is also likely to be low, given the anticipated low numbers of benthic organisms in the area due to the inhospitable nature of the sea floor

On the basis of these sea-bed investigations and the deductions drawn from their results, this area has been selected as the dumping site for dredge wastes from Lien Cheu. Based on the guidelines outlined above, and the findings of these investigations, it is anticipated that there will be no significant environmental impacts from the dumping of dredge wastes at this location.

16. Conclusions and Recommendations

16.1 Conclusions

(Findings on the region)

Central region of Vietnam is not enjoying the economic boom prevailing in the south and north region. To cope with this situation, the national government proposed or approved several projects in the region including the East West Transport Corridor, Dung Quat oil refinery, the South North Highway through Hai Van tunnel and industrial zone development as well as agricultural development. Transportation infrastructures including port facilities are in poor condition in the region to serve for the economic development.

(Port of Danang)

Port of Danang consists of two ports, i.e. Song Han port at the mouth of Han River and Tien Sa port on the west coast of Son Tra peninsula. Cargo throughput of Danang port was 870,000 tons in 1997, of which 70-80 % was handled at Tien Sa port. Existing two piers in Tien Sa port are deteriorated and require rehabilitation of its pile structure. Nguyen Van Troi bridge is used for port access, however, it allows only traffic under a weight of 13 tons. Upgrade of the bridge is also in urgently required.

(East West Transport Corridor)

East-West Transport Corridor Project is being studied by ADB and regional countries. The route No.9 and the second Thai-Lao Mekong bridge were selected for early implementation. This report assumed that R9 will be developed firstly followed by R18. R16 will have a low priority.

(International Transit Cargo)

Southern provinces of Lao PDR and northeast Thailand are deemed as the hinterland of the new port subject to the completion of R9 and Route R16/R18 of the East West Transport Corridor project. Projected cargo volumes in 2020 are 646,000 tons through R9 and 822,000 tons through R16/18. It is assumed that R9 will be developed firstly followed by R18. R16 is deemed to have a low development priority

(Natural Conditions)

Wind observations were also carried out in each project area throughout a year. The most frequent wind directions are NE and W in Lien Chieu.

Offshore waves were observed at two points on the coast of the central region. One ultrasonic wave recorder was placed on the seabed in the mouth of Danang Bay and the other one was positioned off the Ky Ha Cape in Quang Nam Province. The maximum waves observed were 5.7[1/] m at the Danang Bay mouth and 5.1[2/] m at the Ky Ha offshore observation point.

Based on the observations and statistical analysis of 30 historical typhoons, offshore wave height for the return period of 50 years was estimated at 9.7[3/] m in the deep sea off the Danang Bay and Chan May Cape, and at 8.8[3/] m in the deep sea off Dung Quat Bay. Design wave height for the main breakwater is 6.0[3/] m in Lien Chieu.

(Seabed Soil Conditions)

Soil boring investigations revealed that a thick clay/clayey sand layer exists in Lien Chieu waters. A stratum of fine sand was identified from -12 to -20 m in Lien Chieu.

(Demand Forecast)

A considerable increase in cargo throughput is envisaged in the central region owing to the economic growth and industrial development. Projected seaborne dry cargo from/to the central region will reach 10-20[4/] million tons in the year 2020. Expected cargo throughput in 2020 is about 10.7 million tons in Danang port complex (of which 8.5 million tons at Lien Chieu area).

(Capacity of the Present Port)

The capacity of Tien Sa port is assessed using a numerical simulation model, POSIM, assuming irregular ship arrivals and cargo capacities. In case that No.1-4 berths are rehabilitated and utilized, the port capacity is estimated at about 1.7 million tons and at about 2.2 million tons after the completion of Berth No.5. If Tien Sa No.6 berth were developed, the port capacity would reach 3.1-3.3 million tons. The capacity of Song Han port is deemed to remain at the present level, i.e. about 200,000 tons.

(Master Plan for Lien Chieu)

Requirements for new berths in Lien Chieu Port are estimated at two full size container berths with a total length of 660 m, one multipurpose berths of 270 m and 8 conventional general cargo berths with a total length of 1,020 m. The main breakwater has

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[1/] This height is the significant wave height ($H_{1/3}$), which is 9.0 m in the maximum wave height (H_{max}), caused by Typhoon Friz on 25 September 1997

[2/] $H_{1/3}$, H_{max} is 7.9 m, caused by Typhoon Friz

[3/] $H_{1/3}$

[4/] exclude crude oil and oil products

a length of 1,450 m to shelter the port waters, and 8 million m^3 dredging is required for the 2,700 m long approach channel and turning basin with a depth of -13 m. Land reclamation is planned for the wharves with a total area of 96 ha.

(Initial Stage Development Plan)

Since a new port development generally requires a large initial investment in breakwater and/or channel dredging at the first stage, a proper size of development is necessary to be a feasible project. ISP is proposed as a package plan for the first stage of development in Lien Chieu.

Maximum size of calling container vessel is considered at about 30,000 DWT in the initial stage. A multi-purpose berth with an alongside depth of –12 m and two conventional cargo berths are proposed for the ISP. Maximum size of calling container vessel is considered at about 30,000 DWT in the initial stage and the design depth of channel and turning basin is –11 m with a -12 m pocket dredging in front of the multi-purpose berth.

(Implementation Plan for the Lien Chieu and Tien Sa Development)

It is predicted that if the Tien Sa No.6 is developed, the first berth of Lien Chieu will become necessary by 2006/ 2010 depending on high/low cargo growth. In case that the Tien Sa No.6 is not developed, Lien Chieu will become necessary by 2004/2007 depending on cargo growth case. It is concluded that Lien Chieu has an advantage in land transportation, future development and rational development of hinterland although Tien Sa has an advantage in terms of less initial investment.

(Port Facility Design)

After comparing several designs of breakwater and quaywall, it was concluded that composite gravity type structure with hybrid caisson will be appropriate for deep sea breakwater and quaywall from the viewpoint of technical and economical aspects. In particular, the proposed structure will be suitable for the marine structure with high design wave heights and soft foundations.

(Cost Estimates for Lien Chieu)

The costs of implementing the Master Plan are estimated at US$359 million in which the costs for ISP is US$158 million. Breakdowns are summarized in the table below.

(US$ million)	Cost of MP	ISP
Breakwaters, seawalls, groins and others:	64.4	42.2
Quaywalls and yard pavement:	118.6	38.5
Dredging:	40.8	14.8
Road, bridge, buildings, and other utilities:	16.9	11.6
Cargo handling equipment and navigation aids:	49.0	18.5
Engineering services, contingencies and tax:	69.0	32.1
Total:	358.6	157.7

(Economic Analysis)

The results of the economic analysis indicate that port development projects of Lien Chieu viable from the viewpoint of the national economy. Economic Internal Rate of Return of ISP is shown below including sensitivity tests.

	EIRR of ISP	Sensitivity tests[5/]
Lien Chieu:	19.4 % (High growth)	16.3 %
	18.4 % (Low growth)	15.5 %

(Port Administration and Operations)

Although several port administration and management bodies are identified in Vietnam, such as Vinamarine, Vinalines, local government and the military, Vinamarine will be an adequate body for the development of the new commercial port in the central region.

(Financial Analysis)

Owing to the fairly large investment in breakwater construction and capital dredging in the first stage, financial return of the Lien Chieu port development is not so attractive for the private investment, however, it is in a feasible range for the public sector subject to the procurement of soft loans like ODA. The result of the financial analysis is shown in the table below.

Financial Indicators	High Growth Case	Low Growth Case
FIRR:	5.7 %	5.1 %
Sensitivity tests[5/]:	3.3 %	3.0 %
Debt service coverage ratio:	Min. 1.36	Min. 1.48
Operating ratio:	39-53 %	40-67 %

[5/] subject to 10% increase in development costs and 10% decrease in economic benefits

(Environmental Survey)

Field surveys covered waves, currents, water pollution, shoreline sediments, terrestrial flora and fauna, and local residents and cultural assets. Although coral reefs were found near the project area, their location is limited and generally in poor condition. Bottom habitat of particular high value/importance has not been detected. The hinterland is unfertile, low productivity farm land and the area likely to be lost to waterfront use is currently low value, low populated land.

(Initial Environmental Examination for Lien Chieu)

Initial environmental examination indicated the need for a EIA study on changes in current patterns, disposal of dredged material, impacts on water quality, shoreline change, traffic load on access roads and relocation of inhabitants.

(Preliminary EIA for Lien Chieu)

To assess the impact of the port development, changes in tidal currents, beach accretion and erosion, the dispersion of water pollution and disposed materials are identified by means of computer simulation. Relocations of inhabitants are assessed at about 20 for the implementation of ISP of Lien Chieu. As a result, no significant adverse effect is shown in the preliminary EIA.

(Overall Evaluation of the Project)

Maritime transportation borne by the port development will greatly contribute to the development of the central region in terms of foreign currency earnings, job opportunities, trade promotion and industrial development. However, the development of a new port requires a fairly large capital investment in breakwaters and reclamation work in the deep sea area, so that financial feasibility is very critical in connection with construction cost and port revenues. As seen from EIRR, the port development projects in Lien Chieu are economically effective and will have no particular difficulty in technical, environmental aspects. For the development of Lien Chieu, it is feasible if a soft loan is available as FIRR is calculated at 5.1-5.7 % while other financial indicators are in the preferable range.

16.2 Recommendations

16.2.1 Basic Strategies on Development of the Key Area of the Central Region

As already recommended in the Study on the Integrated Regional Socio-Economic Development Master Plan for the Central Region of the Socialist Republic of Vietnam prepared by the JICA study team in March 1997, the Central Region has significant roles and development needs in the international, national, and regional context under the general understanding that accelerating economic growth of the Central Region is important for the economic unification of the country.

In the international context, the Central Region should form an economic network with inland countries and regions in the Greater Mekong Sub-region and become a trade processing center of the Sub-region. In the national context, it should achieve an accelerated economic growth to mitigate widening economic disparities among regions, thus contributing to the economic unification of the country. In the regional context, it should pursue development quality, which is socially and economically balanced and environmentally sustainable development.

While the above recommended concept is considered generally applicable to port development planning in the Central Region, following points need to be carefully considered to secure sound, steady and practical development.

(1) In order to avoid possible adverse impacts of drastic and random development, the target projects and their location need to be critically selected under careful coordination with the parties concerned.

(2) Development schedule should be appropriately controlled to be harmonized with local life and culture.

(3) Initial scale of the target projects should be down-sized as far as possible so as not to jeopardize national and regional financial soundness.

(4) Private sector participation in the development schemes is desirable in principle but needs to be controlled carefully to mitigate its adverse effects on the national and regional economy and society.

(5) Experiences in most advanced countries show that drastic industrialization is often harmful, if not properly controlled, to sound development. Vietnam should take advantage of its "latecomer" position and avoid the mistakes made by other countries.

16.2.2 Objectives and Basic Framework of Port Planning for the Area

While the detailed objectives of port planning vary widely depending on their type, coverage, time span, target facility and so on, the overall objectives of port planning for the region can be summarized as follows:

(1) to be a guideline for long-term investment and operational improvement schemes of the target ports.

(2) to be a base for short-term/urgent development plan of which contents are required to be consistent with total development scheme.

(3) to provide port users, investors, and other business entities concerned with the future prospect of a business environment and thus to guide the business behavior of the private sector in a proper direction consistent with the port development.

(4) to promote harmonized development of other infrastructures necessary to realize the proposed port development schemes.

(5) to be a component of the national port plan so that the port development of the Area can be appropriately coordinated with the overall concept of national port development.

(6) to be a base for consideration of various financing agencies in their investment or financial plan.

In order to achieve the above objectives and to satisfy various requirements of the Study, the port planning framework is designed as follows:

(1) Master Plan (MP) for port development in the three key areas with target year of 2020.

(2) Initial Stage Plan (ISP) of port construction for each site of the three key areas within the framework of the Master Plan.

(3) Feasibility Study (FS) on short-term port development plan for a selected site with target year of 2010

Among the above three types of planning, ISP has a unique function in particular to cope with the potential port development demand expected in the three sites, namely Chan May, Danang and Dung Quat. The objective of ISP is to propose a minimum reasonable package of port facilities to be developed at the initial stage of total development scheme under the proposed master plan for the ports. In an ISP, the schedule of port development including commencement timing and final target year is normally not indicated. ISP is, therefore, an appropriate way of planning for such a case as when confirmation of the exact timing and volume of potential cargo traffic is considered difficult due to the uncertain situation of background factors such as industrial location, public acceptance of the project, and so on. In case of Danang Port, ISP is identical to the short term development plan of which development schedule is clearly defined for the feasibility analyses in the study. On the other hand, only ISPs are proposed for Chan May

Port and Dung Quat Port, mainly because of the reasons stated in the above paragraphs. In any case, ISP is useful enough for further study for the projects.

16.2.3 Port Development Strategy for the Three Key Sites

The final goal is to realize well balanced national development by creating a third social and economic core of the country following the other two advanced areas, namely Hanoi and Ho Chi Minh City. For successful achievement of the above objectives, each of the ports to be developed in the three target sites namely Chan May, Danang, and Dung Quat, needs to have a clearly defined function, scale and development timing which is conceived to fit the original character of each development site. In this regard, the following are the most important points in developing ports in the region:

(1) With the view to avoiding possible unproductive competition among the ports, duplication of functions and facilities should be strictly checked. This is especially important for international container handling facilities at the initial stage of the project when the actual cargo demand of the region is relatively small and inadequate to attract the major container lines.

(2) Construction of port facilities for industrial cargoes to be originated mainly from the direct hinterland of the port should be started upon confirmation of actual location of planned industries in the site.

(3) Considering the severe financial position of Vietnam, the initial stage investment for the ports should be minimized to the extent possible.

(4) On the other hand, the full scale potential port development concepts need to be appropriately planned and authorized with a view to promoting overall regional development and attracting private sector investment in the hinterland of the ports.

(5) Financial resources for public port development should be diversified to promote participation not only of domestic/foreign private sector but of the relevant local provinces so that the port development concepts could reflect their will and desire in particular.

16.2.4 Functional Allotment to Ports in the Area

Functional allotment to ports in and around the area is proposed in the Conclusion of this Chapter. In connection with the proposed allotment, the following points are recommended:

(1) An international commercial hub port must be able to accommodate at least Panamax size container ships and have a large volume of cargo to enable shipping lines to make frequent calls at the port. When shipping lines call a port frequently, users generally enjoy such benefits as reasonable shipping freight rates, more options in selecting favorite shipping services, overall scale merit of cargo handling and so on. In this context, it is recommended that utmost efforts of the country should be concentrated in developing

commercial port functions with international standard container terminals at Danag Port Complex, which has historically served as a commercial port and is strategically located to become a transport junction. The port could attract an adequate number of ship calls as a hub port of the country and this may be very effective not only in attracting international transit cargoes from/to the neighboring countries, but in accelerating development of the industrial zone behind the site, through stimulating investment in various related infrastructures including the road network to the hinterland.

(2) In the long term, Chan May has the potential to be a multi-functional port due to its advantageous location, moderate natural conditions, locally prioritized industrial development schemes and active promotion policy of the province. In the short term, however, immediate and large scale commercial port development in this site may be relatively risky mainly due to the existence of Danang Port Complex, uncertain status of commercial cargo demand for the port, and the fact that industrial development in the hinterland is in the initial stage. Considering the above situation, the first stage of the development of this site shall be focused on promotion of industrial location of appropriate scale at the industrial park behind the Chan May Bay with timely construction of a feeder port for the province. Since the People's Committee of Thua Thien-Hue has designated development of the Chan May Port as a top priority project in the province as a means to raise living standards in this area, it is recommendable that the central government should consider to support, if possible and appropriate, the project financially or institutionally, because it could also have a vital role for future national economic development, provided that the project scale and construction timing are reasonably planned and selected.

(3) A large industrial zone with a full scale oil refinery is to be developed in the direct hinterland of Dung Quat Bay, which means that the expected major function of the port is to serve industrial cargoes from/to the industrial zone. While public port functions may be required in the long term, the initial development components of the port should be focused on such industry related facilities. Port development schedule of this site should accordingly be coordinated with the planned industrial development, so that timely construction and reasonable scale of the port facilities concerned can be secured.

16.2.5 Port Administration, Management and Operation

Chapter 13 of the Report illustrates the present system of Vietnamese port administration, management and operation which is formed mainly under domestic administrative requirements and considerations. While it is natural that an administration system of a certain sector of a country is established for her own benefit and convenience under the political and social system of the country, international requirements are an important factor as well for the port sector administration concerned in particular. This is because the port facilities and its service activities should be designed and provided for the port users who have their own requirements for the benefit of their international business and global shipping economy. The port users, whether they are shippers, shipping lines and other port related entities, want to use a port which is managed and operated well under a simple and transparent administration system, so that they can coordinate their business activities easily with the direction of port sector development and management policy of the government. In this context, the current system of port administration of this country may need to be simplified under well coordinated institutional systems. Some suggestions in this regard are as follows.

(1) Generally speaking, the basic port sector development policy and nation wide port administration are to be under MOT for all commercial ports.

(2) While VINAMARINE is responsible for overall regulatory functions in the maritime sector and for some ship, port and shipyard operational management functions under MOT, VINALINES is engaged in comprehensive shipping and maritime related activities including the management and operation of Saigon Port, Haiphong Port and Cai Lan Port under direct supervision of the Prime Minister's office. This kind of administration may jeopardize consistent policy decision making in port sector affairs and effective utilization of maritime human resources. If the two organizations can not be amalgamated for some reason, further coordination by MOT may be required. Full privatization of the operation and management functions of VINALINES may be another alternative to promote overall economic efficiency of the major ports.

(3) If the situation allows, the administration of river ports should be simplified. Too many administrative organizations are involved in the river port affairs, which makes it difficult to keep a consistent and comprehensive port policy. Since the function of Vietnamese river ports is mainly limited to related local areas, it may be reasonable to let the local communities manage them under the overall supervision of MOT and/or IWB.

16.2.6 Procurement of Financing Source for Port Development and Private Sector Participation

Procurement strategy of financial resources is always one of the critical issues for successful port development which normally requires a large amount of investment. There may be several ways to procure funds for a port project. In recent years, it can be often observed in many developing countries that construction funds from private sector are mobilized through privatization of a core function of a port. This selection, however, is not always successful nor appropriate from the public port development concept point of view. If the purpose of privatization is to improve efficiency of port operation through competition, this selection may be justified generally for any type of port development including a port of highly public function like the target port development of the Study. However, if the government wants (mainly because of heavy shortage of original funds) instant money for the project by simply selling to the private sector a vital part of the potential port development site and/or its function, such a policy should not be applied. Considering the aspect pointed out in the above paragraph, it may be better for the government to use its own funds for the projects (at least for the initial stage of the projects) including utilization of possible soft foreign loan or combination of public and private financing sources.

16.2.7 Attraction of International Transit Cargo

The potential international transit cargo traffic from/to the neighboring countries through the project ports can not be realized simply by increasing the cargo handling capacity of the ports. Several critical conditions as shown in the following paragraphs need to be satisfied. The most important and basic requirements are to provide fast, reliable and efficient services at a reasonable price, which is not easy to achieve, particularly for a newly developed port. Moreover, in order to compete successfully with other ports for such transit cargo, overall performance of total transit corridor from origin to destination including road network, cross border services, port and shipping performance should be sufficiently competitive.

(1) For the project ports in the Central Region, the international cross border facilities, custom clearance and documentation need to be improved and simplified in particular.

(2) Since scale merit on cost performance of cargo handling operation and shipping is significant the international container traffic, the newly developed container port in the Region should attract as many ship calls as possible, so that the port can establish its position as a international container hub port. This can be achieved by developing the relevant infrastructures and institutional systems of the port under coherent overall policy.

(3) Service level and tariff policy of the rival ports need to be studied and analyzed, so that overall performance of the corridor can be sufficiently competitive through constant improvement of service and careful adjustment of the tariff and charges of the port.

16.2.8 Engineering Surveys and Studies

Considering Vietnam's lack of experience in constructing large scale seaports with long and deep breakwaters and quays, it is important to collect the basic engineering data and information necessary for economical design and construction. To this end, following items are recommended to be included as apart of the engineering analyses.

(1) Wave observation over a period of at least three years at the appropriate offshore point of the project is essential for the analyses of anomalous high wave (for selection of design wave), and normal wave (for the study on calmness of sheltered water, sand drift, construction planning and so on).

(2) Annual shoreline survey and sounding at the project sites to check long term effect of possible topographic changes on shoreline and sea bottom is vital for assessing the impact of the completed project structures and for determining if countermeasures are necessary.

(3) The sedimentation/siltation phenomenon is still one of the difficult themes in port and coastal engineering. Discussions on this subject have been made at Lien Chieu in the Study within the limit of the Scope of Work which is in detail enough as an analyses for planning stage. In order to confirm the results of the Study and improve its accuracy, in particular on prediction of sedimentation volume in the approach channel and basins, however, it is recommended that the Study should be followed, if possible, by deeper survey and analyses, for example, measurement of salt water wedge, full scale computer simulation and site experiment by test pits. These data are also useful for control or improvement of safety and efficiency of ship navigation and berthing performance in a port.

16.2.9 Detail Design and Cost Estimates of the Project Structures

For the detail design of the project structures, following points need to be examined:

(1) In order to cope with the soft foundations observed at the construction sites of Lien Chieu and Chan May in particular, confirmation of stability of the structures, estimation of consolidation settlement of the reclaimed land and selection of effective countermeasures need to be carefully examined based on an adequate number of borings and minute sample testing.

(2) Since the design condition of wave protection facilities is quite severe due to the considerably high waves observed at the offshore points of the project sites, the project

breakwaters should carefully be designed referring to advanced technology and experiences of foreign countries.

(3) Type of the end section (final or temporary) of sea-wall or breakwater at the final stage of ISP needs to be carefully selected depending on the next stage construction schedule of the structures.

(4) In reviewing the proposed cost estimation of the projects, it is important to consider possible future inflation of price and changes in taxation policy.

16.2.10 Implementation of Port Construction Works

Following actions and cares are essential for safe, economical and efficient construction of the project structures under severe natural conditions and financial constraints.

(1) Careful construction planning and supervision are essential in preventing possible accidents and disasters due to the high waves during construction works. To this end, it is highly recommended to carry out the detailed weather and wave forecasts based on recorded observation of air pressure, wind velocity and wave height at the construction site.

(2) The offshore structures under construction are not strong enough against high waves. To avoid possible disaster by high waves, it is recommended to complete the structures leave the structures before the typhoon and north-east monsoon season.

(3) Since soft subsoil conditions are observed at the construction site in Lien Chieu and Chan May, removal and replacement of soft foundation and reclamation should carefully be executed on the basis of the deformation monitoring of the foundation.

(4) Since this is the first time for Vietnam to construct a deep sea port in the open sea area, it is recommendable to confirm any shoreline changes or channel siltation through parallel observation with actual progress of the construction works. If any countermeasures would be necessary, appropriate actions should be taken accordingly.

(5) The Study recommends a large scale caisson structure for construction of the breakwaters and wharves. In this case, it is important to prepare an appropriate base for construction works of such a large caisson, considering various factors including construction method of caisson, workability and economy.

16.2.11 Periodical Review of Port Plans

Periodical review of port plans is always required for proper promotion of port development, particularly under highly sensitive or unstable economic or social conditions. As already pointed out, cargo traffic demand in the region is expected to increase depending on economic development not only of the region but of the inland neighboring countries, and also on industrial location expected at the hinterland of the target ports. On the other hand, recent economic trend of the major Asian countries including Vietnam implies unstable/uncertain position of the total cargo flow demand to be generated by such sensitive situation of the regional economy. It should be clearly understood, therefore, that a certain level of uncertainty may creep into cargo traffic forecasts, and that there may be a certain gap between estimated potential cargo traffic demand and actual future cargo traffic to be served by the project port facilities.

Considering the above point, it is important to understand that the original plan might lead the development policy of the ports in an undesirable direction. In this sense, constant review and adjustment of the plans are essential to meet any contingency in the surrounding situation. For the three target ports in the Central Region, the recommended master plans should be carefully reviewed and adjusted, say, at least every five years.

16.2.12 Authorization of the Recommended Plans

How to realize the recommended development plan of the ports is another important point for effective implementation of the projects. There are many cases observed in developing countries where the project development as recommended in the studies fails to be successfully realized. The major reasons (apart from apparent failure in planning) for this type of failure can be summarized as follows:

(1) Lack of practicability, applicability or flexibility in proposed schemes
(2) Basic change in the government's policy for the target port development
(3) Shortage of funds for the development
(4) Failure in developing other port related infrastructure and facilities
(5) Lack of proper control by the government of related private sector activities.

In order to avoid the above mentioned failures, the plans should officially be authorized through proper procedure by laws, regulations or any other form applicable to the country concerned. This is particularly effective in securing public expenditure on a long-term basis for the projects themselves as well for other public works necessary for the projects. The plan also needs to be open to the public so that business activities concerned could be properly coordinated.

16.2.13 Human Resources Development Policy for Port Sector Development

The Vietnamese institutional and organizational structure and capability for port sector administration have been generally well developed so far. Considering the dramatic changes in various requirements of port sector administration and engineering in future, however, there would be substantial shortage and weakness in staff resources. Therefore, a systematic training strategy for port administration and management/operation staff and engineers should be established.

While on-the-job training is always one of the best ways to train the staff, this is not considered effective when they need to acquire special knowledge or capability for an advanced concept and technology or newly developed engineering systems. In this case, the government should organize specially designed training courses or promote positive participation in an appropriate ODA based technology transfer classes prepared by advanced foreign countries. Exchange of government officials among the other different ministries or agencies is another effective way to give the staff wider knowledge and experience which is considered vital for higher level administrative staff of the sector. Considering current and future administrative and engineering requirements, following subjects may be most recommendable for the Vietnamese port staff training.

(1) Overall mental attitude as public service personnel
(2) Instilling cost consciousness in the management and operation staff
(3) Coastal/port engineering and structural design for a river mouth and deep sea area (deep sea break water, quay, navigation channel/basin, and coastal protection etc.)
(4) Oceanographic surveys and analyses on wave, current, sand drift and so on
(5) Investment planning , legal and safety inspection for port operation staff
(6) Privatization policy and practice for headquarters staff
(7) Computerized operation for cargo handling, accounting, and statistics

16.2.14 Improvement of Port Statistics

Accurate and reliable port statistics including cargo handling volume, number of ships calling, port operation performances and other data/information are essential as a base of port planning, administration, management and operation. Although some port related data and statistics in Vietnam are well collected and compiled, following suggestions may be useful for further improvement of the port statistic system of the country.

(1) Since port statistics are recognized by major countries of the world as one of the most basic data sources not only for the port sector development but the national economic development policy making, the total systems for the statistics have been improved accordingly under the responsible government agencies. While it may be a difficult task to establish a complete port statistics system, which may sometimes be expensive, it is recommended to make further efforts for upgrading accuracy, reliability, consistency, coverage and contents of the statistics.

(2) With a view to achieving the above mentioned objectives, standardization of statistics forms under jurisdiction of MOT need to be established, which may require a practical proposal supported by an intensive study on the subject.

16.2.15 Natural and Social Environment Conservation

Based on the overall assessment conducted under the Study, it can be understood that development of port function itself does not generally have any serious adverse effects on the existing environment of the area. The possible increase of population with corresponding economic activities as a result of port development may, however, cause general increase of the basic load on the environment system. Under the situation, following suggestions may be useful for effective conservation and/or even upgrading of the environmental quality of the area:

(1) While the detailed environmental impact assessment is supposed to be officially conducted before commencement of the construction works, under the regulations concerned of the government, by the executing agency of the project for MOSTE approval, this procedure should not be considered as an objective of the port sector environment administration. It is more important, in this context, to understand that the final objective is to secure better quality of environment for the residents, workers and visitors of the port so all people can fully accept and enjoy the existence of the port and its activities.

(2) In order to achieve the above objective, it is essential to establish an environmental policy in respect to port development and institutional and organizational arrangements for effective port sector environmental administration. Preparation of an action program for environment conservation activities and provision of appropriate level of budget for execution of the policy are also vital accordingly.

(3) At the actual implementation stage of the project, following items needs to be considered:

1) Tracing surveys on the impact to water quality and marine life as a result of construction works need to be conducted throughout the construction period of the project facilities.
2) For the environmental factors such as water quality, heavy metal in the bottom materials and other hazardous materials, which may have some effects on human and marine life, need to be carefully checked in EIA not only at the port development sites but across wider areas including the industrial zones, urbanized areas and upstream lands of the rivers, so that a comparative assessment could be made among the different types of the areas.
3) Regarding relocation of residents in and around the project sites, it is important to pay maximum attention to their quality of life through appropriate measures including adequate compensation, creation of job opportunities, and so on.

16.2.16 Financial Status of Danang Port Development Project

As illustrated in Conclusion of the Report, the short term development plan of Lien Chieu area is considered financially viable although the calculated value of FIRR under the worst case (10% increase for the cost and 10% decrease for the income) is only slightly over the possible lowest interest rate of available funds for the project. While it appears that the financial position of the project may not be adequately sound under this estimation, this does not necessarily mean that the project would be financially risky, because some potential income sources and cost saving factors were not fully counted in the calculation under the principle of being on safe side. In this context, however, following suggestions may be useful in further strengthening the financial status of the project:

(1) EIRR of the project is substantially higher than the FIRR. This means that there may be considerable amount of external economy of the project, which could be internalized, for instance, by collecting a kind of special tax or charge from the direct external beneficiaries such as local port related industries and general private entities in a certain zone of Danang city. For the nation wide benefit of the project, it may sometimes be justified, if the situations allow, that an appropriate portion of the general income tax be used for a new port project at the initial stage of development in particular, when the financial position is normally weak and tight.

(2) With a view to increase the project income, one possible scheme is to rent for general commercial use a part of the available land and space created as a result of construction of the major project facilities. While the potential income from such an operation is not

included in calculating the FIRR of the project in the Study, the executing agency of the project could enjoy substantial benefits depending on its devises and will.

(3) While the cost estimates of the project are reasonably proposed in the Study, potential cost saving factors may still be found in the detail design and construction stage. Utmost efforts in this regard should be made in economic design, bidding process and procurement of construction materials.

16.2.17 Development of Tien Sa and Lien Chieu Areas of Danang Port

The port function and capacity allocation between Tien Sa and Lien Chieu areas is one of the most critical issues in the Danang port development policy. The focus point of the issue is to what extent Tien Sa port should be developed at the initial stage of the development scheme in connection with total future port traffic demand and the port capacity to be developed at Lien Chieu area.

In selecting the most reasonable port development plan from possible alternative development packages of Tien Sa and Lien Chieu, following points need to be considered:

(1) Tien Sa area does not have enough future expansion room which makes it considered inefficient for development of a large scale container port, from the cost performance point of view.

(2) The location of Tien Sa area is not convenient enough for cargo transportation from/to the industrial zone of Danag city.

(3) It is estimated in the Study that the maximum capacity of the current Tien Sa port would be about 2.2 million ton/year, provided that the current port facilities would be fairly rehabilitated and maintained, and the back up land transport system including the access road and bridge would be improved accordingly.

(4) Balance of total port capacity requirement need to be accommodated by new port development at Lien Chieu area.

(5) Since the development project at Lien Chieu area is a totally new port development scheme, the construction term of the project is quite long, at least four to five years are required before operation at the first berth can begin.

(6) On the other hand, the cargo traffic demand at Danag Bay area will be increasing continuously, and therefore the corresponding port capacity for the demand needs to be improved accordingly.

(7) Considering the above points, the port capacity of Tien Sa port should be upgraded so as to accommodate the increasing traffic demand, at least for several years from now. This

means that it is not realistic to start the new port development at Lien Chieu without any capacity expansion at Tien Sa .

(8) In this case, however, the development scale of Tien Sa port should be minimized due to its limited expansion room and the economically/functionally inefficient nature of this site as pointed out in the above paragraphs 1) and 2).

(9) Selection of this development policy can be supported also by the situation that due to the unstable economic circumstances of Asian countries which makes the estimated future cargo traffic demand somewhat uncertain. This policy allows the executing agency of the project to observe any changes in the economic and social environment of the region for a while, so that it could adjust the scale and timing of the new port development accordingly.