E1799 VOL. 11

The Northern Delta Transport Development Project (NDTDP)

Environmental Assessment Corridor 1
Phase 1

Waterways Improvement

Ministry of Transport, Vietnam Inland Waterway Administration (VIWA), Project Management Unit of Waterways (PMU-W)
8 April 2008

9R6212.21

HASKONING ASIA GOVERNMENT SECTOR CONSULTANCY
HASKONING NEDERLAND B.V.

Barbarossastraat 35
P.O. Box 151
Nijmegen 6500 AD
The Netherlands
+31 (0)24 328 42 84 Telephone
0031 (0)243609634 Fax
info@nijmegen.royalhaskoning.com E-mail
www.royalhaskoning.com Internet
Arnhem 09122561 CoC

Document title	The Northern Delta Transport Development Project (NDTDP) Consulting services for feasibility studies and preliminary design for the Northern Delta Transport Development Project (NDTDP)
Document short title	Appendix
Status	
Date	08 April 2008
Project name	NDTDP
Project number	9R6212.21
Client	Ministry of Transport, Vietnam Inland Waterway Administration (VIWA), Project Management Unit of Waterways (PMU-W)
Reference	9R6212.21/R007/JHL/Nijm

ABBREVIATIONS AND ACRONYMS

AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BBDT	Benkelman Bean Deflection Test
BOD	Biological Oxygen Demand
CEA	Cost-effectiveness Analysis
CEP	Commitment for Environmental Protection
DP	Displaced Person (or Project-affected Person, PAP)
DO	Dissolved Oxygen
DONRE	Department of Natural Resources and Environment
DWT	Deadweight tonnage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMDP	Ethnic Minority Development Plan (or Indigenous People's Development Plan, IPDP)
EMD	Environmental Management Division
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
FS	Feasibility Study
GDP	Gross National Product
GIS	Geographic Information System
GOV	Government of Vietnam
GPS	Global Positioning System
GSO	General Statistics Office
HCMC	Ho Chi Minh City
HDM4	Highway Development and Management Software Version 4
ICD	Inland Clearance Depot
IMF	International Monetary Fund
IPDP	Indigenous People's Development Plan (or Ethnic Minority Development Plan, EMDP)
IWPM	Inland Waterways and Port Modernization Project
IWT	Inland Waterway Transport
IWTC	Inland Waterways Transport Cost Model
JBIC	Japanese Bank for International Cooperation
LAD	Least Available Depth
LEP	Law for Environmental Protection
MARD	Ministry of Agriculture and Rural Development
MMTRR	Multimodal Transport Regulatory Review

MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MRC	Mekong River Commission
MT	Multimodal Transport
MTIDP	Mekong Transport Infrastructure Development Project
MTO	Multimodal Transport Operator
NH	National Highway
NDTDP	Northern Delta Transport Development Project
NLF	National Logistic Forum
NPV	Net Present Value
NWTC	Northern Waterway Transport Corporation
O-D	Origin-Destination
PAP	Project-affected Person (or Displaced Person, DP)
PC	People's Committee
PCU	Passenger Car Unit
PDLC	Physical Distribution and Logistics Centre
PDOT	Provincial Department of Transport
PIANC	International Navigation Association
PIP	Project Implementation Plan
PMU1	Project Management Unit No. 1
PMU-W	Project Management Unit – Waterways
PPC	Provincial People's Committee
PPMU	Provincial Project Management Unit
PRA	Participatory Rapid Appraisal
PSP	Private Sector Participation
QCP	Quality Control Plan
RP	Resettlement Plan
RC	Resettlement Committee
RED	Roads Economic Decision Model
RNIP	Road Network Improvement Project
RPF	Resettlement Policy Framework
RRMU7	Regional Road Management Unit No. 7

SA	Social Assessment
SEA	Strategic Environmental Assessment
SOE	State-owned Enterprise
SWTC	Southern Waterway Transport Corporation
TD	Technical Design
TDS	Total Dissolved Solids
TEU	Twenty-foot Equivalent Unit
TOR	Terms of Reference
UNCTAD	United Nations Commission on Trade and Development
UNDP	United Nations Development Programme
USD	United States Dollars
VAT	Value-added Tax
VESDI	Vietnam Environment and Sustainable Development Institute
VIRESS	Vietnam Registry
VITRANSS	Vietnam National Transport Strategy Study
VIWA	Vietnam Inland Waterway Administration
VLSS	Vietnam Living Standard Survey
VND	Vietnamese Dong
VNMC	Vietnam National Mekong Committee
VOC	Vehicle Operating Cost
VRA	Vietnam Road Administration
VWD	Vehicle Weight & Dimensions
WB	World Bank
WTO	World Trade Organization
3PLs	Third Party Logistics Providers

CONTENTS **PAGE**

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Background of the Northern Delta Transport Development Project (NDTDP)

The Ministry of Transport (MOT) of the Government of Viet Nam is responsible for the planning, design, construction, maintenance and operation of all major modes of transport in Viet Nam: highways, railways, aviation, and inland waterways. MOT has recently undergone restructuring creating individual and separate modal departments responsible for the administration and management of the various modes of transport. Functional departments responsible for the state-wide administration and management of planning, investment, finance, institutional development, and associated science and technology was likewise created.

Presently, MOT is concentrating through the Vietnamese Inland Waterway Administration (VIWA) and Project Management Unit Waterways (PMU-W) on the improvement of the navigation conditions in both the Mekong Delta and the Red River Delta. Major national inland waterway related works have been tendered by PMU-W through both national and international competitive bidding. Within the scope of the Northern Delta Transport Development Project (NDTDP) being financed by the International Development Association PMU-W has appointed Consultants to prepare Feasibility Studies and Preliminary Designs (similar to Basic Designs) for the Project.

Objectives of the NDTDP

The objectives of *the Northern Delta Transport Development Project* is to enhance the efficiency, environmental sustainability and safety of transport infrastructure and services through the alleviation of physical and institutional bottlenecks in two main waterway corridors in the Northern Delta Region.

The specific Project objectives are to

- reduce transport tariffs and improve service quality in two key inland waterways of the Northern Delta Region.
- enhance sustainable management and operations of the two pilot ports in the Northern Delta Region.
- increase safe river access to the waterways through ferry boat stages in the Northern Delta Region.
- enhance the sustainable management of the waterway sector.

Study Methodology and Data Sources

The environmental impact assessment was conducted on an incremental approach in order to provide the optimum support to planning and feasibility study. A regional scanning of the Red River Delta was initially conducted based on secondary literatures and environmental information was provided to the planning team. The information generated was part of the basis for the environmental screening of specific components and their alternatives. Subsequently, a follow-up collection of primary data, i.e. sampling and laboratory analysis and site inspection, were conducted for the selected project components.

The secondary sources of information include project documents and published researches and reports on the Red River Delta. Among these are

- Sourcebook of existing and proposed protected areas in Vietnam by Birdlife International, World Bank, Royal Netherlands Embassy and the Ministry of Agriculture and Rual Development (MARD) 2004, 2^{nd} ed.
- Red River Delta Master Plan by Binnie & Partners, Snowy Mountains Engineering Corp Ltd. AACM International Pty Ltd. And Delft Hydraulics, 1995. UNEP, Government of Vietnam, MOSTE
- Red River Waterways Project Vietnam TA No. 2615-VIE by Haskoning Consulting Engineers and Architects and Delft Hydraulics, 1998. . Gov Socialist Republic of Vietnam, MOT, VIWA.
- Day River-Ninh Co River Mouth Improvement Project – Vietnam by Haskoning Nederland BV Coastal and Rivers, 2003. Ministry of Transportation, PMU Waterways
- Northern Delta Transport Development Project. Consultancy Services for Feasibility Study and Preliminary Engineering Design. Inception Report by Royal Haskoning, SMEC and Center of VAPO 2007. , MOT, VIWA, PMU-Waterways

Numerous researches on environment related topics regarding the Red River Delta were also accessed in the worldwide web.

Primary data collection consisted of collection of water samples, soil samples, stream sediment samples, collection of selected specimens for identification, air quality and noise measurement. The primary data collection was done in November and December 2007 by the Environment Protection Centre (VESDEC) of the Vietnam Environment and Sustainable Development Institute (VESDI). Chemical analysis of the water, soil and stream sediment samples were done by the Institute of Chemistry of the National Academy of Sciences and Technology.

Parameters analyzed are the following:

- ***Water quality*** (20 parameters): Temperature, pH, salinity, TDS, turbidity, SS, DO, Fe, BOD_5, NH_4^+, NO_3^-, total N, total P, Zn, Cr, Cd, As, oil, phenols and total coliform.
- ***Soil quality*** (9 parameters): pH, Al, Fe, As, Pb, Cd, Cr, Hg and total oil.
- ***Sediment quality*** (10 parameters): pH, Al, Fe, As, Cd, Pb, Cr, Hg, pesticides (at some sites) and grain sizes.
- ***Air quality*** (9 parameters): Temperature, humidity, wind speed, CO, SO_2, NO_2, TSP, PM_{10}, Pb.
- ***Noise*** (dBA)
- ***Vibration***: L_x, L_y, L_z (dBA)

- ***Aquatic organisms*** (3 parameters): phytoplankton, zooplankton, benthic animals
- ***Fish*** data provided by Institute of Ecology and Biological Resources (IEBR) based on their 2007 surveys.
- ***Flora***: Listing of vegetation species at each sampling sites.

Air quality, noise and vibration tests were done by the SINTEP. The parameters measured include:

- Temperature
- Wind speed
- Total suspended particulate (TSP)
- Particulate Matter 10 (PM10)
- Sulfur dioxide (SO_2)
- Nitrogen Dioxide (NO_2)
- Carbon Monoxide (CO)
- Noise
- Vibration

The sampling stations, locations, samples collected for the entire project region are tabulated in **Table 1.1**, while **Figure 1.1** shows the location of the stations.

A GIS database has been created for the storage and to facilitate the analysis information. Environmental data (i.e. water quality, soil quality, stream sediment quality and air quality) were assessed by comparing with the standards set by the Government of Vietnam and with standards set by globally recognized institutions and governments such as the Dutch Standard for Sediment Pollutants.

For a better understanding of the environmental condition and how it varies with time and space, basic statistical and spatial analyses were done when data sets allow.

Consultations with the local authorities were also conducted as part of data collection.

Among the consulted stakeholders were the port authorities / management, the provincial DONREs and the stakeholders that will likely be directly affected by the various components of the project.

Purpose and Structure of this Volume

This volume contains the environmental impact assessment of the NDTDP Corridor 1 Waterways Improvement. The environmental impact assessment was conducted to ensure the environmental sustainability of the project and its components as well as to fulfill the environmental permitting requirements of the Government of Vietnam and the lending institution.

The contents of this volume are:

Chapter 1- Introduction, this section

Chapter 2- An outline of environment related policies, legal and administrative framework that are pertinent to the waterways improvement project.

Chapter 3- The description of the waterway improvement sub-projects to be undertaken under the NDTDP

Chapter 4 – The existing environmental condition of the study region and specific work sites

Chapter 5 – Prediction and assessment of the impacts to the environment of the various project components

Chapter 6 – Analysis of the various alternatives considered by the NDTDP

Chapter 7 - The proposed environmental management plan describing the mitigation measures and monitoring measures

Chapter 8- describes public involvement and consultation activities.

Chapter 9 – Listing of references used in the study

Chapter 10 – Attachments and appendices

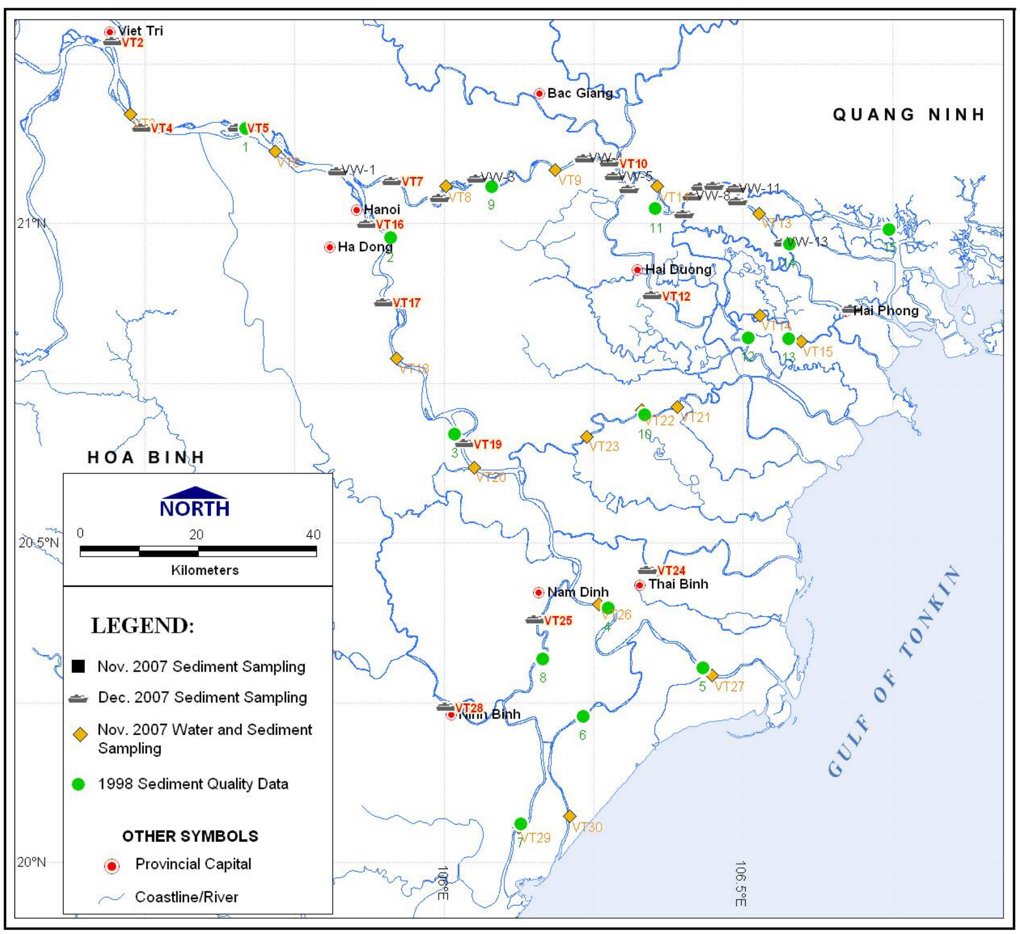
Table 0-1. List of Sampling Stations, Locations, Media Collected and Measured Parameters Corridor 1

Sample No	Location	Coordinate	Collected Media & Measured Environmental Parameters					
			Water	Soil	Sediment	Air Quality & Noise	Vibration	Aquatic Organism
VT1	Nhu Thuy landing site - Nhu Thuy – Lap Thach – Vinh Phuc province	21^{0}19’47.4” 105^{0}26’35,2”	■	■	■	■	■	■
VT2	Viet Tri Port – Viet Tri city – Phu Tho Province	21^{0}17’56.3” 105^{0}26’36.6”	■	■	■	■	■	■
VT2	Viet Tri Lake – Viet Tri city – Phu Tho province	21^{0}18’07.8” 105^{0}26’05.5”	■	■	■			■
VT3	Vinh Tuong – Vinh Phuc province	21^{0}15’08.6” 105^{0}26’56.8”			■			
VT4	Sontay Port –Sontay city - Ha Tay province	21^{0}09’36.5” 105^{0}30’53.9”	■	■	■	■	■	■
VT5	Chu Phan Ferry – Vinh Phuc province	21^{0}09’34.3” 105^{0}38’49.1”	■	■	■			■
VT6	Hong Ha Commune – Dan Phuong District – Ha Tay province	21^{0}09’52.9” 105^{0}38’02.8”			■			
VT7	Phu Dong landing site – Sai Dong District – Hanoi City	21^{0}02’41.2” 105^{0}57’34.0”	■	■	■	■	■	■
VT8	Trung Mau Commune – Gia Lam District- Hanoi City	21^{0}04’02.0” 105^{0}59’48.5”			■			
VT9	Dai La Commune – Gia Binh District – Bac Ninh Province	21^{0}06’00.2” 106^{0}12’06.1”			■			
VT10	Kenh Vang Port – Luong Tai District – Bac Ninh Province	21^{0}06’58.0” 106^{0}14’43.7”	■	■	■	■	■	■
VT12	Cong Cau Port – Hai Duong City – Hai Duong Province	20^{0}’54’46.2” 106^{0}20’34.9”	■	■	■	■	■	■

Sample No	Location	Coordinate	Collected Media & Measured Environmental Parameters					
			Water	Soil	Sediment	Air Quality & Noise	Vibration	Aquatic Organism
VT13	Hiep Son Commune – Kinh Mon District – Hai Duong Povince	20^0'59'28.3" $106^0$23'21.2"			■			
VT14	Truong Tho – An Lao District – Hai Phong City	20^0'50'50.8" $106^0$33'52.0"			■			
VT15	Truong Son – An Lao District – Hai Phong City	20^0'51'26.0" $106^0$32'47.6"			■			
VT31	Bat Trang – An Lao District – Hai Phong City	20^0'51'09.7" $106^0$30'05.0"		■				
VT32	Trung Lap – Vinh Bao District – Haiphong City	20^0'43'28.2" $106^0$27'53.1"		■				
VT37	Hai Phong port – Hai Phong City		■		■	■	■	
VW1	Duong River	$21^0$09747' $105^0$8215'			■			
VW2	Duong River	$21^0$04553' $105^0$99461'			■			
VW3	Duong River	$21^0$08213' $106^0$0746'			■			
VW4	Duong River	$21^0$10485' $106^0$22312'			■			
VW5	Duong River	$21^0$06866' $106^0$30368'			■			
VW6	Confluence (Kinh Thay – Thai Binh – Duong River)	$21^0$0571' $106^0$31421'			■			
VW7	Kinh Thay river	$21^0$02446' $106^0$4093'			■			
VW8	Kinh Thay River	$21^0$05431' $106^0$4262'			■			
VW9	Kinh Thay river	$21^0$06524' $106^0$43543'			■			
VW10	Kinh Thay River	$21^0$06624' $106^0$44865'			■			
VW11	Kinh Thay River	$21^0$06742' $106^0$48707'	■		■			

Sample No	Location	Coordinate	Collected Media & Measured Environmental Parameters					
			Water	Soil	Sediment	Air Quality & Noise	Vibration	Aquatic Organism
VW12	Kinh Thay river	21^{0}03373’ 106^{0}50834’			■			
VW13	Kinh Thay River	21^{0}02041’ 106^{0}534’	■					
VW14	Han River	20^{0}94272’ 106^{0}5986’			■			
VW15	Han River	20^{0}86732’ 106^{0}68065’	■		■			

Figure 0-1. Location of Sampling Stations



POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Vietnamese Policy in Environmental Impact Assessment (EIA)

At present, the most relevant environmental policies of Vietnam for environmental assessment are as follows:

2.1.1 Law on Environmental Protection (LEP)

The LEP was approved by the National Assembly on November, 29, 2005 and issued on December 12, 2005 through Order No.29/2005/L/CTN by the State President and enacted on July 01, 2006. The LEP is made up of 15 chapters, 136 articles, including Chapter IIl which contains the guidelines for environment assessment (SEA articles 14, 15, 16, 17), environment impact assessment (EIA articles 18, 19,20, 21, 22 23) and commitment in environmental protection (CEP, articles 24, 25, 26, 27).

Decree No. 80/2006/NĐ-CP dated August 9, 2006, detailed guidelines in implementation of some articles of the LEP.

This decision includes 3 chapters, 25 articles, of which 12 articles of the chapter I are guidelines for SEA, EIA and CEP: This decision lists the inter-sectoral, inter-provincial projects and EIA reports that are under the jurisdiction of the Ministry of Natural Resources and Environment (MONRE). According to this Decree the projects that are required to conduct EIA are: (1) Road projects of class IV with length of over 50km; and (2) the construction and rehabilitation of river or sea ports for ships of 1,000 DWT and over. The EIA reports for these types of projects should be approved by MONRE, the provincial people committee or MOT. Transport projects of lower capacities are required to prepare CEP for appraisal by the district People Committee.

The following sections give an overview of the SEA, EIA and CEP (after Hilaf Hong Duc (http://www.vilaf.com/index.asp?progid=50003&cateID=EDC3D673-C29E-C598-6145-0759F43E23D0).

- *Strategic Environment Assessment Reports*

Projects that are subject to strategic environment assessment reports include strategies and plans on national socio-economic development at the national or provincial level. The agency responsible for building a national strategic project must prepare and submit a strategic environment assessment report to the relevant appraisal body.

The appraisal is one of the grounds for approving the project. A strategic environment assessment report must include the following contents:

i. general descriptions of the objectives, size and features of the project;
ii. descriptions of the natural, economic, social and environmental conditions of the project;
iii. a prediction of possible negative effects on the environment;
iv. sources of data and appraisal methods; and
v. proposed solutions and directions for the implementation of the project.

The MONRE is responsible for forming a Strategic Environment Assessment Report Appraisal Board with regard to projects belonging to the authority of the National Assembly, the Government and or Prime Minister. The relevant ministries have a responsibility to form Strategic Environment Assessment Report Appraisal Boards with regard to the projects under their respective authority. Provincial People's Committees are responsible for forming Strategic Environment Assessment Report Appraisal Boards with regard to the projects under their respective authority or provincial People's Councils' authority.

- *Environmental Impact Assessment Reports*

Article 18.1 of the new Environment Law provides a list of the projects that are required to conduct environmental impact assessment. These include projects of national importance such as urban area development projects, large scale projects for exploitation of natural resources, and projects for the development of IZs, HTZs and EPZs. Appendix I of Decree 80 implementing the Law on Environment dated 9 August 2006 ("**Decree 80**") provides a more comprehensive list of projects requiring environmental impact assessment reports, including all telecommunications infrastructure construction projects, projects on building and repairing ships and projects on exploitation of oil and gas.

The environmental impact assessment report must be made filed together with the feasibility study of the project. The contents of an environment impact assessment report must include project specifications, operational technology of the project, measures to minimise negative effects on the environment, an undertaking to apply environment protection measures during the construction and operation phases, and opinions of the local commune People's Committee and the population community where the project is carried out. These opinions may be in agreement or disagreement with the project from an environmental protection perspective and must be set forth in the report for the relevant appraising body's consideration.

To obtain the opinion of the community, the project owner has to send a document containing brief contents of the project, environmental impact of the project, measures to minimize such impacts to the People's Committee and National Front Committee at commune level. A dialogue may be launched if required by the People's Committee or the National Front Committee.

An environmental assessment report may be appraised by an appraisal board or an environment assessment service agency. The MONRE is responsible for providing the conditions and guidelines for environment service agencies. The MONRE is authorised to form the environment impact assessment report appraisal board, or select an environment impact assessment service agency in respect of projects belonging to the authority of the National Assembly, the Government or the Prime Minister or inter-provincial or inter-ministerial projects. Other ministries are authorised to form environment impact assessment boards or select environment impact assessment service agencies with regard to projects under their respective authority. Provincial People's Committees are responsible for forming environment impact assessment report appraisal boards, or selecting environment impact assessment report appraisal service agencies with regard to the projects under their respective authority and provincial People's Committee's authority.

The agency organising the appraisal has to inform the project owner about the appraisal result within 3 days of receiving such a result from the appraisal council or the appraisal service agency.

- *Environment Protection Undertaking*

Pursuant to Article 24 of the Environment Law, projects that are not subject to the compulsory environment impact assessment reports must provide an undertaking to protect the environment. The contents of the undertaking must include: (i) the project site; (ii) the form and scale of production, trading and services, materials and raw materials used for the project; (iii) likely waste to be produced from the project; and (iv) an undertaking to apply measures to minimise and treat waste and comply with the laws on environment protection. The undertaking must be registered with the local district People's Committee where the project is located before commencement of the project.

Appendix 4 in this Circular gives the structure and content of an EIA report.

The other relevant regulations are:

- Law on Mineral Resources, approved by the National Assembly on March 20, 1996.
- Law on Forest Protection and Development (1992, revised in 2004)
- Land Law, approved on November 26, 2003 by the National Assembly.
- Law on Water Resource, approved on May 20, 1998, by the National Assembly.
- Law on Forest Protection and Development (1992, revised in 2004)

2.1.2 Decree 81/2006/NĐ-CP of the Government

This Decree prescribes the penalty for the violation of environmental regulations. Chapter I describes the general provisions for penalties, Article 9 of Chapter II describes the penalties for violating the EIA regulation and strategic environmental assessment. Project owners can be fined for not conducting an EIA and for not implementing mitigation measures contained in the approved EIA report.

2.1.3 Vietnamese Standards for the Environment (TCVN)

The Vietnamese Standards for the Environment were published by the former Ministry of Science, Technology and Environment (MOSTE) in 1995, 2000, 2001, 2002 and by the Ministry of Science and Technology (MOSTE) in 2006. The environmental standards include standards for air, water, soil and noise. In general, the list of biophysical parameters is broad enough such that most monitoring programmes can employ the standards as basis for evaluation. However, in the absence of standards such as sediment quality, it is a common practice for ODA projects to use standards from other countries or international organisations.

The relevant Vietnamese standards ared:

- Ambient Air Quality Standard (TCVN 5937-2005) and TCVN 5938 - 2005
- Surface Water Quality Standard (TCVN 5942-1995)
- Acoustic Standard (TCVN 5949-1998)
- Fresh Water Quality for Protection of Aquatic Life (TCVN 6774-2000)

- Domestic Wastewater Standard (TCVN 6772-2000)
- Irrigation Water Quality Standard (TCVN 6773-2000)
- Industrial Effluent Standard (TCVN 5945-2005)
- Permissible Noise Level for vehicles (TCVN 5948-1999)
- Vibration and Shock Standards created by Construction and Industry (*TCVN 6962 - 2001*)
- Soil Quality Standard – Permissible Limits of Pesticides in Soils

2.1.4 Vietnamese Administrative Set Up in Environmental Management

From 2002, the Government of Vietnam has established the administrative and institutional set-up for environmental management. The institutions responsible for environmental management are the following:

- *Ministry of Natural Resources and Environment (MONRE)*

A Prime Ministerial Decision established MONRE on November 11, 2002. MONRE merges numerous departments.

- *Department of Environmental Impact Assessment Appraisal*

This Department is under MONRE. As stated in Decree 91/2002/ND-CP, the Department's function is: *To appraise environmental impact assessment reports of projects and of business and production establishments.*

The Department of EIA Appraisal of MONRE is responsible for organizing EIA Committee for approving SEA, EIA reports guided by the government (Decision N 80/2006/ NĐ – CP).

- *Sectoral Ministries*

According to the LEP (2005) the sectoral ministries are responsible for the environmental management of activities within their sectors. The ministries' responsibilities include the review and approval of EIA reports of the sectoral development projects. For examples, the Ministry of Transport is responsible for approving development projects guided by the Government (Decision 80/2006/ND-CP).

- *Provincial People Committees (PCs)*

Provincial PCs have responsibilities in environmental management in their territories. Accordingly, PCs have functions of reviewing and approving EIA reports for the development project guided by the Government (Decision N 80/2006/ NĐ – CP) in their territories.

- *District PCs*

District PCs have function in reviewing and appraisal CEP reports for the development projects guided by the Government (Decision N80/2006/NĐ – CP) in their territories.

- Provincial Departments of Natural Resources and Environment (DONRE):

In each provincial DONRE there is an Environmental Management Division (EMD). The EMD is responsible for supporting the PC in environmental management in accordance with the LEP and related laws and regulations. Hence, it is DONRE - and in particular, it's EMD - that will likely play a key regulatory role in environmental monitoring during project construction and operation of the NDTDP.

In case that the project will be divided into many sub-projects, each sub-project will have separate EIA or CEP reports, provincial DONREs or District DONREs, respectively, will organise committees for approving each EIA or CEP reports.

2.2 EIA Review and Approval Process

The following is the current standard procedure for environmental review and appraisal in Vietnam:

a) The project owner undertakes EIA study with or without an assistance of consultants.

b) A full EIA study should be conducted during the feasibility study (FS) stage of the project. Content and structure of an EIA report should be in accordance to the *Appendix 4* of the Circular 08/2006/TT – BTNMT of MONRE

c) The project owner submits seven (7) sets of EIA reports together with a letter requesting for the review and approval of the EIA report together with one (1) copy of Feasibility Study Report of the proposed project to the relevant agencies (Department of EIA Appraisal of MONRE or provincial People Committee or Ministry of Transport.

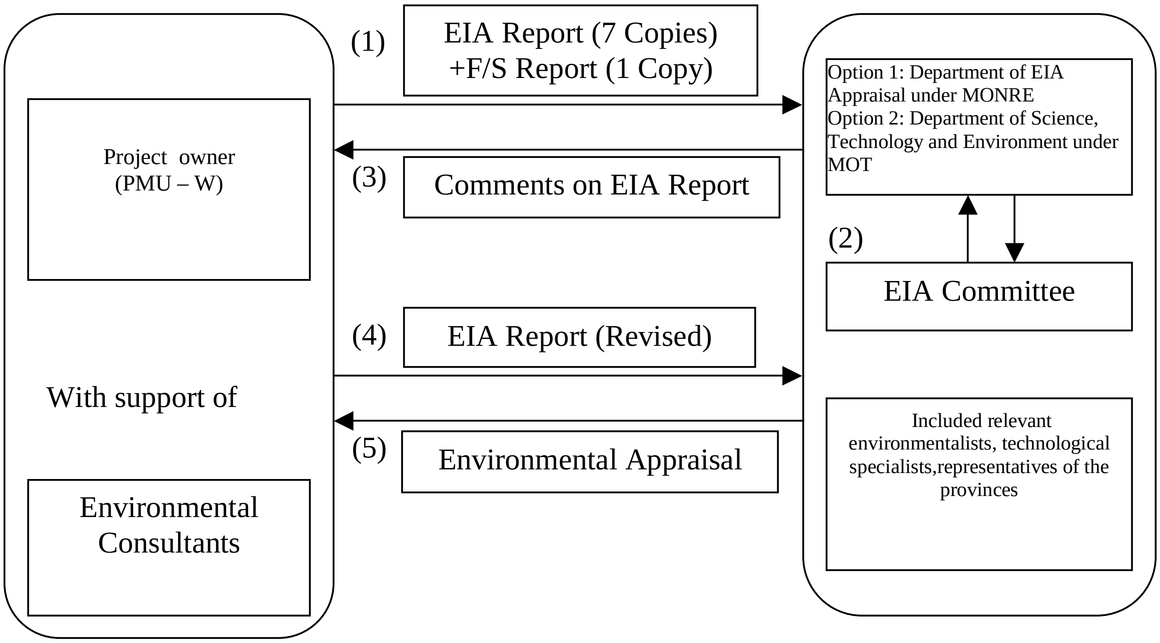
d) After receiving all EIA and F/S reports the relevant environmental authority organizes a Committee, consisting of environmental specialists and technological experts, representatives of Department of Natural Resource and Environment (DONRE) of the concerned provinces for appraisal of the EIA report.

e) The comments and views of the Committee on the EIA report are given to the project owner.

f) The project owner conduct additional studies to clarify all required items of the Committee and revises the report in response to the comments raised by the Committee.

g) An Environmental Approval Paper will be issued after the reception of the revised EIA report, which met the requirements of the Appraisal Committee.

The procedure of EIA for this project is presented in the following figure.



2.3 World Bank Social and Environmental Safeguards Policies

The World Bank safeguards operational policies that are relevant to the NDTDP are:

2.3.1 OP 4.01 (January 1999) -Environmental Impact Assessment:

The World Bank's Operating Procedure (OP) 4.01 contains the Bank's policy requiring projects proposed for the Bank's financing to conduct environmental assessment to ensure their environmental sustainability and to improve decision making. This operating policy enumerates the different environmental assessment instruments (depending on the project) that maybe submitted in order to comply with the Bank's requirement. OP4.01 also defines the basis for the environmental screening of the projects for the purpose of determining the appropriate extent and type of the environmental assessment. Further, the operating policy stipulates the Bank's requirement for institutional capacity building to be included in the project if the borrower has inadequate legal and technical capacity to implement the EA related functions. The need for public consultation, disclosure and conditions for implementation are likewise contained in OP4.01.

This Operational Policy statement was updated in March 2007 to reflect issuance of **OP**/**BP** 8.00, *Rapid Response to Crises and Emergencies*. The Bank may exempt a project from any of the requirement of this policy if it would prevent the effective and timely achievement of the objectives of an emergency operation.

2.3.2 OP 4.04-(June 2001) Natural Habitats:

The Bank recognizes conservation of natural habitats as one of the measures needed to protect and enhance the environment for long-term sustainable development. OP 4.04 contains the Bank's position and conditions on projects located within or projects that may impact on important natural habitats.

The project will not significantly convert or degrade any protected areas, known as natural habitats, or established or proposed criticical natural habitats as defined in the policy.

2.3.3 OP 4.11 (July 2006) Physical Cultural Resources

This policy expresses the Bank's recognition of the importance of physical cultural resources as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices.

As such, the policy contains the Bank's recommendation on how the physical resources can be protected from project impacts and managed within the context of the environmental assessment. Also, the operating policy contains the Bank's conditions for consultation and disclosure and emergency operations under OP 8.00.

In some isolated cases, the physical re-location of some graves and burial sites will be required and therefore this policy is triggered. The re-location will be planned closely with the resettlement process in the detailed design phase.

2.3.4 OP 4.12 – (Dec 2001) Involuntary Resettlement

OP 4.12 contains the Bank's policy on involuntary resettlement as a consequence of development projects. The policy contains the World Bank's procedures for management and compensation for project affected households subject to involuntary resettlement when a Resettlement Plan (RP) is required to be prepared. This includes process for determining eligibility to benefits by affected persons, the required planning instruments and resettlement instruments. Triggers for OP 4.12 include: involuntary taking of land or other assets; and when the involuntary taking of land or other assets results in adverse impacts on the livelihood of displaced persons.

This policy is triggered by the project. Therfore the project has prepared a Resettlement Plan for sub-component A1 and a Resettlement Policy Framework to address resettlement related to future sub-projects, consistent with the EA approach.

2.3.5 OP 4.10 – (July 2005) Indigenous Peoples

This policy is part of the Bank's mission of reducing poverty and sustainable development by ensuring that the development process fully respects the dignity, human rights, economies, and cultures of Indigenous Peoples. The policy sets the procedure and requirements for project proposed for Bank financing that affects Indigenous Peoples. The process calls for screening, social assessment and the preparation of Indigenous Peoples Plan.

This policy is not triggered by the project, given there is no evidence that Indigenous People will be affected by the project. Phase I will not affect ethnic minorities and phase II, with the locations for sub projects still unknown, is unlikely to affect ethnic minorities.

This is because ethnic minority communities in the Northern Delta are traditionally found in upland areas away from actual river deltas.

PROJECT DESCRIPTION

3.1 Overview

The Red River Delta is one of Vietnam's extensive river systems located in the northern part of the country (**Figure 3-1**). The delta, with its interconnected canals and tributary rivers stretches to about 2,000 kilometers and plays a key role in the economic development of Vietnam. About 67% of the region's total freight (ton-km) is transported via inland waterways and 33% of the goods produced are carried by road systems, with only a small percentage being carried by rail.

In 2003, the region contributed 23% to the country's Gross Domestic Product (GDP) from 22% in 2000, mainly from agriculture (rice) and industries (timber, cement, coal, building materials and fertilizer). Adequate and good access to markets of agricultural products and manufactured goods are important considerations for economic development.

To attain economic sustainability in the region, upgrading of the inland waterway transport (IWT) system is needed. At present, navigation along the transport corridor is limited due to physical constraints which have to be addressed. Existing constraints identified include limited water depth, numerous shoals, narrow channels with sharp bends and obstructions on the riverbed, such as, sunken barges and big rocks. Other problems that require attention are bank erosion and sedimentation.

The Northern Delta Transport Development Project (NDTDP) is being implemented for the improvement of waterways in the Northern Delta Region.

The NDTDP Project as a whole will have three main components:

- Component A: Multimodal Transport Corridors;
- Component B: Ferry Boat Stages; and
- Component C: Institutional Strengthening.

This EIA report focuses on project investments along Corridor 1 only, which is Subcomponent A1.1.

The overall project implementation schedule is included in the Project Implementation Plan. All investments under the project (physical and institutional) will be divided into two phases. The phases are delineated according to current readiness to implement and not by year of implementation. Phase I investments refer to investments for which all key preparatory works have been completed and Phase II investments refer to all the remaining investments for which preparation is ongoing or will take place during the first two years of the Project.

Sub component A1.1 will be implemented in Phase 1.

Sub Component A1.1 : Improvements to National Waterway Corridor 1.
The northern corridor between Viet Tri and Quang Ninh, a distance of 280 km;

The investments are to improve the standard and connectivity of the river network, concentrating on links within and to the Northern Delta Region as none of the corridors provides good transport continuity at present.

Corridor 1 comprises a 200 km inland waterway section between Viet Tri and Haiphong and an 80 km coastal section between Haiphong and Quang Ninh. The inland waterway section follows the Red River to Hanoi and then branches off along the Duong, Kinh Thay, Han and Cam Rivers to Haiphong. These river sections are designed as a Class II waterway[1]. The coastal section between Haiphong and Quang Ninh will also be Class II and presently has sufficient width and depth.

The minimum design widths and least available water depths (LAD) for the two corridors will be as follows:

Corridor /Section	Length – km	Width - m	LAD – m
Corridor 1			
Viet Tri - Haiphong	180	80	3.2
Haiphong – Viet Tri	100	>80	>3.2

The proposed improvements for Corridor 1 will generally include dredging to the required widths and depths, the construction of groins and bank protection in selected areas, some bend corrections and removal of obstacles. At one bridge, the Duong Bridge, additional air clearance will be provided by construction of a lifting span. Navigation aids will be installed throughout the corridor allowing day and night vessel passage.

Once improved, the corridor will be able to accept convoys of fully loaded 4x400 DWT barges over their entire length.

Shoal areas have been identified at four locations along the Red River between Viet Tri and Hanoi (km 0 – 57) and at 16 locations between Hanoi and Haiphong (km 200). Improvement of the navigation channel will be achieved both by dredging and by river training works, comprising the construction of groins, training dikes and bank protection works. Groin fields have been proposed at 14 of these shoal areas together with relatively minor dredging works and, in the remaining 6 areas where groins are not feasible, the channel will be improved by dredging.

As far as possible, capital dredging has been kept to a minimum and river training has been selected as the preferred solution for achieving the required channel depths and widths in order to minimize annual maintenance dredging costs for which VIWA has only a limited budget. Groin fields have been proposed in shoal sections to decrease the river cross-section thereby maintaining sufficient flow velocity to prevent the future accumulation of sediments in these sections.

Groin fields have been proposed in all the shoals areas along Corridor 1 except some sections of the lower reaches towards Haiphong where the river channel is too narrow to accommodate lateral groins. Here, channel dredging alone has been proposed.

Groins will be constructed as rockfill dikes transverse to the direction of flow from the existing river banks to one or both sides of the navigation channel. The extent, spacing and dimensions of the groins have been designed using equations derived from experience gained of river training works in Europe and the US. Rockfill mattresses or

[1] According to Vietnamese standards, Class I waterways are designed for 1050 DWT self-propelled vessels or 4x400/600 ton barge convoys: minimum dimensions - rivers LAD >3m, width >90m, canals LAD >4m width >50m. Class II waterways are designed for 600 DWT vessels or 4x400/600 ton barge convoys: minimum dimensions - rivers LAD 2-3m, width 70-90m, canals LAD 3-4m width 40-50m.

loose rockfill berms will be provided to control bed erosion around the heads of the groins. In some locations, lateral diversion dikes are included to direct the flow of the river or to close secondary channels.

Substandard bends occur at 7 locations: four of these will be improved by realigning the channel, but in the Kinh Thay River (km 132, 134-5) and the Han River (km 183), bend straightening is not possible without cutting the lateral flood control dikes. At these bends, traffic will be controlled by navigation aides (speed restrictions). At one bend (km 183), the channel is only navigable safely by single barges and barge convoys will need to be broken up and barges ferried around the bend singly.

Bank protection works have been included in the project in areas where the river banks are being actively eroded and where they are close to the existing flood dikes. Two types of bank protection have been selected: Reno mattresses (rock-filled, wire-framed mattresses) and concrete blocks precast onto geotextile matting. Loose riprap was also considered but experience has shown that this to be liable to vandalism. Reno mattresses are the cheaper of the two alternatives and have been selected for rural areas. Concrete block protection has been adopted in urban areas where local inhabitants require bank access for the mooring of small vessels.

Air clearance is a constraint beneath four bridges along Corridor 1 for the larger vessels at high water. One bridge, the Duong Bridge will be provided with a lifting span to give sufficient air clearance. Three other bridges (Phu Duong, Ho and Binh bridges) have slightly substandard air clearances but here it is proposed to restrict movements of large vessels at extreme high water levels by navigation aids.

The control of the deposition/erosion regime of certain river stretches by river training will result in changes to the overall dynamics of the river and new areas of shoaling and bank erosion may be expected to occur in other sections, requiring further river training works in the future. These are more likely to be needed in the Red River where the riverbed is very wide compared to the more confined and stable channels of the Duong, Kinh Thay, Han and Cam Rivers in Corridor 1.

The adopted strategy of river training as opposed to continuous maintenance dredging is a solution that will eventually lead to the establishment of a sustainable stable navigation channel with diminishing maintenance dredging. However, this is expected take a number of years to achieve and should be considered an incremental process, requiring annual monitoring of bed levels and bank erosion and the construction of further river training works as and where required.

3.2 Description of Existing Waterway

NDTDP’s Corridor 1 is about 280 kilometers which connects Quang Ninh with Viet Tri and runs through / along Hai Phong, Pha Lai and Ha Noi (**Figure 3-1**). The corridor is divided into 15 different sections comprised by rivers, canals and a coastal channel. The river system and length of each section are enumerated in **Table 3-1.**

Figure 0-1. Location of the river system in Corridor 1

Table 0-1. List of river system in Corridor 1

River Section	Length
Red River from Viet Tri to the bifurcation with the Duong River	17 km
Duong River	
Kinh Thay River between Trai Son and Nong	8 km
Cam River between Nong and Dinh Vu	24 km
Bach Dang River between Pharung and Dinh Vu	12 km
Phi Liet River between Trai Son (bifurcation with Kinh Thay River) and Ben Dun	8 km
Da Bach River between Ben Dun and Pharung	23 km
Han River	22 km

The coastal channel, as well as, sections from the coastline going to Hai Phong port are accessible to Class I sea vessels. It is envisioned that the whole corridor must be accessible to at least Class III. Presently, parts of Corridor 1 are only accessible to lower class of vessels. This is due to sharp bends, a large number of shoals that limit navigation during the dry season when water depth is low and limited vertical clearances at bridges during the wet season. The main constraints are present in the Duong and Kinh Thay rivers.

Eight main waterways of the Corridor 1 river network will require upgrading. In terms of waterway classification, the upgraded waterways will be at least Class III (Corridor 1a/b) according to the role and functional requirements for waterway classes as shown in **Table 3-2**.

Table 0-2. Role and functional requirements for inland waterways (Class I - Class IV)

Class	Role and functional requirements in the inland waterway transport system
I	Inland waterway that is part of a transport corridor in which cost effective use can be made of barge convoys up to 4 x 600 tons and self-propelled vessels, including river-sea going fleet, with capacity up to 1,000 tons.
II	Inland waterway that is part of a transport corridor in which cost effective use can be made of barge convoys up to 4 x 400 tons and 2 x 600 tons capacity and self-propelled vessels up to 600 tons capacity.
III	Inland waterway that is part of a transport corridor that allows the cost-effective

	use of barge convoys up to 2x400 tons capacity and self-propelled IWT vessels up to 300 tons capacity.
IV	Inland waterway that is a part of transport corridor that allows the cost-effective use of self-propelled IWT vessels up to 100 tons capacity and barge convoys up to 2x100 tons capacity.

1.4 Project Need

Need for Waterway Improvement

The inland waterway system is the most important component of the region's freight transport network. Aside from being more extensive than roads and railways, it is an efficient mode of transport system for heavy bulk cargo, in an economic manner without adverse environmental impacts. Likewise, IWT's extensive system of rivers, tributaries and canals serve as economic linkages between growth centers and the surrounding rural areas, proving its value for economic development and poverty reduction.

IWT cargoes are carried through these waterways to/from a number of industries and key river ports (Viet Tri, Hanoi, and Hai Phong) which are mostly located in and near the main corridor. 94% of the bulk cargoes transported via the IWT system are construction materials (sand and gravel), cement, and coal. Transport of rice, grains, fertilizer, POL (petroleum, oil and lubricants) and manufactured goods represents a small percentage of the inland waterway flow in the project area. A regular flow of these commodities to target markets and consumers will be vital to their needs and the economy.

Despite of huge potentials of the Red River System for inland water transport, it is hampered by many navigational constraints, bridges, safety hazards, and riverbank stability. The IWT fleet is not operating at full capacity for navigation is slow and barges often have to wait for upcoming tides to pass shallow stretches of rivers. Bend radii in the waterways are often less than 500 m and barge convoys have to be broken up in order to pass these parts of the river. Hence, there is the need to improve the inland waterways to ease navigation and improve connectivity with other river and coastal ports.

.

Based on VIWA's inventory in August 2007, major bottlenecks present in Corridor 1 waterway network which are important considerations for the NDTDP's waterway improvement, consisted of the following:

- ③ Limited navigation width due to a sunken barge (Red River)
- ③ Meandering river (Red River)
- ③ Limited water depth due to rocks on the river bed (Red River, Duong River, Phi Liet River, Da Bach River)
- ③ Limited water depth due to shoal (Duong River Kihn Thay)
- ③ Shallow and narrow channel due to shoal (Duong River, Han River)
- ③ Damaged groins (Red River, Duong River)
- ③ Too sharp bend for navigation, narrow channel (Kihn Thay River, Phi Liet River)
- ③ Bridge too low vertical clearance (Duong Bridge and Ho Bridge at Duong River)
- ③ Bank erosion (Duong, Han, Phi Liet)

③ Old bridge causing problem to safe navigation (Da Bach River)

Main constraints existing in Corridor 1 Red River system and proposed mitigating measures under the NDTDP are detailed in **Table 3-3**. Location of each bottleneck is shown in **Figure 3-2**.

Table 0-3. Description of Constraints/Bottlenecks and Mitigation in Corridor 1[2]

River	Code	Chainage	Description of Constraint/Bottleneck	Mitigating measure envisaged
Red	C1_R01	59-63	Tam Xa groin field is damaged. River is meandering	Groins to be repaired
	C1_R02	53-54	Navigation width is limited due to sunken barge	Barge to be removed
	C1_R03	59	Limited water depth due to rocks on the river bed. Length: 20 m, width: 10m, elevation: +0,8 m, located 50 m from centerline	Rocks to be removed
	C1_R04	59-60	Limited water depth due to rocks on the river bed. Length: 91 m, width: 13m, elevation: +2 m	Rocks to be removed
	C1_R05	60	Limited water depth due to rocks on the river bed. Length: 70 m, width: 10m, elevation: +2,3 m, located 40 m from centerline	Rocks to be removed
	C1_R06	63	Limited water depth due to rocks on the river bed. Length: 25 m, width: 4,5m, elevation: +2,2 m, located 30 m from centerline	Rocks to be removed
	C1_R07	71	Limited water depth due to rocks on the river bed. Length: 15 m, width: 5m, elevation: +3,2 m, located 30 m from centerline	Rocks to be removed
Duong	C1_D01	0+500	Limited water depth due to rocks on the river bed. Length: 15 m, width: 8m, elevation: +1.15 m, located 35 m from left side channel	Rocks to be removed
	C1_D02	3+500	Limited water depth due to rocks on the river bed. Length: 45 m, width: 8m, elevation: -0.1 m, located 40 m from right side channel	Rocks to be removed
	C1_D03	7	Limited water depth due to rocks on the river bed. Length: 12 m, width: 7m, elevation: 1.9 m, located 25 m from left side channel	Rocks to be removed
	C1_D04	8	Limited water depth due to rocks on the river bed. Length: 30 m, width:35m,	Rocks to be removed

[2] Corridor 1: Viet Tri - Ha Noi - Pha Lai - Hai Phong - Quang Ninh (11/5/2007)

River	Code	Chainage	Description of Constraint/Bottleneck	Mitigating measure envisaged
			elevation: 0.7 m, located 40 m from left side channel	
	C1_D05	10	Limited water depth due to rocks on the river bed. Length: 42 m, width: 13m, elevation: -0.25 m, located 35 m from right side channel	Rocks to be removed
	C1_D06	11	Limited water depth due to rocks on the river bed. Length: 25 m, width: 12m, elevation: -0.25 m, located 80 m from right side channel	Rocks to be removed
	C1_D07	12	Limited water depth due to rocks on the river bed. Length: 9 m, width:6 m, elevation: -0.1 m, located 40 m from left side channel	Rocks to be removed
	C1_D08	14+300	Limited water depth due to rocks on the river bed. Length: 12 m, width: 6m, elevation: -0.25 m, located 60 m from right side channel	Rocks to be removed
	C1_D09	15+500	Limited water depth due to rocks on the river bed. Length: 35 m, width: 8m, elevation: -0.4 m, located 50 m from right side channel	Rocks to be removed
	C1_D10	22	Limited water depth due to Trung Mau shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_D11	26	Limited water depth due to Thuong Den shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_D12	31	Groins A Lu at right bank (L=50m, W=12m, 50 m from channel center line) are out of order and not required but cause problem to the navigational width	Groins to be removed
	C1_D13	30-32	Left bank: Erosion prone area	Bank protection
	C1_D14	32	Groin Nghia Chi (Length: 200 m, width: 15 m, elevation: +1.3 m, located 70m from center line) is out of order and causes problems to the navigational width	Groins to be removed
	C1_D15	33-34	Limited water depth due to shoal Nghia Chi	Dredging required

River	Code	Chainage	Description of Constraint/Bottleneck	Mitigating measure envisaged
	C1_D16	50	Groin Chi (Length: 250 m, width: 10 m, elevation: +0.8 m, located 30 m from center line) is out of order but causing problem to the navigational width	Groins to be removed
	C1_D17	53	Shallow and narrow channel due to Chi Nhi shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_D18	56	Limited water depth due to Dai Lai shoal	Dredging required
	C1_D19	64	Limited water depth due to Van Doan shoal	Dredging required
	C1_D20	65	Limited water depth due to Than shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
Kinh Thay	C1_KT01	0	Limited water depth due to Lau Khe shoal. Volume redged each year: 2002: 19,535 m3; 2003: 17,747 m3, 2004: 15,584 m3	Outcrop cutting, dredging, bank protection
	C1_KT02	11+500	Limited water depth due to Vinh Tru shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_KT03	18	Crossing of Keo. Too sharp bend for navigation, narrow channel water flowing diagonally with high velocity	Outcrop cutting
	C1_KT04	19+500	Limited water depth due to Mac Ngan shoal	Dredging required
	C1_KT05	22+500	Limited water depth at Tien Xa. Volume dredged each year: 2003: 9,952m3, 2004: 9,082 m3	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future, outcrop cutting and bank protection
	C1_KT06	21	Too sharp bend for safe navigation	Bend improvement, bank protection
	C1_KT07	24-25	Too sharp bend for safe navigation	Bend improvement,

River	Code	Chainage	Description of Constraint/Bottleneck	Mitigating measure envisaged
				bank protection
	C1_KT08	25+500	Limited water depth due to Kenh Giang 1 shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_KT06	21	Too sharp bend for safe navigation	Outcrop cutting, bank protection
	C1_KT07	24-25	Too sharp bend for safe navigation	Outcrop cutting, bank protection
	C1_KT08	25+500	Limited water depth due to Kenh Giang 1 shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_KT09	27	Limited water depth at Kenh Giang 2 Volume dredged each year: 2002: 11,390 m3; 2003: 16,660 m3, 2004: 7,790 m3	Dredging required
	C1_KT10	33	Limited water depth due to Ben Trieu shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_KT11	34+500	Limited water depth due to Kinh Chu shoal	Area has to be dredged and groins to be constructed to concentrate the flow in order to limit sedimentation in the future
	C1_KT12	37+500	Limited water depth due to rocks on the river bed. L=8m W=6m, 15 m from the channel centerline	Rocks to be removed
Han	C1_H01	0-1	Left bank: Erosion prone area	Bank protection
	C1_H02	5	Shoal Nhat Son; Volume dredged each year: 2002: 22,422 m3; 2003: 21,316 m3	Dredging required
	C1_H03	4-5	Right bank: Erosion prone area	Bank protection
Phi Liet	C1_PL01	2	Narrow channel and sharp bend	Dredging and outcropping required

River	Code	Chainage	Description of Constraint/Bottleneck	Mitigating measure envisaged
	C1_PL02	4+100	Narrow channel and sunken barge (level: -0,76 m, length: 40 m, width: 20m)	Remove sunken vessel and dredging
	C1_PL03	6	Rocks (natural) located on the bed level, decreasing the water depth, located 15 m from the center line	Dredging
Da Bach	C1_BD01	1+500	Rocks (natural) located on the bed level, decreasing the water depth (length: 70 m, width: 40 m, 20 m from the center line)	Dredging
	C1_BD02	9	Old bridge pier located in the river causing problem to safe navigation (elevation: +0,79 m and 15 m from centerline)	Remove old bridge pier

Need for Navigational Aids

The Red River system has many navigational limitations that need to be addressed in the NDTDP. These include many shallow areas near the banks, sharp bends, eroding riverbanks, sunken vessel, low bridge vertical clearances, shoals and other obstructions. Navigational safety along the waterways is of utmost importance and aids to navigation are found to be insufficient and in poor conditions due to lack of financial support for their maintenance, operation and repair. Likewise, a lot of navigational aid markers/signs do not meet the technical standards as set in Decisions No.342/QD-KT4, No.22-TCN269-2000 and QD4099/28-12-2000 OD-BGTVT of VIWA.

The NDTDP's waterway improvement in Corridor 1 will upgrade the physical conditions of the main river system and more likely, traffic volume along the corridor will increase in the future. To ensure safe and efficient navigation, the project needs to improve existing navigational aids and modernize them closer to international standards.

Need for Bank Protection

Riverbank erosion is a natural phenomenon of alluvial rivers which is usually aggravated by flash flood, heavy rainfall and human activities, such as, encroachment and sediment mining. Increase in movement or traffic of vessels in riverbanks may also cause erosion due to wave action. Usually, severe erosion in a river is detected through the volume of accumulated sediments or when it meanders.

Impacts of soil erosion to life and property are many and have to be considered. Riverbank erosion decreases the integrity of its foundation, leading to the loss of vegetation and limited water depth that is crucial for safe navigation and access of water vessels. Maintaining stability of rivers can be achieved by installation of bank protection in identified key points. In certain cases, bank protection is needed after waterway improvements to stabilize bank and to maintain channel alignment

Severely eroded banks in some parts of the Red River delta have been installed with dikes for bank protection. However, the dikes are now in worst conditions and additional bank protection has to be installed. Particular areas in need of upgrading and/or additional bank protection system are sections of the Red River, Duong River, Han River and Phi Liet

River. These concerns have been recommended by the NDTDP waterway improvement project for investment.

Figure 0-2. Location of constraints in Corridor

3.3 Project Improvements

The waterway network improvements of the NDTDP will provide better access and safe navigation along the corridor, stimulating IWT development in the region and economic expansion. The waterway improvement proposed for Corridor 1 will have the following components:

a) Groins – 13 groin fields
b) Dredging
c) Bend Correction
d) Bank Protection in 6 locations
e) Closure of secondary channels (guidance dam in 2 locations)
f) Improvement of Duong Bridge
g) Removal of obstructions
h) Aids to Navigation

3.4.1 Groins

Groins are one of the most common and effective method of erosion control that are often constructed (nearly) perpendicular to the river banks, beginning at the riverbank with a root and ending at the regulation line with a head. Their main function is to create a navigation channel, while at the same time keeping the current from the river banks, thus preventing severe bank erosion.

Groins are applied, in some cases, to meandering rivers for river training where flow is directed to prevent lateral erosion that would form meanders. Likewise, they also help to increase/improve river width or depth for efficient navigation.

Two alternatives are considered for groins, pile groins (permeable) and rock groins (impermeable). Rock groins are recommended for NDTDP because of the following reasons:

a) More suitable to deflect and concentrate flow
b) More suitable to push the river away from the bank, avoiding erosion
c) Scouring head more suitable to maintain water depth
d) Damage easier to repair
e) Construction works are easier

The length, elevation, and spacing between groins should be determined according to local wave energy and bank slope. If they are too long or too high, groins tend to accelerate down drift erosion, trapping more silt and sand. They are ineffective if they are too short, too low, or too permeable. Groins may be permeable, allowing the water to flow through at reduced velocities, or impermeable, blocking and deflecting the current. Permeable groins are fabricated from piles, bamboo or timbers, whereas impermeable groins (also called solid groins or rock armor groins) are constructed using rock, gravel, gabions, etc.

NDTDP's waterway improvement project has recommended sections of the Red River, Duong River and Kihn Thay River for groin repair/installation. Of particular attention is the meandering river located between Red River and Duong River which interferes with navigation that needs to be repaired.

3.4.2 Dredging

Dredging is usually done for deepening or widening of rivers and waterways to maintain water depth and navigation safety. The operation is often carried out using the cutter suction dredger or at specific locations, by grab/clamshell or backhoe dredger.

Various dredging companies in Vietnam own a fleet of dredgers for executing dredging works both in the coastal zone and inland waterways. Most of them are using cutter suction dredgers which can operate in dry seasons and wet seasons (provided flow velocities remain below approx. 2.5 m/s) and can achieve a sufficiently high production to warrant their economic use.

In the Red River Delta, major limitations to the IWT vessels are low water depth, narrow channel, sharp bends and obstructions on river beds at certain sections of the Corridor 1 river system. Dredging and outcropping will be major activities to be taken for the waterway upgrading project in the region (**Figure 3-3**).

Figure 0-3. Dredging works at Khuyen Luong Port

Initial activity of the project will be the completion of the preliminary engineering design based on technical Vietnamese standards selected in accordance with 22TCN 2692000, 22TCN22295 and other standards and guidelines selected by the VIWA for the rehabilitation, repair and improvement works for upgrade waterways to a satisfactory operating condition. International standards have been used in addition to national standard as required. Issues for consideration in the detailed design work will include confirmation of dredge disposal methods and locations, including options for commercial sale of dredge for reuse.

Prior to dredging operations, LAD (Least Available Depth) assessments, hydrographic data and weather conditions will be determined to assure the efficiency and accuracy of the operation. Location of dredging site will be earmarked for future improvements, depending on LAD requirements.

Dredged material will be properly disposed in disposal areas on land. Since large-scale dredging can lead to erosion of the surrounding areas, measures to prevent erosion and other impacts will be implemented.

The total required area of the disposal sites would be determined using the calculated dredging quantities plus tolerances, multiplied by the bulking factor, whilst using a fill height of 1.5m. For example, a dredging volume of 1 million m^3 and following the abovementioned approach, a disposal area of 93ha will be required. The suitability of a discharge area is determined by environmental, social and economic factors.

Maintenance dredging of some sections of the upgraded waterway corridor will be required especially in canals where the flow velocities are limited and high levels of sedimentation occur. The methods of dredging and disposal of dredge material will be similar to the initial dredging activities as described

3.4.3 Bend Cutting / Bend Correction

Bend correction will be undertaken in 3 locations. What was initially planned to be bend cutting was modified because of significant socio-economic impact. Instead, sharper sharper bends has been accepted as a design policy, and waterway restrictions are also implemented by means of aids to navigation.

At Km 131-132 on the Kin Thay River, a community whose business is to a large extent centered on the small ferry landing is located close to the river bank and within the turn. The bend correction originally planned will be replaced by dredging that will not affect the community and by aids to navigation. This will consist primarily of dredging, groins and waterway restrictions through enhanced signage along the banks. The ferry landing will be improved through the project's construction contracting. Similarly, at Km 183 the bend correction will be avoided by use of aids to navigation and on the Phi Liet River, at Km 2, the bend correction will be avoided by use of aids to navigation.

3.4.4 Bank Protection/ Slope stabilization

The banks of the Red River system are in constant erosion as can be observed on site and satellite images. Due to the morphological characteristic of the river and forces of nature such as, typhoons and flash floods, the integrity of most riverbank continue to degrade. Present day measures to protect agricultural lands, lives and properties from the impacts of this phenomenon, include extensive installation of bank protection, such as, dikes and groins on critical areas. The imminent threat created by the deteriorating condition of these protection at present, has prompted the need to upgrade existing bank protection system.

Bank protection activities will be implemented on identified critical sections of the main waterway part of the NDTDP Corridor 1. The works will be implemented mainly along the banks of Red River, Duong River, Han River and Phi Liet River waterways. The 4 bank protection alternatives considered for Corridor 1 are: (1) Reno mattress; (2) concrete mattress; (3) rip-rap; (4) combinations. The recommended bank protection for NDTDP are (1) Reno mattress for rural areas; and (2) concrete mattress in urban areas.

Bank protection techniques to be implemented are based on the standards set by MARD.

3.4.5 Guidance Dam

A guidance dam will be constructed on the Red River at 22 km. This is a location where the river channel bifurcates around a large shoal in the middle of the river. The guidance dam will concentrate the water flow into the navigational channel.

3.4.6 Duong Bridge Improvement

The low vertical clearance of Duong Bridge and two other bridges are among the bottlenecks of Corridor 1. To avoid socioeconomic and resettlement impacts, as well as long term hindrance of traffic, Duong Bridge will be upgraded to allow the central part to be lifted hydraulically whenever a large vessel sails beneath the bridge. Other bridges with similar restrictions will be dealt with through the provision of aids to navigation.

3.4.7 Aids to Navigation

One important aspect that has to be considered in the upgrading of the physical conditions of the Red River system in Corridor 1 is navigation safety. Inland waterway accidents usually occur in areas near river bends, shoals, bifurcation/convergent zones, eroded areas, and areas with heavy traffic flows. The project's river improvement will enhance the navigation system through installation of buoys, markers, and signs at designated points along the river channel to lower the possibility of accidents and ensure the safety of water vessels and the public. Sufficient and properly located navigational aids will guarantee a safe and efficient passage along the corridor.

Vietnam's Navigational aid markers/signs are based on technical standards set in Decisions No.342/QD-KT4, No.22-TCN269-2000 and QD4099/28-12-2000 OD-BGTVT of VIWA (**Figure 3-5**). Existing aids to navigation in Corridor 1 is presented in **Table 3-4**.

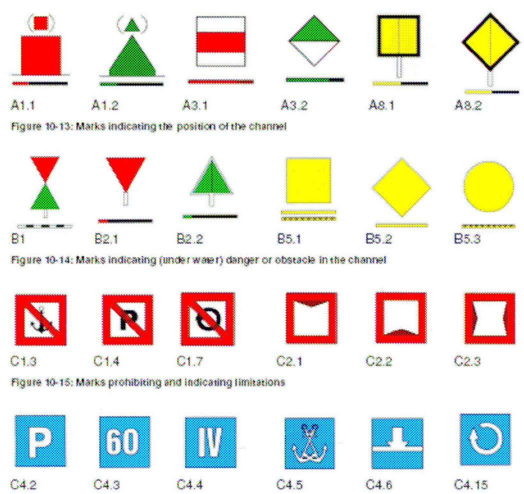
Almost all channels and obstacles in the corridors have been installed with markers with battery operated light. At present, these navigational aids are in bad condition, not properly maintained and managed due to lack of financial support. Improvement and development of new markers based on Vietnamese and international standards are envisioned in the waterway improvement project in the corridor and some of these navigation signs are illustrated in **Figure 3-4**.

Table 0-4. Existing aids to navigation in Corridor 1

Name of River/Channels	Length (km)	Buoys (piece)	Mark (piece)	Light (piece)	No Light (piece)
Coastal line	24.5	6	0	48	29
Cai Trap	4	8	0	8	6
Banh Dang River	7.5	Not under VIWA management. No Information			
Dinh Vu	1.5				
Cam River	24(9)				
Han river	8.5	6	0	27	30
Chanh River	19	7	1	34	23
Bach Dang River	1.5	Not under VIWA management. No Information			
Da Bach River	23.5	29	1	57	16
Phi Liet River	8	2	0	24	42
Kinh Thay	44.5	24	1	155	69
Thai Binh	1.5	4	1	4	6
Duong River	68	80	3	186	115
Red River	64.5	56	1	29	32

Note: On the Cam River only 9 km from Vat Cach port to Nong confluence is under VIWA management.

Figure 0-4. Vietnam's navigational aid markers /signs



3. 7 Implementation Cost

The estimated cost of project implementation for Corridor 1 under Phase 1 is presented in the following table.

Table 0-5. Investment Cost for Corridor 1

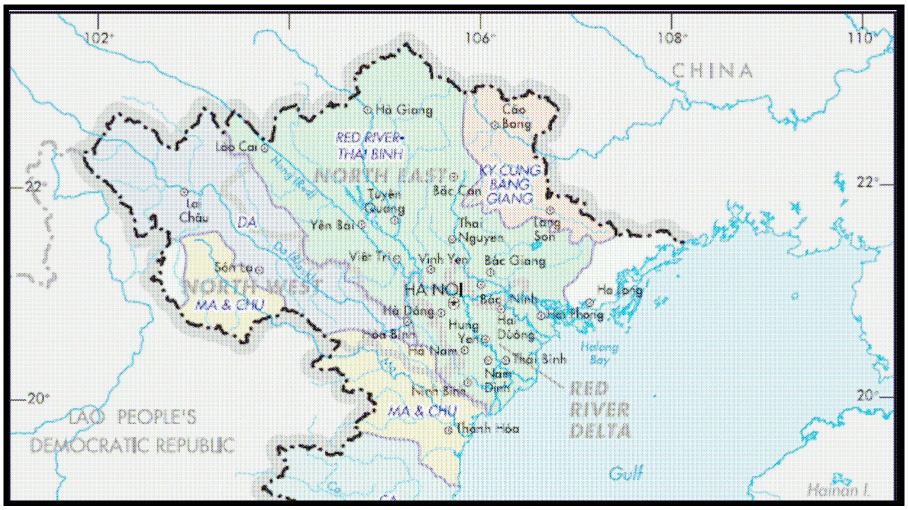
Item	GOV Resettlement / land management (Million US Dollars)	IDA Civil works / others (Million US Dollars)	Total (million US Dollars)
Corridor 1	3.56	56.85	60.41

4 EXISTING ENVIRONMENTAL CONDITION

4.1 Location

The project region (**Figure 4-1**) of the Northern Delta Transport Development Project (NDTDP) covers 13 provinces and cities, namely: Phu Tho, Vinh Phuc, Ha Tay, Ha Noi, Bac Ninh, Ha Nam, Ninh Binh, Nam Dinh, Hung Yen, Hai Duong, Thai Binh, Hai Phong and Quang Ninh, of which 11 provinces are located in the Red River Delta. The following map shows the coverage of the NDTDP study Region.

Figure 4-1. Coverage of the NDTDP Study Region



The project region is geographically bound by the following:

③ China in the Northeast with the border line of 132.8 km (in districts of Binh Lieu, Hai Ha and Mong Cai town of Quang Ninh province);

③ Provinces of Yen Bai, Thai Nguyen, Bac Giang and Lang Son in the North-Northwest;

③ Provinces of Hoa Binh and Thanh Hoa in the west – southwest;

③ The East Sea to the east and southeast with the coastline of 425 km (from Hai Hoa commune, Mong Cai town, Quang Ninh province to the Tong estuary at Kim Hai commune, Kim Son district, Ninh Binh province.

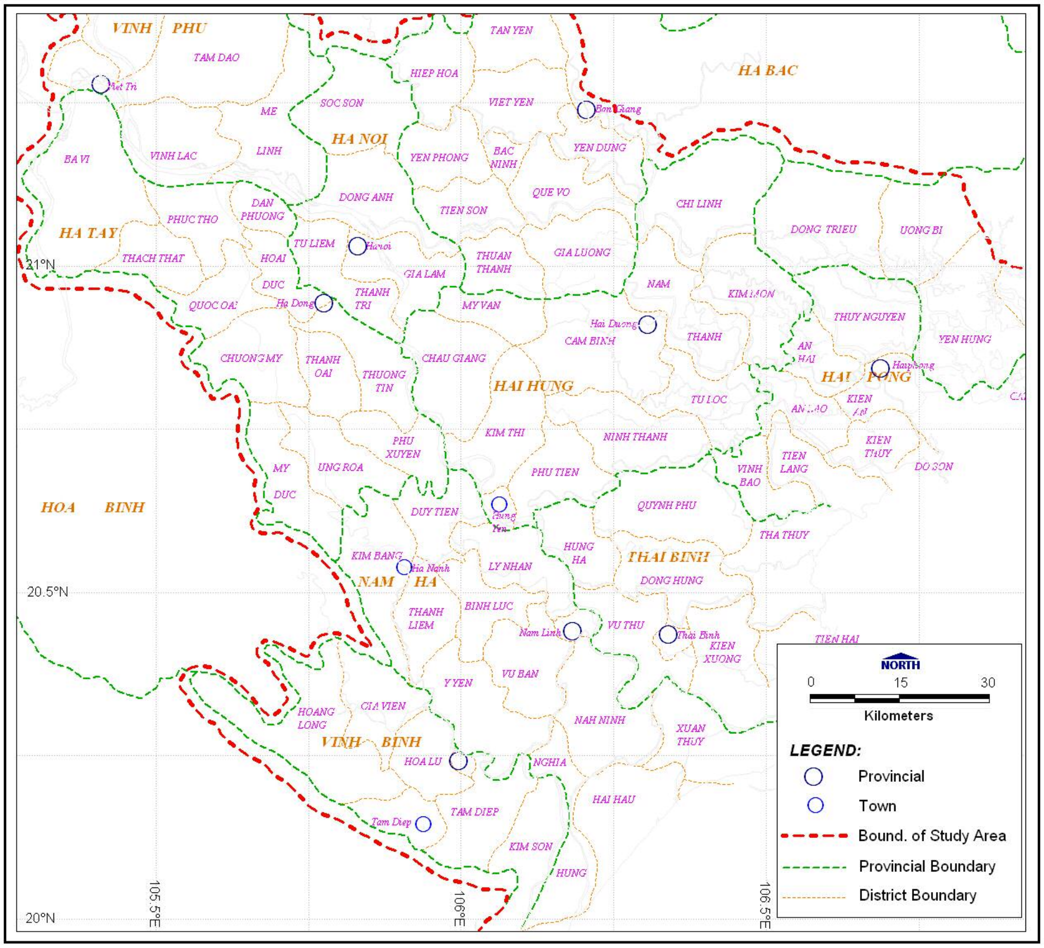
Table 4-1 enumerates the provinces and cities encompassed by the NDTDP.

Table 4-1. The provinces within the NDTDP project region

Provinces of the Red River Delta		Other Provinces
Bac Ninh	Hung Yen	Quang Ninh
Ha Nam	Nam Dinh	Bac Giang
Ha Noi City	Ninh Binh	Phu Tho
Ha Tay	Thai Binh	Tuyen Quang
Hai Duong	Vinh Phuc	
Hai Phong		

The provinces and towns that make up the study region are shown in **Figure 4-2.**

Figure 4-2. Map showing the towns and provinces within the NDTDP study regions



The NDTDP project region has been subdivided into three planning corridors. The provinces traversed by each corridor are enumerated in **Table 4-2**.

Table 4-2. The provinces traversed by the different corridors and Corridor 1 in particular.

Corridor 1: Viet Tri – Ha Noi - Pha Lai - Hai Phong - Quang Ninh	Corridor 2: Ning Binh - Hai Phong - Quang Ninh	Corridor 3: Ha Noi – Day / Lach Giang
Phu Tho	Ninh Binh	Ha Noi
Vinh Phuc	Nam Dinh	Ha Tay
Ha Tay	Thai Binh	Hung Yen
Ha Noi	Hung Yen	Ha Nam
Bac Ninh	Hai Duong	Thai Binh
Hai Duong	Hai Phong	Nam Dinh
Hai Phong	Quang Ning	
Quang Ninh		

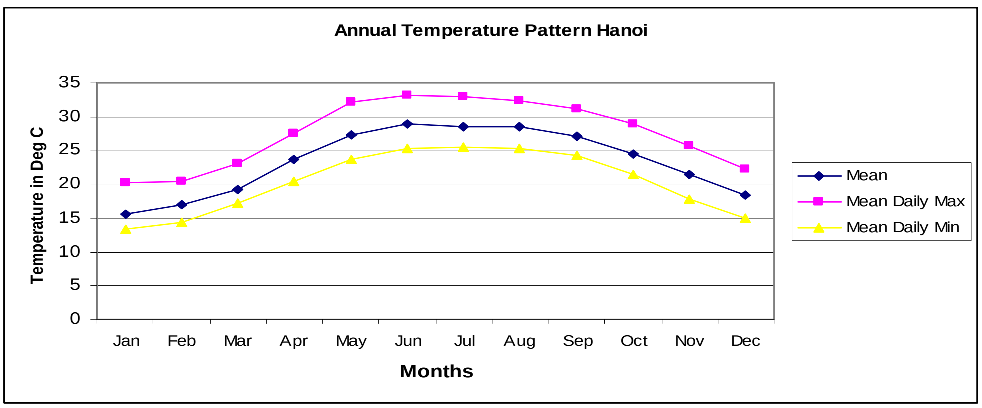
4.2 Overview of the Physical Environment

Due to the regional geographic scope of NDTDP a description of the existing environmental condition of the Red River Delta region is presented. This section presents a synthesis of the environmental data collated from existing literatures and primary data collected under this project. For most environmental components, a regional description is presented followed by a description of the conditions prevailing in specific segments of Corridor 1.

4.2.1 Climate and Air Quality

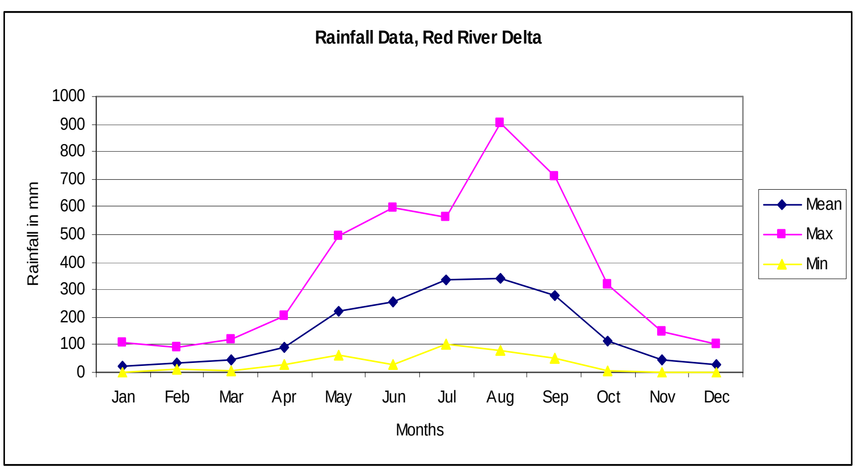
The climate that prevails in the region of Vietnam, including the Red River Delta is tropical to sub-tropical. The cooling of northern region of Vietnam during the winter months (December to February or March) is caused by northeast monsoon winds emanating from the edge of the Tibetan Plateau into Vietnam (Stirling et al., 2006). The graph shown in **Figure 4-3** below shows the average monthly temperature variation in Hanoi. The winter climate in the north is cold enough to interfere with year-round rice cultivation. The winter monsoon is devoid of moisture (see **Figure 4-4**) hence dry season prevails in the northern region during the winter season.

Figure 4-3. Average Monthly Temperature



After, Binnie et al. 1995. Red River Delta Master Plan

Figure 4-4. Average Monthly Rainfall, Hanoi



After, Binnie et al. 1995. Red River Delta Master Plan

Rainfall

The highest rainfall within the study region is experienced in the coastal areas of Quang Ninh with annual rainfall of 2000 – 2400 mm and rainy days of 130-160 days. The average of rainy days is 90-120 per year and the highest rainfall in a day was recorded at 422.5 mm (Tien Yen, 03 September 1973). The lowest rainfall in the study region occurs in the districts of Haiduong, Hung Yen and Dong Trieu district in Quang Ninh with annual rainfall of 1200 - 1600mm. In other places in the study region, rainfall is evenly distributed with an average of 1,600-2,000 mm over 110-160 rainy days per year. The highest rainfall in this particular region was recorded at 490.5 mm (Phulien, 22 September 1927). Rainfall generally declines towards the winter season.

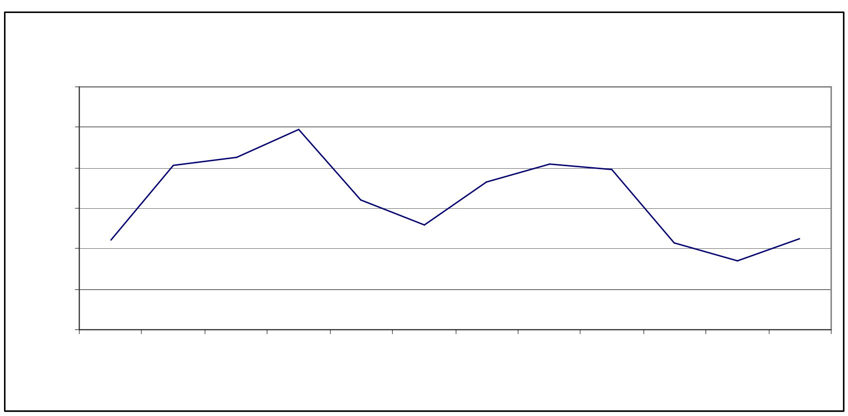
But towards the end of winter a condition of almost incessant drizzling rain persists in the lowland. This precedes the onset of the warm southwest monsoon winds which prevails during the rainy season from April to October. The southwest monsoon carries with it a lot of moisture and typhoons. Climatic data shows that an average of 15 typhoons affect the Red River Delta every 10 years (Nguyen Duc Ngu et al., 1992, cited in Binnie et al., 1995).

The annual average relative humidity in the project region ranges from 82 to 86%. The dry season sets at the beginning of winter with relative humidity falling to 76-77% (November and December) in coastal areas and rarely to 80% in plains. The highest relative humidity occurs in March averaging 90-92%.

The content of salt in the air in coastal region is high. It is highest during the dry season (winter and spring) and declines in the rainy season. In Thai Binh – Ninh Binh, the salt content in the air within an area of 5 km from the coastline is 1.5 to 2.5 mg/m^3.

The plot of the monthly average of relative humidity based on readings from the Hanoi weather station is shown in **Figure 4-5**

Figure 4-5. Monthly Average Humidity, Hanoi



annual average evaporation in the coastal areas of Doson – Haiphong is 1,138 mm and 1,250 mm in Kim Son – Ninh Binh.

Wind Pattern

As described by Thanh et al.(undated), during the NE monsoon during October - April, the NE and N wind reaches an average of 3 - 4m/s. These winds that blow parallel to the direction of coast reach a frequency of 70 - 80% from December - January. During the SW monsoon which prevails during the period of May -September, the average speed of wind is from 4 to 5m/s with the prevailing wind direction of SE, S and E. Every year, the Red River Delta is under the influence of 2 - 5 typhoons occurring from June – September. During such condition, the wind speed reaches 45 - 50m/s. Typhoons that coincided with the spring tide caused very destructive storm surge that ravaged the coastal areas. Under this condition the sea level can rise up to 5 - 6m with very strong waves that can breach the sea dikes.

These extreme conditions need to be considered when designing the offshore structures.

4.2.2 Special weather phenomena

There are special weather phenomena that occur from time to time in the northern region of Vietnam. These can be extreme weather conditions that can result to destruction of loss of lives and properties. These conditions are described in the following sections:

Storm

The coastal area from Quang Ninh to Ninh Binh is most susceptible to storms. Quang Ninh for instance, experiences one of the highest frequencies of storm in Vietnam. On the average, 3 to 5 storms traverse North Vietnam's plain annually. Heavy rains are usually associated with storms which threaten transport facilities and operation. The storm season is usually from June through October with 40% of the storms occurring between the months of July and August. But storms can also occur outside of these months. Recently, storms have been experienced in September and October. For instance, the 5th storm in 2007 hit Ninh Binh in late September. The floods brought about by the typhoon caused severe damage over a wide area.

Some of the strongest storms that have affected the Northern Delta are listed in **Table 4-3**.

Table 4-3. Extreme wind conditions recorded in the Northern Delta

Locality	Wind speed	Storm
Haiduong	> 40 m/s (>grade 13) 38m/s (grade 13)	Joe, 23 July 1980 Wendy, 9 September 1968
Haiphong	50 m/s (grade 16) > 50 m/s (>grade 16) 44 m/s (grade 14)	Sarah, 21 July 1997 Wendy, 9 September 1968 Warren, 20 August 1981
Quangninh	45 m/s (grade 14) >40 m/s (grade 13) 40 m/s (grade 13)	Winnie, 3 July 1964 Wendy, 9 September 1968 Carmen, 17 August 1963

Source: Trajectory map of storms in the South China Sea and their influences on Vietnam from 1894 to 2001 (National Center of Meteo-Hydrological Forecast)

Hoarfrost

With winter colder than the rest of the region, some places in Quang Ninh, Phu Tho and Vinh Phuc may experience hoarfrost. On average, hoarfrost occurs in Mong Cai in 0.5 days per year and in Hoa Binh in 0.9 days per year.

Fog

Fog usually appears in coastal areas, particularly islands and high mounts. The highest number of foggy days is found at Phu Lien at 38.3 days, Coto island: 9.8 days, compared wit 20 to 30 days in other regions. The month with much fog is March. In provinces of the Red River Delta, fog rarely appears (10-20 days per year), and usually in winter, if any.

Drizzle

Drizzle is a common phenomenon in winter, particularly in March. The average number of days of drizzle in the whole region is 6.0 to 43.1 days per year. The highest number of drizzly days occurs in Hung Yen. In general, the occurrence of drizzle is less in islands, e.g. Coto 11.3 days and Bach Longvy: 6.0 days.

Thunderstorm

Thunderstorms usually occur at the beginning of the rainy season with strong winds, heavy rains, thunders and lightning. The average number of days of thunderstorm is lowest at Bach Longvy Island at 23.2 days/year and it is highest in midland provinces at 77.0 days per year.

4.2.3 Air Quality

There are reports that ambient air quality is deteriorating partly due to the use of dirty fuel and the increasing number of motorized vehicles. Industries are among the stationary sources of air pollution in Vietnam. For Instance in Hai Phong, it is said that the operations of the cement plant has caused the deterioration of air quality. A demonstration on air quality monitoring conducted by DOSTE Haiphong City and VCPE in 1998 showed exceedances of the TCVN and WHO standards for TSP and PM10 respectively. **Table 4-4** summarizes the outcome of the air quality demonstration project done by DOSTE Haipong City and VCPE.

Table 4-4. Summary of TSP and PM 10 Monitoring in Haiphong, 1998

Date	TSP (mg/m^3)					PM10 (mg/m^3)		
	DOSTE	Ngo Quyen	Lach Tray Street	Nguyen Trai School	Dang Hai	Health Center	Ngo Quyen	Ha Ly
Mean	0.138	0.322	0.334	0.322	0.106	0.139	0.066	0.099
Geo Mean	0.105	0.215	0.298	0.255	0.094	0.117	0.054	0.077
Min	0.035	0.019	0.109	0.041	0.028	0.053	0.018	0.027
Max	0.448	0.680	0.700	0.650	0.160	0.318	0.179	0.295
N	12	12	12	12	12	13	12	12
N above STD	2	8	9	8	0	9	4	6
Standards 24 hours	0.200 mg/m^3 -24 hr TCVN standard (TSP)					0.050 mg/m^3 - 24 hr WHO Guideline (PM10)		

(http://www.vietnam.re.kr/AsaProgram/Asaboard/download.php?bn=bulleting&f_name=airpollution.doc).

It can be gleaned from **Table 4-4** that the Vietnamese standards and the WHO guidelines for Total Suspended Particulate (TSP) and Particulate Matter 10 (PM10) are exceeded in Hai Phong. The same scenario could prevail in other provinces in the NDTDP region where coal fired thermal power plans and cement plants are located.

Similar situation seems to prevail in Ninh Binh as indicated by the air quality data obtained for NInh Binh and Tam Diep (**Table 4.5** - SMEC NIP Feasibility Report). The table below indicates the exceedance of the TCVN standards for total suspended particulate matter and NO_2. Like Hai Phong, Ninh Binh hosts a power plant and a cement plant.

Table 4-5. Air quality in Ninh Binh and Tam Diep town

Sample	Location	Noise (dBA)	Dust (mg/m^3)	NO_2 (mg/m^3)	CO (mg/m^3)	SO_2 (mg/m^3)
NB1	Le Hong Phong Street	62-75	0.44	0.25	5.1	0.15
NB2	Ninh Binh thermo electric enterprise	50-65	0.4	0.17	2.5	0.12
NB3	Collective Ninh Binh thermo electric enterprise	50-72	1.75	1	2.3	0.29
NB4	House of culture for children	55-72	0.37	0.2	3	0.25
NB5	Residential area belong to NH1 (at Km)	50-70	0.38	0.05	1.5	0.18
TD1	Sanitation landfill in Tam	50-55	0.28	0.41	12.2	0.003

	Diep town					
TD2	Dong Giao food production enterprise	58-69	0.4	0.19	3.5	0.36
TD3	Residential area beside brick Vuon Chanh enterprise.	55-63	0.4	0.29	5.1	0.33
TCVN-5949		75	-	-	-	-
TCVN-5937	1 hr averaging	-	0.3	0.4	40	0.5

Source: SMEC NIP FS

Widespread construction is another cause of the elevated concentrations of TSP in the atmosphere. Large construction works are simultaneously being undertaken in and around Hanoi and other major cities of the Red River Delta.

4.2.4 Air Quality Measurements Corridor 1

Air quality measurements have been undertaken in the NDTDP study region in December 2007. The results of the air quality measurements for selected ports in Corridor 1 are enumerated in **Table 4-6**. It can be gleaned from **Table 4-6** that at present, 1h – average concentration of SO_2, NO_2, CO, are well within the permissible limits of 0.35, 0.20 and 30 mg/m^3, respectively, set by the Vietnam Standard for Ambient Air Quality. Concentration of (TSP) and PM10 are also well within the permissible limits. But note that TSP is relatively high in Phu Dong Port and Kenh Vang Port.
The dusty condition of some of river ports has been noted during the site surveys. These site surveys are being done in inspection being done in the course of the conduct of the environmental assessment of the NDTDP. The dusty condition is due to the lack of maintenance of the port roadways which are covered by spilled soil and fine dust materials (**Photo 4-1**). This condition poses health hazards not only to the port works but also to the people residing along the port access road. The following photographs illustrate the problem:

Photo 4-1. Dusty Condition in Viet Tri Port

For the protection of environmental health as well as public and occupational health, basic housekeeping and maintenance are implemented in the NDTDP ports. Noise could likewise be a concern in the relatively big ports of the NDTDP region. It is noted during the site visit that the ports are not only used for shipping and receiving cargoes. Facilities for crushing coal and iron ores are noted to be present. **Photo 4-2** shows one of the crushers in Viet Tri Port used for diminution of iron ores prior to shipping to China.

Other locations in Corridor 1 where air quality is a possible concern are the following areas:

- The clay manufacturing areas of Gia Binh, Bac Ninh
- Pha Lai, the vicinity of the Pha Lai Coal Thermal power plant
- The cement and concrete producing areas of Kinh Mon, Hai Duong; and
- The industrial zones of Hai Duong and Hai Phong in the lower reaches of Han River.

Table 4-6. Air Quality Measurements in some ports of Corridor 1, December 2007 NDTDP

Sta No	Site Location	T °C	R. Humidity (%)	Wind speed (m/s)	TSP Mg/m^3	PM10 mg/m^3	SO_2 mg/m^3	NO_2 mg/m^3	CO mg/m^3	Noise dBA	Vibration dBA		
											L_X	L_Y	L_Z
VT-1	Nhu Thuy landing site – Nhu Thuy – Lap Thach – Vinh Phuc province	21.5	78	1.2	.01	0.01	0.095	0.024	0.259	54.4	24.7	24.1	32.2
VT-2	Viet Tri Port – Viet Tri City – Phu Tho Province	24.3	75	1.8	0.12	0.03	0.161	0053	0.266	52.4	28.9	31.9	25.1
VT-4	Sontay Port – Sontay city – Ha Tay Province	20.0	75	1.5	0.01	0.01	0.118	0.028	0.531	67.4	23.5	25.2	38.3
VT-7	Phu Dong Port - Gialam – Hanoi city	18.5	80	3.0	0.16	0.05				60.8	32.8	30.1	39.3
VT-10	Kenh Vang Port – Luong Tai – Bac Ninh	19.5	75	2.5	0.19	0.10	0.181	0.035	1.024	60.2	27.4	29.9	36.6
VT-17	Hong Van Port - Hong Van - Thuong Tin District - Ha Tay Province	19.5	81	1.2	002	0.01	0.237	0.047	0.763	75.8	69.9	69.1	64.5
VT-37	Haiphong port – Haiphong city	19.2	75	2.0	0.07	0.03	0.257	0.038	1.041	61.1	43.9	48.7	32.0
	TCVN 5937 : 2005				0.3	-	0.35	0.20	30	60			
Source: VESDEC – SINTEP. Dec. 2007										TCVN 5949:1998			

Note: - Sampling duration: 60 minute

- The Vietnamese Standard (TCVN 5937 - 2005) for PM10 (24h average) is 0.15 mg/m^3.
- The Vietnamese Standard for Noise at residential. administrative area = 60dBA in day time (6 am – 6 pm) at mixed residential and commercial area = 75 dBA in day time.
- The Vietnamese Standard for vibration caused by construction activity at residential. administrative area = 75 dB (7 am – 7 pm)

Photo 4-2. Ore Crusher and stockpile of iron ore in Viet Tri Port

The following photographs show some of the areas of concern.

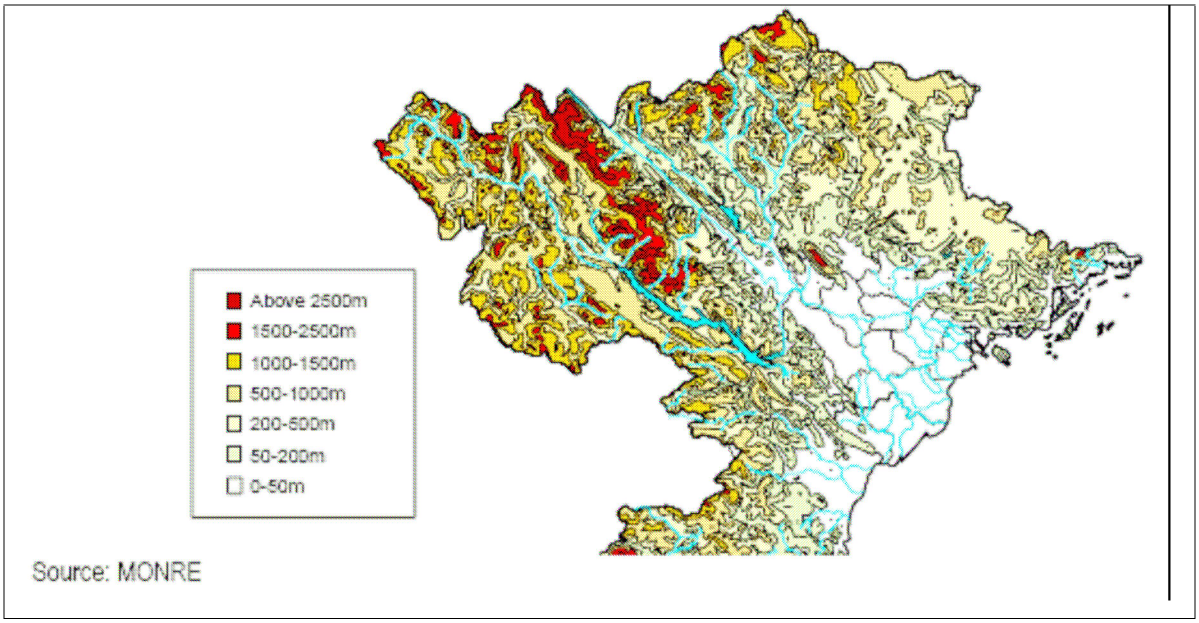
Photo 4-3. The Pha Lai Coal Thermal Power Plant

Photo 4-4. Concrete aggregate production , Quang Ninh

4.2.5 Topography and Geology

The topography of the study region is relatively flat, slightly sloping towards the coast in the NW-SE direction. The general altitude is low, about 2-3 m from Hung Yen to the south and 1-2 m in Thai Binh and Ninh Binh. The frequently flooded regions in Ha Nam, Nam Dinh and Ninh Binh have elevations of only 0.6 to 1m ASL. The inland region is transected by dike systems along the Red River and branches into independent segments with coastwise stretches on sand dunes. Low mountains and hills with elevations of 50 m to 100 m are scattered from Nho Quan (Ninh Binh) to Kim Bang (Ha Nam). The topography of the study region is shown **Figure 4-6**.

Figure 4-6. Topographic Map of the Study Region



The topography traversed by Corridor 1 is a broad plain starting from Viet Tri. This is only interrupted by limestone hills in the vicinity of Hai Duong and Quang Ninh.

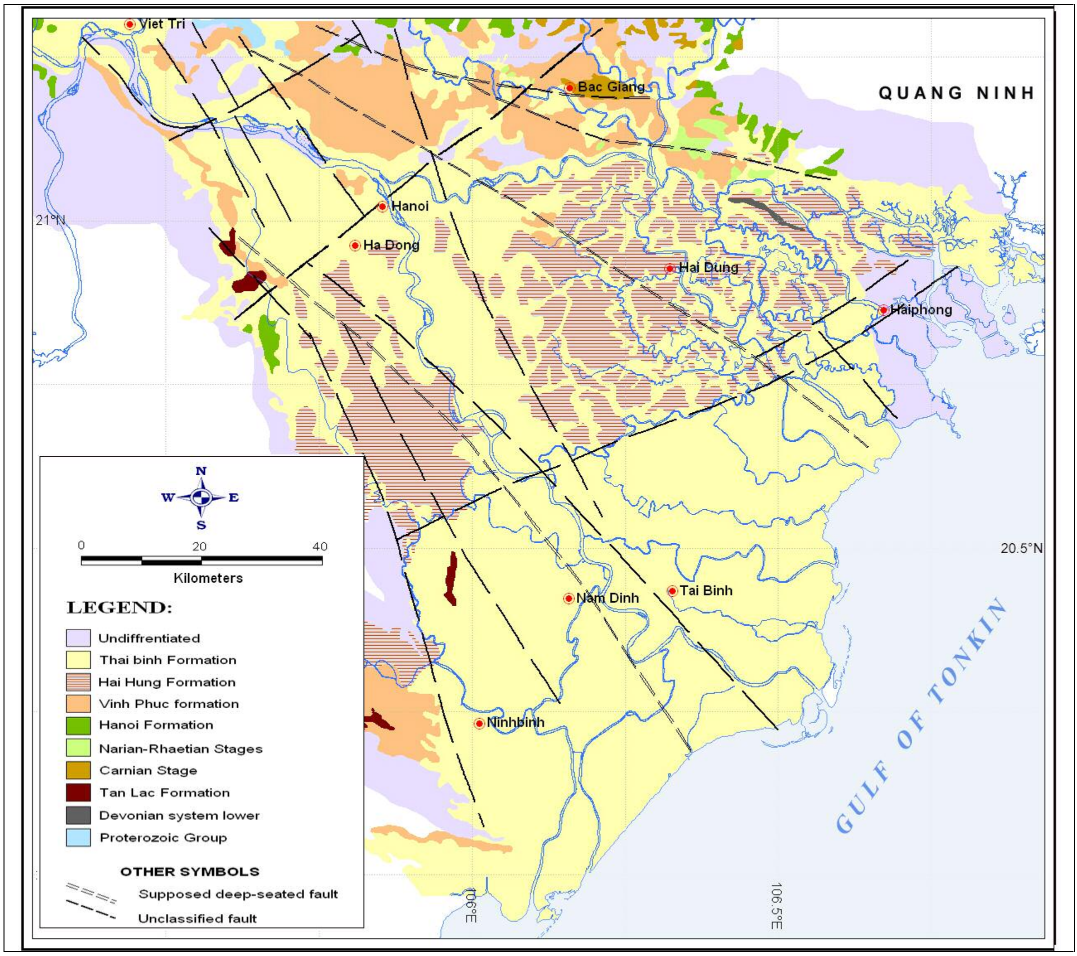
The Red River Delta was developed over a Cenozoic depression. It is filled up with Tertiary sediments up to to a thickness of about 5,000 m, Quaternary sediments up to 250 m thick and overlain by a 30 m to 60 m thick deposit of Holocene sediments *(Tiep, 1994 cited in Thanh).*

The geologic map of the Red River Delta is shown in **Figure 4-7**. The descriptions of the underlying (adopted from the Geology and Mineral Resources Map of Vietnam, Dept of Geology and Minerals of Vietnam, 2001) exposed in the Red River Delta are described as follows:

- Proterozoic Goup -This group consists of very old (2,600 to 570 million years before preset) crystalline and metamorphic rocks. This could be considered as the basement of the Red River Delta.
- Lower Devonian - This formation consists mainly of white-gray, brown gray sandstone, siltstone, clay shale and grit stone with local interbeds of limestone and sericite schist. This formation is about 400 million years old before present

- ③ Carnian Stage (Upper Triassic) – This is characterized by fine grained red continental sediments grading upward to medium and coarsed grained sediments, then more or less carbonate sediment. This formation is about 220 million years old before present.
- ③ Norian-Rhaetian Stage – Van Lang Formation, this consists of quart conglomerate and gritstone, medium-grained, medium to thick bedded sandstone, violetish-gray clay shale with some interbeds of gritstone, bearing plant remains. Upper part is composed of dark gray siltstone, gray sandstone interbedded with black-gray coaly shale.

Figure 4-7. Geologic Map of the NDTDP Study Region



- ③ Hanoi Formation – This formation is less than 2 million years old before present. This consists of two origin types, the fluvial sediments and the fluvi-proluvial sediments. The former consists of coarse grained beds: pebble, grit intercalated with some sand and silt with thickness varying from 2 m. The latter is made up of quartz pebble, granule, sand mixed with some silt.
- ③ Vinh Phuc Formation – Upper Pleistocene, this formation is less than a million years old. This formation is composed of two origin types, the fluvio marine sediments and the marine sediments.
- ③ Hai Hung Formation – Lower-Middle Holocene, this is very young formation in the geological sense. This is about 11,000 calendar years old. It is made up of four origin types, the fluvio-marine sediments, marine marshy sediments, marine sediments and the Lacustrine-marshy sediments.
- ③ Thai Binh Formation – Upper Holocene, this formation is younger still, less than 10,000 years old. It is composed of 6 origin types, the fluvio-marine, marshy marine, fluvial sediments, fluvio-marshy sediments, marine sediments and marine eolian sediments. This reflects the oscillation of sea level during this geologic time.
- ③ Undifferentiated Quaternary – this is the youngest formation composed of unconsolidated sediments occurring in rivers.

As indicated in the geologic map, Corridor 1 is traversing predominantly through the young geologic formation of the Thai Binh Formation. Given the varying depositional environment, sediment characteristics can vary from clay to sand to mixtures of clay-sand-silt of varying proportions.

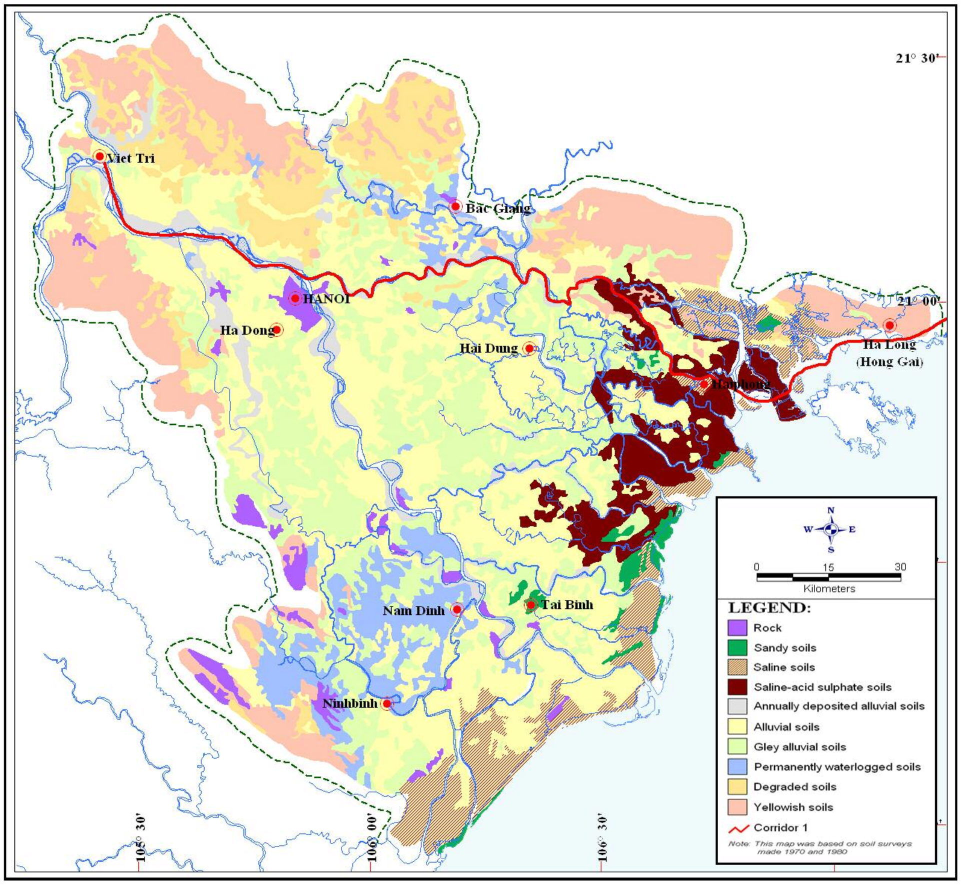
Susumu et al. (2006) described the deltaic evolution during the Holocene based on the results of drill cores obtained from the Red River Delta. Their interpretation of the cores indicated that during the past 9 kyr, Song Hong's sediments filled the incised valleys and with rapid advancement of the river mouth. The river mouth advanced towards the gulf and the delta went through a series of morphological evolution, from funnel-shaped (9–6 cal. kyr BP) to straight (6–2 cal. kyr BP) and finally to lobate (2–0 cal. kyr BP). The morphological change is presumed to be influenced by the shift in hydrologic condition from a tide-dominated bay-head setting to a wave-influenced open-coast setting. The authors inferred that cessation of the sea-level rise at 6 cal. kyr BP had little influence in the change of river-mouth morphology because the pro-gradation rate decelerated from 22 to 4 m/yr, instead of accelerating at that time. Further, it was interpreted by the authors that the river-mouth morpho-dynamic change from straight to lobate was largely caused by an increase in the Song Hong sediment discharge from 17–27 (9–2 cal. kyr BP) to 49 million t/yr (2–0 cal. kyr BP) as a result of anthropogenic deforestation along the upper reaches of the Song Hong (Susumu Tanabe et al., 2006).

This interpretation is supported by the results of the palynological study done in the Red River Delta. Pollen records showed intensified human activities after 3340 cal. yr BP as indicated in the records by large quantities of cultivated Gramineae taxa, possibly including the main wet rice species, *Oryza sativa*, secondary forest, and other upland cultivated plants (Zhen Li et al., 2006).

4.2.6 Soils of the Red River Delta

Ten soil groups have been mapped in the Red River Delta. According to the Red River Delta Master Plan (1995), Seven of these are cultivated and these groups are marine sandy soils, saline soils, acid sulphate soils, alluvial soils, water-logged soil, degraded soils, and yellowish-red soils. The distribution of the different soil types in the Red River Delta is shown in **Figure 4-8**.

Figure 4-8. Soil Map of the NDTDP Study Region



Based on this soil map, soil types along Corridor 1 are annually deposited, alluvial soils in the upper and lower reaches. In the lower reaches saline-acid sulphate soil occurs and in the general area of Hai Phong, saline soils are present.

Soil Quality

The results of the analysis of soil collected from selected ports in Corridor 1 are shown in **Table 4-7**. The results of the analysis are compared with the Dutch Standards for Soil and Sediment Pollutants. As shown by the result, the concentrations of heavy metals are low. But a few soil samples slightly exceeded the Dutch Reference Values for cadmium and mercury. These are in Kenh Vang, Son Tay and Viet Tri lake. Oil pollution seems to be prevalent with oil detected in most of the sampled ports such as Chu Phan, Phu Dong and Kenh Vang. Highest concentration of oil is in the soil sample from the Viet Tri Lake.

The pH values of soil samples collected from the selected ports of Corridor 1 (pH values of 6.78 – 7.18) are neutral.

Table 4-7. Soil Quality, Corridor 1

	Sampling Sites	pH (H_2O)	Al (%)	Fe (%)	As (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Hg (mg/kg)	Oil (mg/kg)
CORRIDOR 1	VT1 Nhu Thuy	6.78	10.25	4.8307	6.40	40.79	0.63	86.47	0.26	ND
	VT2 Port Viet Tri	7.15	8.91	4.2025	7.15	43.42	0.56	64.64	0.20	8.0
	VT2 Lake Viet Tri Lake	6.94	8.64	4.2675	5.15	64.47	0.42	71.49	0.34	23.0

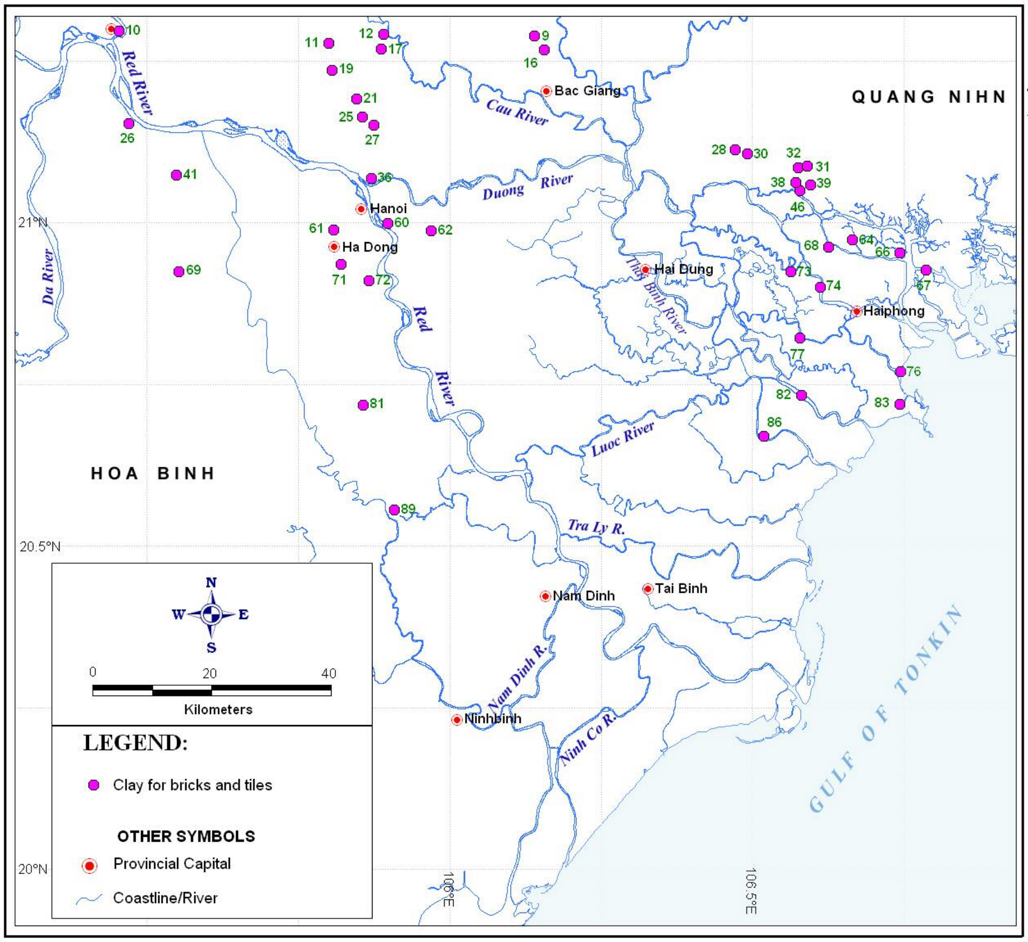
VT4 Son Tay Port	7.13	9.72	4.3108	13.80	76.32	1.12	69.78	0.27	ND
VT5 Chu Phan Ferry	7.09	7.02	3.4660	12.42	78.95	0.70	70.21	0.30	8.0
VT7 Phu Dong Port	7.19	7.56	4.1050	11.41	60.53	0.35	70.21	0.17	12.0
VT10 Kenh Vang Port	7.13	7.83	3.2927	11.13	57.89	0.21	65.07	0.34	10.0
Dutch Reference value				29	85	0.80	100	0.3	

4.2.7 Mineral Resources

Mineral and energy resources are present in the the study region. The largest coal basins of the country are found in the study region. Transport of coal from this source to power plant in Pha Lai and other consumers goes through Corridor 1. Large deposits of non-metallic minerals and industrial rocks like limestone are present in the study region.

Of particular interest to the NDTDP are the clay deposits located along the major waterways of Corridor 1. Clay is a vital material for the management of contaminated sediments that might be encountered during the improvement of Corridor 1. Clay is a cheap alternative to geotextile which is needed as lining for confinement of tainted sediments. Large clay deposits are found in Son Tay and on the banks of the lower reaches of Duong River and in Kinh Thai River.

Figure 4-9. Location Map of Clay Deposits in the NDTDP Study Region



4.3 The Red River System

4.3.1 Geography

One of the more comprehensive references on the geography and The Red River indicate that the total basin area is 143,700 km^2, including that of the Da River. More than 50% of the catchment area is within the territory of China and Laos. The main drainage channel of the Red River extends for about 1,130 kilometers flowing southwards to the Gulf of Tonkin. Among its headwater tributaries are the Lo River, which originates from China's Yunnan Province and the Da River. The Da River is located in Northwest Vietnam and it forms the border between the Lai Châu and Điện Biên Provinces. The Da joins the Red River in Phú Thọ Province. The laterite soils abundance in its mountainous upper reaches in Yunnan, China, give the river its characteristic red color (van Maren 2004). The middle reaches of the Red River flows along a straight southeasterly valley that is controlled by a major geologic structure, the Red River Fault. The 255 km long lower reach of the Red River comprises the triangular Red River Delta plain, bounded by limestone cliffs to the North and South. The gradient of the Red River decreases to

$5.9X10^{-5}$ (Gourou, 1936) downstream of the delta apex at Son Tay after which the river branches into a number of distributaries and discharges into the Gulf of Tonkin.

The width of the Red River varies from more than a kilometer at the segment below the Lo R Confluence to about 200 meters as it approaches the coastline. In Corridor 1, the distributary branches of Duong R, Kinh Thai R and Han R narrows down to less than 500 meters to about 100 meters.

Evidences of active meandering in the past indicated by ancient meanders, buried abandoned river channels and outlines of oxbows are discernible in aerial photos and satellite imageries. However, present day meandering has been controlled by the extensive network of protective dikes.

Large mid-channel shoals, elongated shoals parallel to the river course and occasional islands are among the depositional feature of the river. Active deposition of sediment within the channel has caused shallowing which severely limits navigation in some sections of the river system, thus the need for dredging Corridor 1. Active bank erosion is occurring in certain sections of Corridor 1 contributing to the river's sediment load. The photograph below shows one of the eroding sections of Duong / Red River in Corridor 1.

Photo 4-5. Active bank erosion Red River (7389)

The Red River and its tributaries are wide with bottom sediments consiting of silt and fine sand. The river width can reach as wide as 1 km or moreThe banks of the river are alluvial materials, about 3 to 4 meters high. Bank erosion is evident in some sections. Present day river meandering has been controlled with the construction of an extensive network of dikes. But ancient meander belts and abandoned river channels are still evident from maps and satellite imageries.

4.3.2 Hydrology and Sedimentation of Red River

Vu Trung Than et al. (undated) reported that the Red River drainage system is the largest in North Vietnam. Its mean discharge as measured in Son Tay is 3,640 m^3/sec, equivalent to a mean annual discharge of 114 km^3 . It is estimated that about 74% of this gross discharge flows during the rainy season from June to October. Peak discharge during rainy season is placed at 30,000m^3/sec. As a consequence, salinity of the estuary is substantially reduced and when such condition prevails, a tongue of fresh water may extend as far as 30 kms into the Gulf of Tonkin.

But during the dry months from November to May, the river flow declines to 430 m^3/sec. During this season, brackish water (salinity of 10 PSU) penetrates the various tributaries up to about 22 km inland. The more saline water (30 to 31 PSU) approaches the coastline with 1.5 to 2.5 PSU/km gradients. Salinity differences between surface water and the bottom are marked. The mixing of fresh and marine waters is hastened by tidal action.

The average annual flow distribution in the Red River system is presented in **Table.4-8**.

Table 4-8. Discharge at Selected Stations

Unit	Red River at Son Tay	Red River at Hanoi	Duong at Thuong Cat	Luoc River (estimate)	Tra Ly River (estimate)	Dao River (estimate)	Ninh Co River (estimate)
m^3/s	3,560	2,710	880	350	350	650	200
%	100	75	25	10	10	18	6

<u>Sedimentation</u>

There are a number of estimates of the modern day sedimentation rate of the Red River. It is estimated that the annual discharge of the Red River is about 125 million ton sediments and 70 million ton dissolved matters into coastal zone *(Pho, 1984* cited inThanh et al., undated).

The total suspended sediment load transported by the Red River is close to 100 million tons per year; with this amount the Red River ranks among the 15 largest sediment discharges in the world (Milliman & Syvitski, 1992 in van Maren 2004). Bulk of the sediment is carried off during river discharges between 7000 to 8000 m^3/sec (11% of 100 million ton). This situation according to van Maren (2004) occurs 15 to 16 days per year. Large floods transport large quantities of sediment, but occur only once every few years, and therefore their contribution to the mean annual sediment transport is low. Less than 4% of the total sediment load is transported during the dry season (discharges below 2000 m^3/sec). The largest recorded flood occurred in August 1971, when 28 million tons of sediment was transported during a 10-day flood event with a peak discharge of 33.600 m^3/sec; this is equivalent to the volume of sediment transported during seven dry seasons. However, present-day sediment loads are affected by the Hoa Binh dam constructed between 1979 and 1994. The construction of the Hoa Binh dam has caused sediment starvation having interrupted sediment delivery downstream. The dam construction has nearly halved the sediment concentration in the Red River near its apex. Additionally, the river discharge is regulated by the dam since its completion: in the dry season the river discharge rarely falls below 1200 m^3/s.

The estimate of sediment delivery made by Haskoning is presented in **Table 4-9** below.

Table 4-9. Estimated sediment discharge at the river mouths

River	Estimated sediment output (million tons/year)
Red River	114

Ninh Co River	5
Day River	25

Source: Haskoning 2003

4.3.3 Water Quality

The water temperature of Corridor 1 varies from 27-30°C in Summer to 24-26°C in Winter. The difference between water temperature between the surface and bottom is about 1^{o} C. The pH values of estuarine water reach 8.0-8.5; the pH of surface water is higher than that near the bottom by about 0.05-0.10.

Secondary data on surface water quality is available for certain sections of the Red River and its tributaries. The secondary data on the quality of Red River and its tributaries reported high suspended sediment concentrations which can reach more than 2,000 mg/l. It is reported that the Red River in Hanoi for instance has an annual average of about 847 mg/l which is very much higher than the standard of 80 mg/l.

For the purpose of this EIA, the NDTDP conducted water sampling and analysis of the rivers that make up Corridor 1. Water samples were collected from all the priority ports of Corridor 1. The results of the analysis are shown in **Tables 4-10** and **4-11.**

Table 4-10. Water Quality of Corridor 1, Nov and Dec 2007 Sampling

Sampling Location and River		Temp. (^0C)	pH	TDS (mg/L)	Turbidity (NTU)	SS (mg/L)	DO (mg/L)	BOD_5 (mg/L)	NH_4^+ (mg/L)	Total N (mg/L)	NO_3^- (mg/L)	Total P (mg/L)	Total oil (mg/L)	Phenol (µg/L)	Coliform (MPN/100mL)
VT-1, , Nhu Thuy, Lo R		21	7.2	139	16	24	6.4	13	0.401	2.235	1.024	0.391	ND	0.124	7100
VT-2 Viet Tri Port, Red R		22	7.3	140	36	52	6.3	9	0.154	1.931	0.828	0.359	0.30	ND	1600
VT2 Viet Tri Lake		21	7.4	147	6	12	6.4	8	0.132	0.586	0.622	0.407	0.16	0.146	1200
VT-4, Son Tay , Red R		21	7.4	139	40	60	6.4	7	0.477	1.435	0.782	0.407	ND	ND	4500
VT5 Chu Phan Ferry Red R		22	7.3	131	38	58	6.2	14	0.578	1.044	1.016	0.342	0.34	0.115	2300
VT6 Dan Phuong Red R		22	7.4	138	42	62	6.3	12	0.567	1.226	0.986	0.374	ND	ND	5800
VT7 Phu Dong Duong R		21	7.2	140	36	54	5.8	5	0.797	1.215	1.124	0.359	0.26	0.123	1900
VT10 Kenh Vang Duong R		21	7.3	144	44	56	5.5	4	0.631	1.616	1.312	0.586	0.20	0.115	4800
VW 11 Nam Tan Kinh Thay			7.1	150	48	60	5.8	10	0.218	2.169	1.712	1.635	ND	ND	1,500
VW 13, Kinh Mon Kinh Thay			7.1	175	33	45	5.3	5	0.242	3.678	2.536	2.059	0.12	ND	700
VW 15 An Lao Han R			7.2	255	55	75	4.5	5	0.316	9.155	4.722	1.467	0.15	ND	800
TCVN 5942 – 1995	B	-	5.5- 9	-	-	80	≥2	<25	<1	<15	-	-	<0.3	<20	10,000
	A		6 – 8.5			20	≥ 6	< 4	<0.05	<10			0	<1	5,000

Table 4-11. Concentration of heavy metals in river water of the Northern Delta, Nov and Dec 2007 sampling

Sampling Sites	River	Fe (mg/L)	Zn (mg/L)	Cd (µg/L)	Total Cr (µg/L)	As (µg/L)
VT-1, , Nhu Thuy, Lo R	Lo R	0.026	0.031	0.25	4.15	13.20
VT-2 Viet Tri Port, Red R	Red R	0.028	0.042	0.30	3.98	18.97
VT2 Viet Tri Lake		0.031	0.037	0.18	3.74	22.23
VT-4, Son Tay , Red R	Red R	0.785	0.038	0.27	4.21	5.51
VT5 Chu Phan Ferry Red R	Red R	1.571	0.053	0.31	5.01	8.09
VT6 Dan Phuong Red R	Red R	2.722	0.040	0.28	3.92	9.96
VT7 Phu Dong Duong R	Duong R	0.968	0.039	0.22	3.45	7.59
VT10 Kenh Vang Duong R	Duong R	3.743	0.032	0.34	3.64	12.55
VW 11 Nam Tan Kinh Thay	Kinh Thay	0.336	0.031	0.26	3.18	15.37
VW 13, Kinh Mon Kinh Thay	Kinh Thay	0.985	0.035	0.30	3.29	16.09
VW 15 An Lao Han R	Han R	0.649	0.029	0.28	2.89	10.03
TCVN 5942-1995	B	2	2	**20**	Cr (III): 1000 µg/L Cr (VI): 50 µg/L	100
	A	1	1	0.01	Cr (III): 100 µg/L Cr (VI): 50 µg/L	0,05

Briefly, the results of this 2007 analysis can be described as follows:

pH value: pH values are neutral, varying from 7.0 to 7.6, meeting the Vietnamese Standard for Water Source A of Surface water (TCVN 5942 - 1995)*

Salinity (total dissolved solids - TDS): Salinity show gradual increase from Viet Tri (VT1, VT2) to the estuary area (VT 25, VT 28). The relatively low salinity even in the estuary is attributed to the fact that the 2007 sampling was timed at the end of flood season. .

Organic pollution: Organic pollution of river water is indicated by the concentration of dissolved oxygen (DO) and biochemical oxygen demand (BOD_5^{20}). Organic pollution is evident: at all sites, values of BOD_5^{20} exceed the Vietnamese Standard (TCVN 5942:1995) for the A water source (water for domestic use, BOD standard of □4 mg/L). However, water quality meets the TCVN 5942:1995 standard for the B water source (not for domestic use, BOD limit of □25 mg/L).

The organic pollution loading is highest (DO in lowest, BOD is highest) at VT25 (Nam Dinh port), VT17 (Hongvan port), VT1 (Nhu Thuy landing site) and VT5 (Chu Phan Ferry). Aside from ferry landings, the sites are densely populated. In addition, the elevated BOD observed during this sampling period could be a natural seasonal variation since sampling was done at the end of the flood season.**Nutrient pollution**: Concentrations of NH_4^+, NO_3^- and total N are high, although still lower than the maximum permissible limit of the Vietnamese Standard for Surface Water (TCVN 5942:1995, Source A). But the concentration of nutrients is high enough to cause eutrophication in stagnant water. Concentration of total phosphorus (P) is also high in some sampling sites. Some studies have indicated that concentrations of total N □ 0.5 mg/L, total P □0,1 mg/L can lead to eutrophication in stagnant waters.

Toxic chemical contamination: Phenols and heavy metals (Cd, Cr, As) are considered deleterious. Concentrations of phenols and heavy metals in the rivers of the Northern Delta are much lower than the Vietnamese Standard for Surface water (Source A). Phenol with concentrations of 0.11 to 0.14 mg/l has been detected in water samples from stations VT1 (Nhu Thuy), VT2 (Viet Tri), VT5 (Chu Phan), VT7, VT10.

Oil contamination: Oil contamination is significant in some sampling sites (VT2 – Viet Tri port, VT5 – Chu Phan Ferry, VT28 – Ninh Phuc port). The concentration of oil in water samples collected from this stations exceed the Vietnamese Standard (TCVN 5942:1995) for Source B. Oil contamination is attributed to oily wastes from boats.

Bacteriological contamination: Contents of total coliform (1,300 – 7,100 MPN/100 ml) are rather high at all sites but still lower than the TCVN 5942:1995 for Source A (5,000 MPN/100mL) except for a few sites.

4.3.4 Assessment and Interpretation of Water Quality of Corridor 1

The result of the water quality analysis for Corridor 1 is shown in **Table 4-10**. The spatial analysis of the DO and BOD in Corridor 1 is shown in the following graph (**Figure 4-10**). The graph shows good condition in the upstream section of Red River where DO is high and BOD is low. However, in VT-5 (Chu Phan) and VT-6 (Duong R) and VW11 BOD is high indicating organic pollution.

Figure 4-11 shows the spatial (from upstream to downstream) variation of phosphate and nitrate in Corridor 1. The graph shows increasing concentration in the downstream segments. This is likely due to the presence of dense industrial and residential areas especially in Hai Duong and Hai Phong.

Figure 4-10. DO and BOD in Rivers of Corridor 1

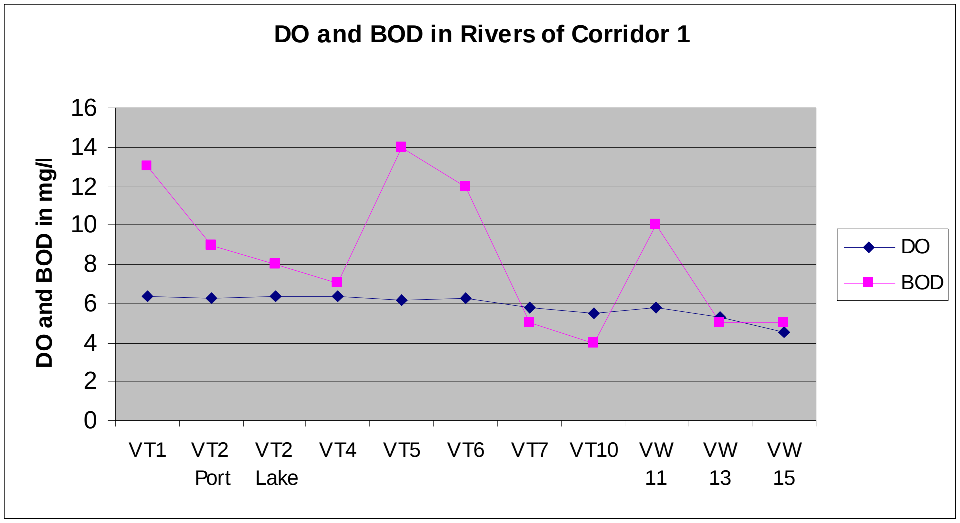
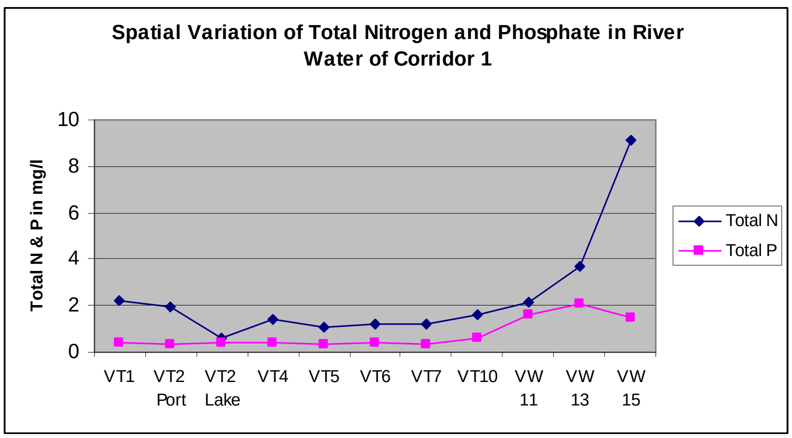


Figure 4-11. Spatial Variation of Total Nitrogen and Phospahte in Rivers of Corridor 1



4.3.5 Sediment Quality in Corridor 1

The trend of suspended sediments in the Red River from the headwater (Nhu Thuy Port, Phu Tho to the downstream segment in Kenh Vang Port shows increasing concentration of suspended sediment. This condition is inferred to be due to the combined effects of rampant dredging in Duong River and active bank erosion. Note that concentration of suspended sediment in VT2-Viet Tri lake is considerably lower than the river. The identical spatial trend exhibited by suspended sediments (**Figure 4-12**) and turbidity measurements (**Figure 4-13**) below shows that the turbid condition of Red River in this segment is mainly due to the sediment load.

Of the heavy metals in the surface water it is only arsenic that shows a distinct declining trend from the headwater to the downstream segment (**Figure 4-14**). It is also worthwhile to note the elevated concentration of arsenic in the headwater stations of Nhu Thuy and Viet Tri Port. The As concentration in the Viet Tri Lake is even higher. The relatively high As concentration in surface water in this segment of Corridor 1 is reflected in stream sediments collected from this segment (see section on *Stream Sediment Quality*).

Figure 4-12. Spatial Variation of Suspended Sediment in Corridor 1

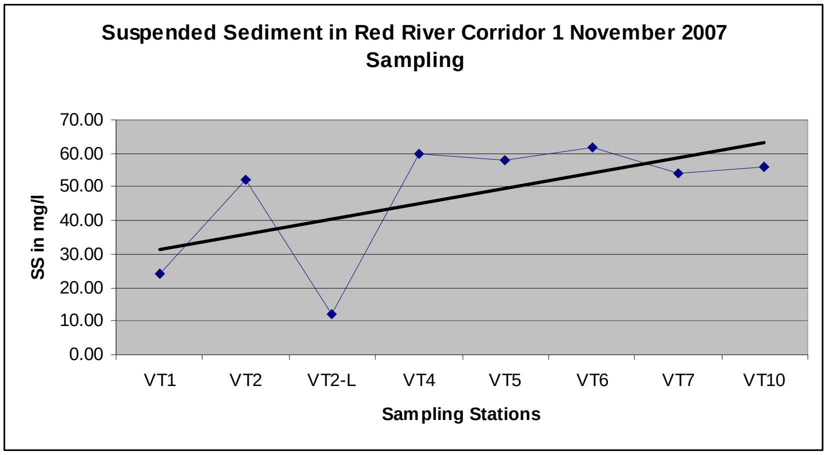


Figure 4-13. Spatial Variation of Turbidity in Corridor 1

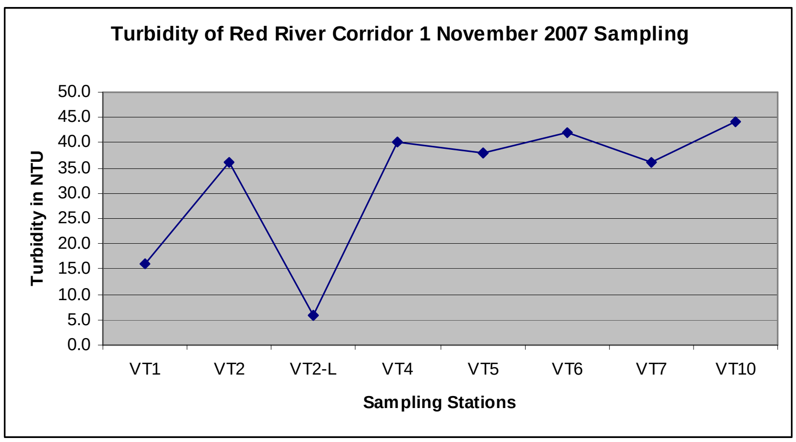
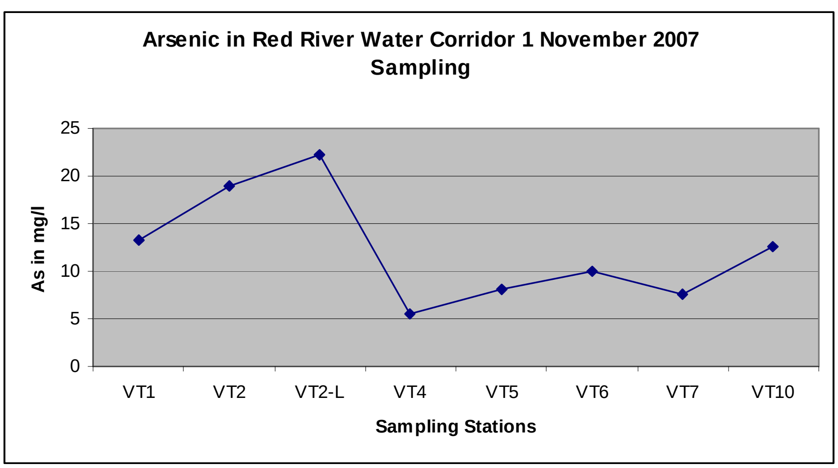


Figure 4-14. Arsenic in Red River, Corridor 1, 2007



4.3.6 Quality of the Stream Sediment of Red River and its Tributaries

River sediment analysis has previously been done in the Red River and its tributaries. The analysis was done in 1997 by the Vietnam National Center for Natural Science and Technology. The analytes included heavy metals, calcium carbonate, pesticides and organic materials and mineral oil. The results of the analysis are presented in **Table 4-12**. The heavy metal concentration in the river sediments are below the Dutch Reference Concentration. For pesticides, in the absence of complete Vietnamese standards the Dutch Pollution Standards for soil is used together with TCVN 5941-1995.

Lindane and DDT concentration in the sediments are below the limits set in TCVN 5941-1995, the Standard for Soil Quality, Pesticide Residue Limits. But concentrations of aldrin and endrin in sediments are above the Dutch Reference concentration.

Table 4-12. 1998 Analysis of Sediments from Red River and Tributaries

Parameters	Unit	Dutch Ref No	*S-1 Red R*	*S-2 Red R*	*S-7 Duong R*	*S-8 Doung R*	*S-9 Kinh Thai*	*S-10 Da Bach R*
Lead	mg/kg	85	6	9.5	30	24.5	20.5	23.5
Cadmium	mg/kg	0.8	0.329	0.575	1.85	1.775	1.35	1.975
Copper	mg/kg	36	15.5	18.75	29.75	19.25	26.75	28.5
Zinc	mg/kg	140	27	26.75	58.5	44.75	26.25	29
Nickel	mg/kg	35	24.5	21	31.5	20.5	18	16.75
Chromium	mg/kg	100	51	55	88	62.5	46	36
Mercury	mg/kg	0.3	0.023	0.025	0.041	0.028	0.027	0.015
Arsenic	mg/kg	29	0.265	0.21	0.494	0.398	0.159	0.155
Calcium Carbonate	%		0.5	0.4	0.75	0.5	0.4	0.2
Pesticides								
Lindane	Ppb	**100***	0.47	0.9	0.45	0.48	0.44	1.18
Aldrin	Ppb	.06	17.98	15.38	7.86	17.87	13.76	37.93
DDD	Ppb	10	5.65	4.6	2.57	3.83	4.46	ND
Endrin	Ppb	.04	ND	ND	3.48	ND	ND	ND
DDE	Ppb	10	56.38	57.06	34.86	52.2	11.41	13.12
DDT	Ppb	**100***	38.07	31.03	12.26	5.06	7.51	4.07
HCB	Ppb		0.26	0.14	0.34	0.13	0.2	0.26
Organic Materials								
Organic Materials	%		0	0.1	2.73	0	0	0.36
Mineral Oils	mg/kg	50	2.3	2.1	184.3	2.4	42.5	2

Note: values with asterisk are limits basec on TCVN 5941-195

Recent sediment sampling and analysis was conducted by the NDTDP and the result of the November 2007 analysis is shown in **Table 4-13.** Analytical results (**Table 4-14**) show that at present heavy metals in stream sediments are well below the reference values set by the Dutch Standard for Sediment Pollutants. Except for a few sites where Cd and Hg slightly exceeds the Reference Value of the Dutch Standard. But they are much lower than the test and Warning values

Pesticide (Persistent Organochlorines) contamination in sediment is much lower than the reference value in the Dutch Standard for Soil and Sediment Disposal.

The following are graphs of the concentrations of metals in stream sediments collected from Corridor 1. It is interesting to note that the concentration is declining from upstream to the estuary as indicated by the black trendline. This pattern is displayed by arsenic, cadmium, aluminum, chromium and iron.

Figure 4-15. Arsenic in Stream Sediments of Corridor 1

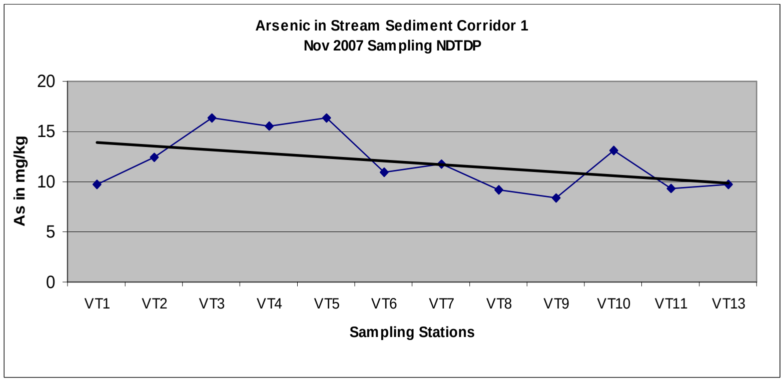


Figure 4-16. Cadmium in Stream sediments of Corridor 1

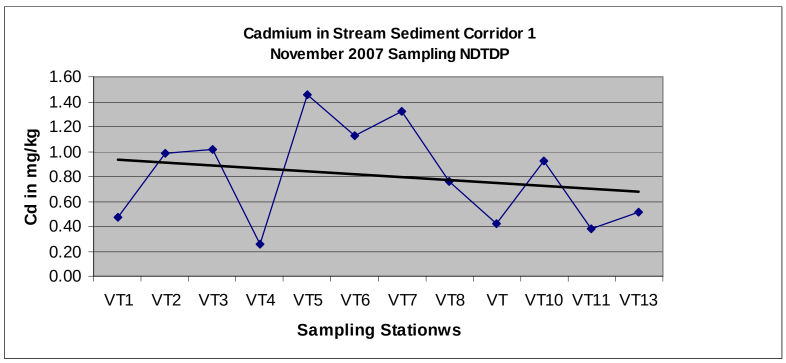


Figure 4-17. Aluminum in Stream Sediments of Corridor 1

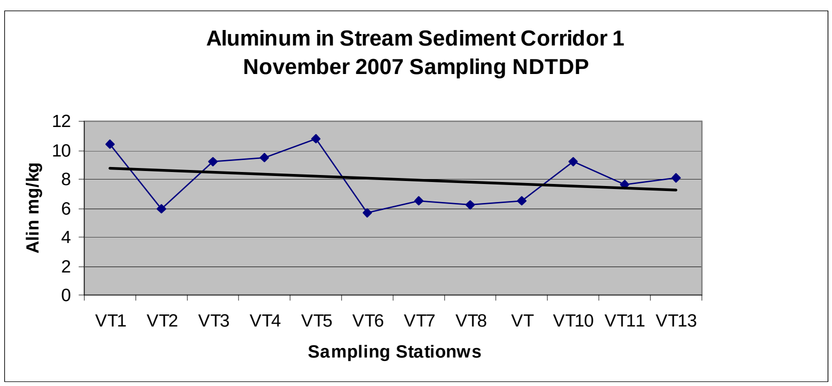


Table 4-13. Stream Sediment Quality of Rivers of the Red River Delta, November and December 2007 Sampling

Sta. #	River / Dredge Area	pH	Al (mg/kg)	Fe (mg/kg)	As (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Hg (mg/kg)	Oil (mg/kg)
CORRIDOR 1										
VT1		7.36	10.44	41623.24	9.68	0.47	49.62	67.14	0.17	ND
VT2	Red R Port	7.22	5.94	35201.76	12.43	0.98	51.32	56.08	0.46	ND
VT2	Viet Tri Lake	7.21	5.46	37431.21	11.26	1.05	53.19	62.21	0.15	ND
VT3	Red R	7.21	9.18	45491.50	16.36	1.02	69.74	68.92	0.24	ND
VT4	Red R	7.22	9.45	42675.36	15.58	0.26	110.53	71.06	0.21	ND
VT5	Red R	7.35	10.80	39642.60	16.32	1.46	106.58	75.34	0.32	ND
VT6	Red R	7.50	5.67	29569.48	10.89	1,13	34.21	59.50	0.41	ND
VW 1	Red R	7.25	3.037	1.995	7.25	.65	29.33	17.562	0.15	
VT7	Doung R	7.61	6.48	30435.98	11.73	1.32	47.37	58.22	0.12	ND
VW2	Duong R/Trung Mau									
VT8	Duong R	7.56	6.21	36826.46	9.24	0.76	39.47	57.36	0.25	ND
VW3	Duong R/Den/Nhgia Chi									
VT9	Duong R	7.66	6.48	21121.06	8.32	0.42	31.58	52.23	0.62	ND
VW4	Duong R/Chi Ni/Dai Lai									
VT10	Duong R	7.51	9.18	36501.52	13.07	0.92	76.32	66.78	0.15	ND
VW 5	Thai Binh /Than shoal	7.16	2.885	1.645	6.08	.40	26.45	19.386		
VW 6	Kinh Thani R /Lau Keh	7.46	3.240	1.715	6.85	.75	27.62	26.764	0.25	
VT11	Kinh Thai	7.60	7.63	39317.66	9.39	0.38	64.47	69.35	0.23	ND
VW 7	Kinh ThaiKM18	7.09	3.240	1.856	7.56	**0.89**	28.550	22.487	0.18	
VW8	Kinh Thai/Tien Xa									
VW 9	Kinh Thai/Km24-25	7.10	2.970	2.625	8.78	**0.95**	28.568	28.568	0.25	
VW10	Kinh Thai/Ken Giang									
VW 11	Kinh Thai /Ben Trieu	7.14	7.560	5.704	11.88	0.3	67.97	42.726	0.20	
VW12	Kinh Thai /Kinh Chu									
VT13	Kinh Thai /Nhat Shoal	7.51	8.10	35743.33	9.67	0.51	75.00	68.07	0.34	ND
VW13	Han R									
VW 14	Han R	7.16	8.370	5.422	12.56	0.65	64.56	38.272	0.15	
VW 15	Han R	7.10	7.155	4.795	10.42	1.05	52.35	46.868	0.2	
VT12	Thani Binh	7.49	9.45	38776.09	10.76	0.66	90.79	73.20	0.62	ND
	Dutch Standard (Reference value)				29	0.80	85	100	0.3	

Note: Yellow shaded Rows- represent sediment quality from proposed dredging areas in Corridor 1

Figure 4-18. Spatial Variation of Chromium in Stream Sediment of Corridor 1

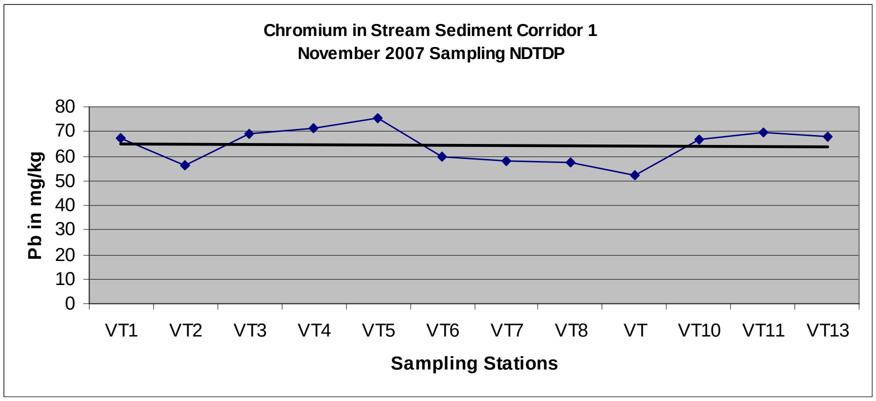
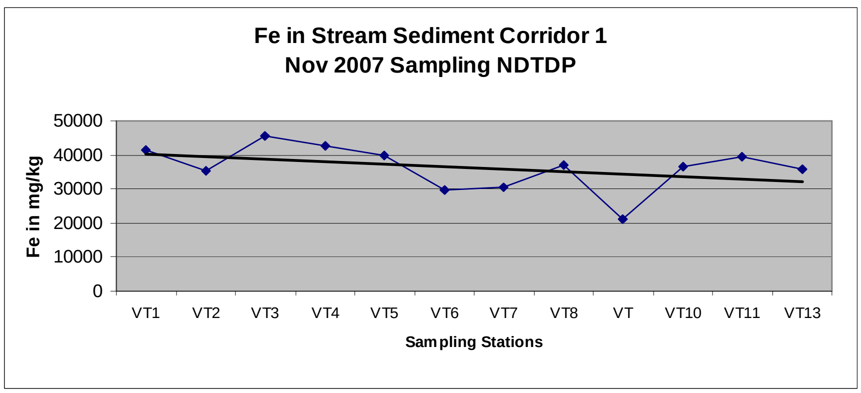


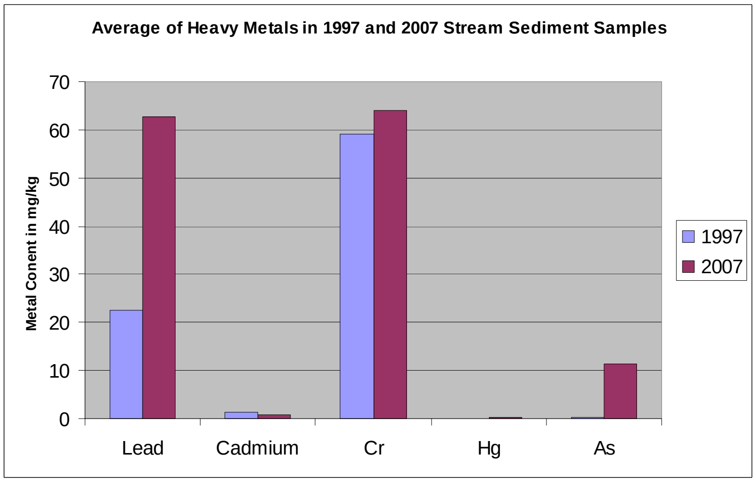
Figure 4-19. Spatial Variation of Fe in Stream Sediment of Corridor 1



4.3.7 Temporal Analysis of Stream Sediment Quality

A tentative comparison of the averages of the heavy metals in the 1997 (n=15) and 2007 (n=29) river sediment sampling shows that heavy metals in the 2007 are higher than the 1997 except for cadmium (**Figure 4-20**).

Figure 4-20. Comparison of Average Concentrations of Heavy Metals in 1997 & 2007 Stream Sediments



4.3.8 Coastal Geomorphology

The tidal flats, beaches, beach ridges, mangrove marshes, tributaries and tidal channels are the landforms in the coastal area. The delta front is a gentle plain and the bottom sediments are pink - brown consisting of fine silt and clay.

The prominent features of the coastline of the Red River Delta are karst islands formation in Halong Bay in the northeastern most corner of the Red River Delta. Along the coast of Halong southwards to Bach Dang estuary is an extensive mangrove swamp which has now been converted into shrimp ponds. The same condition prevails in the Do Son-Thai Binh estuary. Southwards, from Van Uc to Thai Binh estuary, the shrimp ponds are fringed by a belt of reforested mangrove.

Further south of the Thai Binh estuary is the Ba Lat estuary at the mouth of the Red River. The mouth of Red River or Ba Lat is an extensive formation of tidal mudflats. The mudflats closest to the mainland are now cleared of mangrove vegetation and are now used for aquaculture.

A significant stand of mangrove is still present in the outer mudflats. A strand of sandbar, approximately 14 kilometers long has formed at the northern side of the estuary and a southern sand bar of about 11 km long fringes the mudflats south of the mouth of Ba Lat River. Active deposition at the mouth of Ba Lat River is causing the progradation of this part of the coast of Red River Delta.

Southwards from the Ba Lat Estuary, the shoreline is generally straight being protected by a system of sea dike. This shoreline terminates at the Lach Giang estuary and the Day River Estuary. Mudflats have formed at the mouth of the Day River. These mudflats are still vegetated by mangroves and mangrove associated plant species. Active deposition is taking place at the mouth of Day River, causing the seaward progradation of the river mouth.

Near coast dispersion of the sediment plume at the mouth of Ba Lat R, Ninh Co and Day R is induced by tidal flow, freshwater outflow and surface wind. Tran Duc Thanh (undated) described that the during the NE monsoon season from October to April, the NE and N wind prevails with average speed of wind is 3 - 4m/s. The northerly and northeasterly wind occurs prevails with a 70 - 80% frequency from December - January.

During the SW monsoon, May -September, the average speed of wind is from 4 to 5m/s with the prevailing wind direction of southerly and southeasterly directions. A series of Landsat imageries (**Figures 4-21** to **4-24)** of the Lach Giang shows the plume dispersion during different seasons.

Haskoning's analysis of the coast from Ba Lat to Cau Day showed that tidal currents along the coast result in a longshore sediment transport. The layout and development of Lach Giang, which is essentially a spit formation, indicates a net sediment transport along the south-easterly direction. The same process is responsible for the transport of Ninh Co's sediment into the tidal flats of Cua Day. The understanding of this coastal geologic process is important in the design of the Lach Gian By-pass Channel.

4.3.9 Coastal Erosion and deposition

Erosion and deposition of the coast of the Red River Delta was studied by Tran Duc Thanh et al. (1994). The study indicated the shoreline accretes at the average rate of 25 m per year, with a maximum rate of 120 m per year in some area. However, in certain segments of the coast, erosion is the predominant process. Tran Duc Thanh et al. (1994) have identified these areas.

Severe erosion prevails in the Cat Hai (Cat Hai – Do Son part) and Hai Hau (Ba Lat – Lach Truong part).About 6 km of the coast of Cat Hai – Do Son has experienced shoreline retreat at the rates of 4.5 m/year to 13 m/year during the period 1930-2000. The 30 km long Vanly coast which include Hai Hau site was eroding in the past, but the construction of the sea dikes reduced the erosion susceptible area to 17.2 km.

Figure 4-21.Landsat Imagery of the Day-Ninh Co R Estuary showing sediment plume 's northeasterly dispersion during the rainy season. Imagery date is 2002 Jul 12.

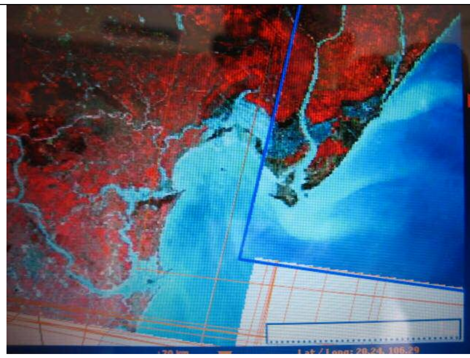


Figure 4-22. 2003 rainy season imagery of the Day-Ninh Co Estuary showing the same northeasterly sediment dispersion pattern. Imagery acquired 2003 July 15.

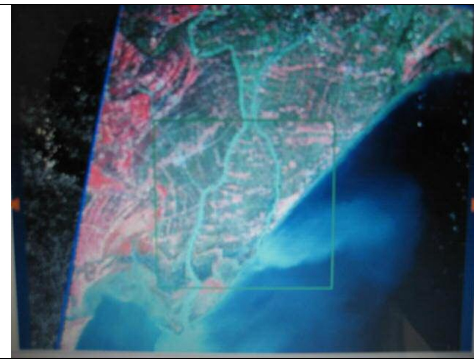


Figure 4-23. End of dry season imagery of the Day-Ninh Co River mouth showing the slow / low dispersion of sediment plume.

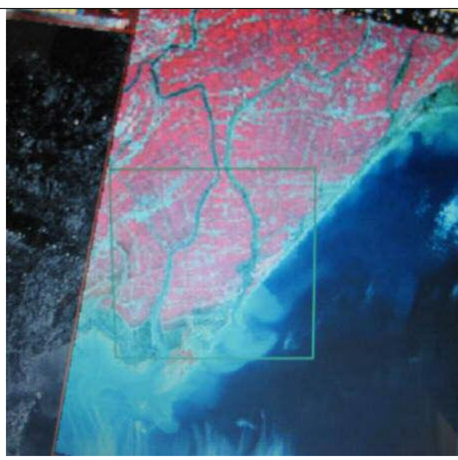
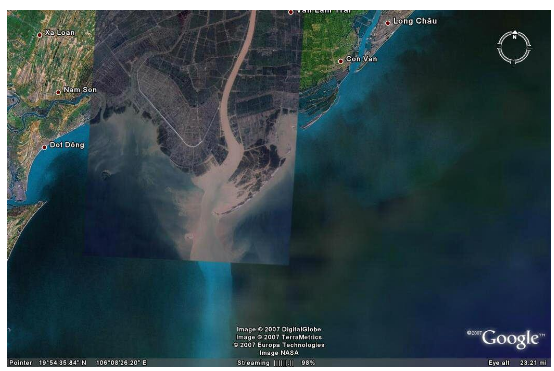


Figure 4-24.Imagery of the Day-Ninh Co River mouth, of unknown date, showing a southerly pattern of sediment plume dispersion, presumably due to a dominantly south flowing littoral drift, driven by a northerly wind[3]



4.3.10 Oceanography

The oceanographic characterization is adopted fromTran Duc Than, et al. (1994). The large-scale flow patterns in the Gulf of Tonkin are dominated by tidal and monsoon currents. The tidal regime of the Gulf of Tonkin is diurnal with a range of 4 m in the north to 2 m in the south. The tidal waves enter the Gulf of Tonkin from the South China Sea and are partly reflected in the northern enclosure of the Gulf. With a length of

[3] Conventionally, reference for wind direction is its point of origin

approximately 500 km and a depth of 50 m, the resonance time of the basin is 25 hours, which is close to the period of the diurnal tides.

The tidal range at the mouth of the Ba Lat varies from 0.5 m during neap tide to 2.5 m during spring tide. The Gulf of Tonkin is connected to the South China Sea which has strongly seasonally varying residual currents forced by the monsoonal wind patterns. While the large-scale flow patterns in the South China Sea correspond to the general wind patterns (southward flow during the NE monsoon, and northward flow during the South monsoon), the circulation patterns in the Gulf of Tonkin are not that obvious. Southward flow dominates near the coastline of the Red River Delta during the NE monsoon (dry season), when the residual flow in the Gulf of Tonkin can be described by the anti-clockwise rotating cell. During the wet season, however, there are 2 circulation cells, which seem to diverge near the coastline of the Red River. As a consequence, in the wet season the residual flow velocity near the Red River is probably weaker and, although primarily directed southward, more variable in direction than during the dry season.

Wind velocities during the dry season are higher than during the wet season, generating higher waves (significant wave height Hs around 1.4 m) in the Gulf of Tonkin relative to the wet season (Hs below 1 m). However, the most pronounced seasonal difference is probably the frequency of occurrence of significant wave heights: Hs is up to 3 m during 10% of time in the dry season whereas Hs is only 2 m during 10% of time in the wet season. In the North of Vietnam, typhoons mainly occur in August and September, during which the significant wave heights in the northern Gulf of Tonkin approach 6 m and the storm-related water level set-up can be up to 3 m (Tran Duc Thanh et al., 1997). It is noteworthy that the most sediment is supplied to the Gulf of Tonkin when wave energy is low. This means that freshly delivered sediment is probably able to settle from suspension in a relatively quiet environment, while redistribution of sediment is expected several months later. This suggests that sedimentation patterns from the buoyant plume are relatively unaffected by wave action, and freshly deposited sediment is able to consolidate. Because consolidated fine sediments are able to resist greater wave-related shear stresses, this phase difference between deposition and subsequent reworking may promote the seaward growth of the subaqueous delta front.

4.4 Biological Status of the Red River Delta

4.4.1 Terrestrial Ecosystems

Natural forests within the project region and peripheral areas are distributed in mountains and hills in the provinces of Phu Tho, Vinh Phuc, Ha Tay, Ninh Binh, Quang Ninh, and Hai Duong. From the altitude of 700m upwards the prevailing forest types are: tropical wet evergreen forest; semi-deciduous forest with dry and rainy seasons; and forest on limestone mountains. In the regions with elevation lower than 700m, forest types may include low mountain subtropical wet evergreen forest, coniferous – broad-leaved forest, forest on limestone mountains and on granite mountains.

Forests in the basin of the Da River (Ha Tay, Phu Tho) have the species composition typical for the Northwest of Vietnam, being rich and abundant with valuable wood (*Pentace tonkinensis*, *Chukrasia tabularis*, *Garninia fragraeoides*, *etc*) and medicinal plants *(Bulbous aralia*, *Polygonum multiflorum*, *etc*.). Quangninh province currently has 150,000 ha of forest with the dominance of semi-deciduous and deciduous forests and with precious wood such as *Garnicia fragraeoides, Pachudia cochinchinensis, Pinus merkusiana* and some subtropical species such as *Castanea vulgaris and Castania, etc.*

The groups of high values include anise, cinnamon in Quangninh, elemi and pine in Hoabinh; The oil containing group including *Vernicia montana* is found in Nammau, Binhlieu, Tienyen and Mongcai (Quangninh); many precious woods are gathered in Halung forest (Hoanhbo); The fast growing species includes *Castania, canarium, Liquidambar, etc*. in Chilinh (Haiduong); the group of medicinal and edible trees is also diverse.

One important terrestrial ecosystems present in the Red River Delta region is the lowland rain forest. WWF (http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0141_full.html) delineated the extent of this ecosystem from the freshwater swamp forests of the Red River Valley south along the north-central coast of Vietnam to the region south of Tam Ky. This ecosystem is reported to be seriously degraded with less than 10 percent of the native vegetation remains. The among the remaining patches of this ecosystem is best preserved in the Cuc Phuong and Pu Mat National Parks. At Cuc Phuong, 1,800 vascular plant species have been described for a small area with limited topographic diversity.

The climatic condition that prevails in this ecosystem characterized by high rainfall and short dry season produced conditions that once supported diverse wet evergreen forests. Primary wet evergreen forest consists of a dense, three-tiered canopy reaching 25-35 m and occasionally 45 m height in undisturbed sites. The upper canopy is dominated by a species of *Hopea*, *Castanopsis hystrix*, and *Madhuca pasquieri*. The fan palm *Livistona saribus* is a common subcanopy species in small gaps.

Although much of the ecosystem's biodiversity has been lost, it still harbors several mammals and birds of conservation significance, including the Owston's banded civet (*Hemigalus owstoni*), white-cheeked gibbon (*Hylobates leucogenys*), red-shanked douc langur (*Pygathrix nemaeus*), and Francois's leaf monkey (*Semnopithecus francoisi*). One endemic bat species is found here (*Paracoelops megalotis*l). There are more than 300 bird species in this ecoregion, including three near-endemic and one endemic species (**Table 4-14**).

Table 4-14. Endemic and Near-Endemic Bird Species.

Family	Common Name	Species
Phasianidae	Annam partridge*	*Arborophila merlini**
Phasianidae	Edwards's pheasant	*Lophura edwardsi*
Timaliidae	Short-tailed scimitar-babbler	*Jabouilleia danjoui*
Timaliidae	Grey-faced tit-babbler	*Macronous kelleyi*

4.4.2 Vegetation of Corridor 1

The predominant terrestrial ecosystem in the Red River Delta, particularly in Corridor 1, is the agro-ecosystem with much of the land area converted to agricultural use. Paddy rice cultivation is the most dominant agricultural feature in the low lying areas of the delta.

The floodplains and river banks bordering the waterways that will be improved in Corridor 1 is dominantly agricultural. Aside from rice, among the crops identified in various parts of Corridor 1 include corn (*Zea mays)* cassava (*(Manihot esculanta crantz)*, sweet potato (*Ipomoea batatas)*, banana (*Musa paradisiacal)*, sugar crane (*Saccharum officinarum)*, etc. The listing of plant species identified in the different areas of Corridor 1 is presented in **Appendix 1**.

4.4.3 Aquatic Flora & Fauna Red River Delta

The main source of secondary information on the aquatic flora and fauna of the Red River Delta is the study by Vung Trung Than et al. (1987).

Phytoplankton

Phytoplankton are the most important primary producers. The foundation of the food web, they transform light and nutrients into energy for herbivores such as zooplankton which, in turn, support higher trophic levels. Phytoplankton grows best in low velocity waters with warm temperatures and high nutrient availability, particularly phosphorus. Phytoplankton growth is generally limited in stream or riverine systems, which have much greater flow velocities. A relative increase in species diversity or richness under unchanged conditions is taken as an indicator of of improving water quality condition. Conversely, the preponderance of a certain species like the blue green algae is an indicator of poor water quality. To evaluate the importance of phytoplankton as a food source, the volume or quantity of algae available for consumption is often the most critical parameter to be considered. For this reason,phytoplankton data is typically expressed in terms of chlorophyll *a* concentration (□g/L) overall biovolume (i.e., □m³/mL), or population densities (i.e., cells/mL) as well as species composition (USACE 2002)

The phytoplankton community of the Red River Delta has a diverse species composition including 183 species dominated by Diatomae, which make up 86.1% of total species. Some genera with numerous species are *Chaetoceros* (28 species), *Coscinodiscus* (18), *Rhizosolenia* (14), *Ceratium* (9), *Navicula* (8), and *Melosira* (6).*Skeletonema costatum* and some representatives of *Pennateae* are often abundant in the upper regions of the estuary where salinity is below 15 0/00.

According to Vu Trung Tang, in terms of the annual cycle, phytoplankton development changes between two seasons: declining rapidly during flood peak months (July - August) and increasing in the dry season. In July-August, the phytoplankton density ranges from 800 to 362,000 cells/m^3 and the mean biomass is 130 g/m^3. Later (October - November) phytoplankton explodes in number, reaching a mean density of 973,000 cells/m^3 and a mean biomass of 470 g/m^3. At the end of the dry season, the phytoplankton development decreases slightly, as a function of a decline in nutrients in the estuary, to a mean density of 368,000 cells/m^3 and biomass of 309 g/m^3. Frequently, phytoplankton develops intensively near the Red River mouth in waters shallower than 20 m where it is controlled by tidal action. Phytoplankton density and biomass increase when the tide is high and decrease when the tide falls, reaching extremes at the times of highest and lowest tides.

Zooplankton community

The Bac Bo estuarine area supports a rich and diverse zooplankton. A total of 185 species have been recorded, including Copepoda (107 species), Cladeocera (14), Siphonophora (8),Chaetognatha (8), Amphipoda (6), Tunicata (6), Protozoa (5), Ostracoda (4), Pteropoda - Heteropoda (3), Rotatoria (2), Cumacea (2), Sergestinae (1), Euphausidae (1) and Nauplius (18). Like the phytoplankton, the zooplankton is divided into three ecological groups, (a) freshwater, (b) estuarine, (c) euryhaline-marine. Fresh water fauna often appears in the upper parts of the estuary and is abundant in number, especially the wet season and at times of neap tide. Contrastingly, euryhaline-marine fauna occurs near the end of the estuary, is richest near Spring tide and in the dry season.

Zooplankton density and biomass vary between 6,130 - 15,500 individuals/m^3 and 240 - 370 g/m^3 respectively. Lowest values are in flood months, but high values are in the dry season (Khuc Ngoc Cam, 1975; Nguyen Van Khoi *et al*, 1980), especially at times of highest tide and during the period from midnight to 5-6:00 am.

Zoobenthos community

The biomass of zoobenthic animals used as food by other species varies over a wide range from 4 - 96 g/m^3 in the dry season and 5.9 - 11.5 g/m^3 in the wet season (Dang Ngoc Thanh *et al.*, 1991).

Zoobenthic community in the tidal mud flats includes 130 species, representing some principal groups such as Polychaeta (34 species), Gastropoda (16), Bivalvia (23), Macrura (17) Brachyura (38). Many of these species are economically important, for example *Ostrea*, *Meretrix*, *Aloides*, *Macta*, *Netica*, *Sanguillaria*, *Penaeus*, *Metapenaeus*, *Palaemon*, *Scylla*, *Portunus*, etc.

Fish fauna

According to Vung Trung Tang (1987), a total of 233 fish species have been identified in the estuary of the Red River Delta belonging to 71 families and 18 fish orders. The families with numerous species are Carangidae (11 species), Cynoglossidae (14), Gobiidae (13), Leiognathidae (11), Sciaenidae (11), Teterodontidae (11), Clupeidae (9), Engraulidae (9) and Mugilidae (6). Some fresh water fish of the families Cyprinidae and Bagridae often occur in water with salinity below 10-12 PSU in the upper regions of the estuary. The representatives of some Priacanthidae, Pomacentridae, and Chaetodontidae are frequently found near coral reefs and some offshore juvenile fish also penetrate estuaries for feeding such as Elasmobranchia, Exocoetus, Sphyraena, Formio, Stromatoidae, and Scombridae.

Despite the mixed origin, estuarine fish fauna of the Bac Bo Delta are related to the Tonkin Gulf fish fauna. Most representatives originated from tropical seas and have adapted to high salinity fluctuations occurring in the estuary (Vu Trung Tang *et al.*, 1987).

The fish fauna of this area may be divided into four ecological groups (a) freshwater, (b) euryhaline-marine (c) true estuarine and (d) regularly anadromous migrants such as *Clupando theissa* and *Hilsa reveesii.*

4.4.4 Fish Fauna of Corridor 1

The fish survey done by the *Phan Mach, Institute of Ecology and Biological Resource in December 2007* describes the fish species that occur in the waterways of Corridor 1 such as the Red River, Cau R and Thai Binh River.

Cau River

89 fish species of 6 orders, 20 families have been recorded in the Cauriver basin. Most of them are native ones, only *Trichogaster Trichopterus*, *Oreocronis niloticus and O.mossambicu* are exotic (from other countries). Most of species belong to carp family (50% of the total species number). Two species are listed in the Vietnam Red Book (2000): *Onlychostoma laticeps* (Vulnerable) (C¸ SØnh in Vietnamese) and *Squaliobarbus curiculus (*Threatened). Twelve of the fish species in Cau River are cultured.

Red River

Along Red River from Viet Tri to the estuary about 64 fish species have been identified of these 12 species are cultured. Three fish species of the Red River are listed in the Vietnam Red Book (2000): *Clupanodon Thriss*a (Linnaeus, 1758) (Vulnerable - level), *Squaliobarbus curriculus (*Threatened - level), *Hemibagrius elongatus* (Giinther) (Vulnerable - level).

Thai Binh river

Sixty-two species have been recorded in this river from Pha Lai to the estuary. Fifty (50) are naturally occurring and 12 are cultured. Two species are listed in the Vietnam Red Book (2000): *Clupanodon Thrissa* (Linnaeus, 1758) (Vulnerable - level) and *Squaliobarbus curriculus* (Threatened - level).

Photo 4-6. *Hemiculter leusisculus* one of the euryhaline fishes of the Red River	**Photo 4-7** *Varuna litterata*, brackish water crab caught in Kinh Thay River
	

The list of fish species of the Red River Delta is attached as **Appendix 2.**

4.4.5 Seasonality of Some Biologic Processes in the Red River

The spawning season of the various aquatic fauna of the Red River Delta is not totally known. However, for some of the important species such as the *Squaliobarbus curriculus* the reproductive season starts from late April to early August, with the best season from May to July (Long Huang Gua, 2004). While other fauna such as freshwater crabs and shrimps coincide with the monsoon season. This is presumed to be due to the availability of increased of habitat (e.g inundated floodplain) for hatchlings in large rivers swollen by monsoonal rains (Dudgeon, 2000). **Table 4-15** summarizes the known seasonal processes of some aquatic life of the Red River Delta.

Table 4-15. Matrix of season and documented seasonality of biologic processes of Red River

Biologic Processes	J	F	M	A	M	J	J	A	S	O	N	D
Rainy Season/Flood												
Peak Zooplankton												
Peak density & biomass phytoplankton												
Peak density & biomass Zoobenthos												
Reproductive season, *Squaliobarbus curriculus* (Long Huang Gua et al. 2004)												
Reproductive Season freshwater shrimps & crabs (Dudgeon 2000)												

4.4.6 Mangrove Ecosystems of the Red River Delta

Dykes have been constructed along most part of the river system and coastline of the Northern Delta for protection against flooding. Only a narrow strip of inter-tidal sand or mud flat beyond the dykes, except near river mouths where deposition is very active and mud flats and sandy islands are expanding due to influx of sediment. Several sandy islands evolved due to accretion including the islands that now make up the Xuan Thuy Nature Reserve. Coastal vegetations, i.e. mangrove are represented by small shrub like trees, apparently an adaptation to the prevailing harsh environment, e.g. climatic conditions. Mangrove replanting along the coast of the Red River delta covers about 7,400 hectares of plantations of *Kandelia candel.* While exotic species *Casuarina equisetifolia* is planted on sandy beaches and dunes.

In places where conditions are favorable for mangrove development, i.e. sheltered, presence of large portion of freshwater and sediments the mangrove stands flourish. This is true for the stretch of the coastline from Do Son Cape to the northern bank of Van Uc River where mangrove communities consist of *Sonneratia caseolaris* and associated mangrove species *Aegiceras corniculatum* and *Acanthus ilicifolius.* In some areas Cyperus malaccenis replaces the *Acanthus ilicifolius* or grows in mixed stands. Prevalent shrimp pond construction has severely reduced the area covered by *Sonneratia*.

In areas where accretion is very active such as the coastline from Van Uc estuary to Lach Troung, the area is open, flat with large swamps and rich in alluvium. The area is exposed to storms and hence not suitable to mangrove growth except in the estuaries of Ninh Co and Tra Ly rivers. Mangrove and mangrove associated species in this area include *Aegiceras corniculatum, Acanthus ilicifolius, Kandelia candel Sonneratia caseolaris.*

In swamps where low salinities prevail the following plant species are present: C*yperus stolononiferus; C. malaccencis, C. tegitiformis, Scirpus aff. Runcoides; Phragmites karka; Myriphyllum spicatum ; Najas kingii; N. indica; Paspalum vaginatum.*

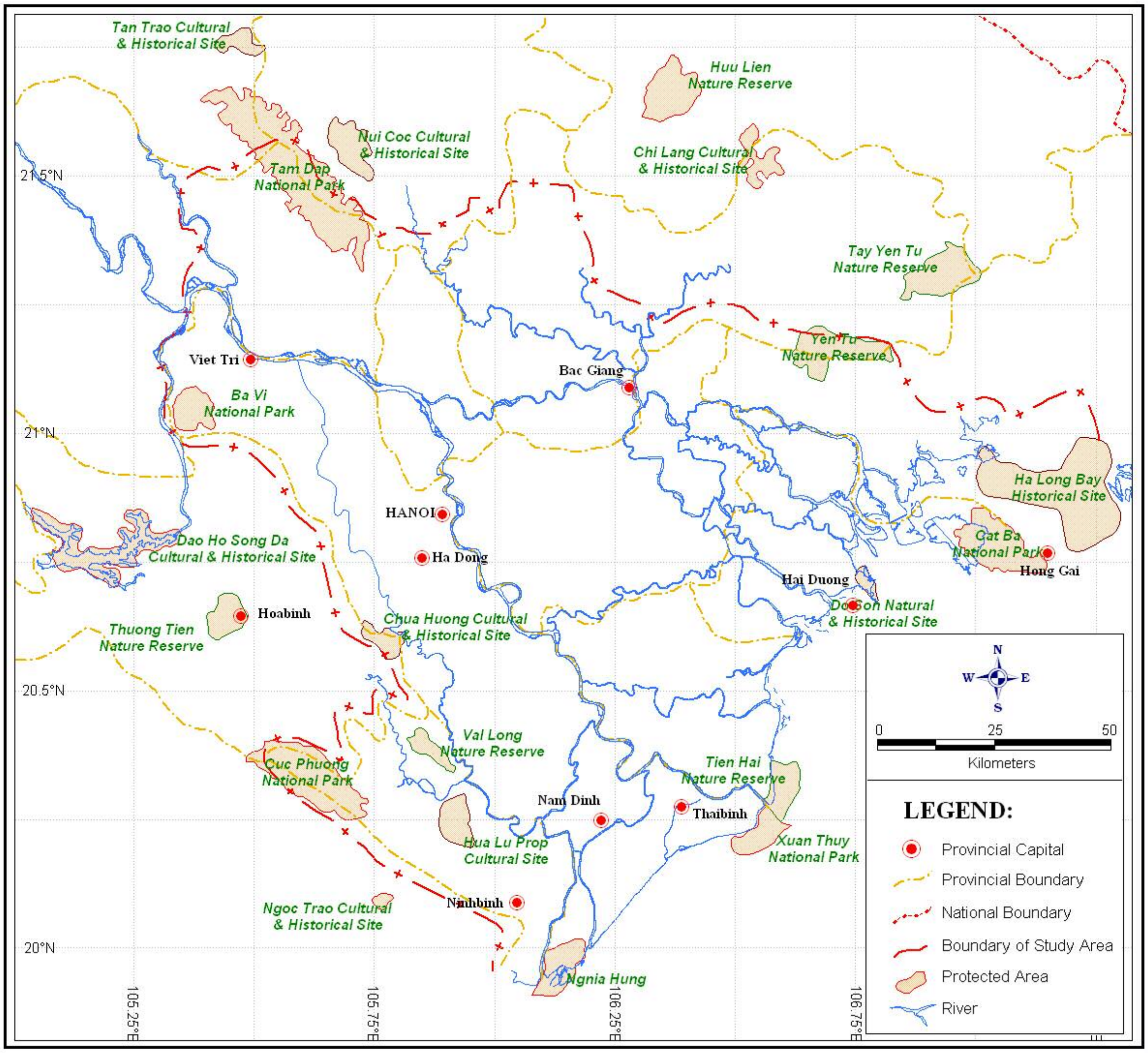
The mud crab, *Scylla serrata*, is the most common crab species in the mangrove swamps and on the tidal mudflats of the Project Area. Other crabs, characteristic of these coastal habitats, are *Uca* and *Portunus* species, *Ocypoda ceratophthalma, Sesarma plicata* and *S. bidens*.

No coral reefs are present along the coast of the Red River Delta. This is presumed to be due to unfavorable condition such as low salinity, high sediment input among others. Seagrass, however are reportedly present in the shallow waters along the coast. are *Ruppia maritima* and *Halophila ovalis*. Seaweeds, recorded from the coastal waters are, amongst others, the Chlorophyta *Chaetomorpha linum* and *C. capillarris* and various *Enteromorpha* species, and the Rhodophyta *Gracilaria asiatica* and *G. tenuistipitata*, and *Gigartina intermedia* and *Ceramium tenuissimum.*

4.5 Protected Areas - Biodiversity Protection and Conservation

The Vietnamese Government has embarked on a biodiversity conservation program. As part of this program it has declared protected areas. A number of the protected areas are located along the coastal zone, along the coastline of the Red River Delta. The locations of these protected areas are shown in **Figure 4-25.** A brief discussion of some of the more prominent protected areas in the study region is presented in the following sections.

Figure 4-25. Protected Areas in the Red River Delta



4.5.1 Cucphuong National Park

This protected area straddles 3 provinces, namely Ninh Binh, Hoa Binh and Thanh Hoa, has typical features of wet tropical forests. It is influenced by monsoon with 3 wood layers , 1 shrub layer and 1 forest floor. The 35-40m high wood layer includes *Parashorea, Ficus retusa, Dracontomelum duperreamum, Sapindus oocarpus, Amoora gitantea, etc.* The 30 m high wood layer includes Castanopsis, etc. In thin broad-leaved forests in limestone mountains of Tamdiep, Hoalu and Giavien, etc. there are wood species such as *Pentace tonkinensis, Chukrasia tabularis, Garninia fragraeoides, etc*. and species of Orchidaceae, Dioscoreaceae, Nephrolepsidaceae, etc. The species composition is very diverse. In primeval forests more than 2,000 species of 221 families, 987 branches are observed. Forests on limestone mountains have 1,937 species, 229 families of 4 orders.

4.5.2 Catba National Park

The Catba Biosphere Reserve includes 13,200 ha of forests (accounting for 60% of the surface area of the island). That is tropical evergreen rain forest. Forests on limestone mountain sides have wood trees such as *Allospondias lakonensis*, Proteas. Particularly, in the pure forest at Trungtrang the precious and rare *Nageia fleury* is found. The total number of vegetation species observed in Catba is 839, belonging to 498 branches, 169 families (Tran Ngoc Ninh, 1997).

This protected area has have 38 mammal species of 9 phyla, 17 families with rare and specious ones such as *Trachypithecus francoisi poliocephalus, Macaca artoides, Macaca mulata, Felis bengalensis, and Panthera pardus, etc*.

Presently forests are shrinking in acreage, wood reserve and biodiversity as a result of overexploitation, not to say annual fire as well as shifting and wandering custom of some ethnic minorities.

4.5.3 Cucphuong National Park,

This park has a very rich species composition with many rare and endemic ones. There are 60 species of wild animals, 4 entomophagous species, 18 dermoptera species, 1 manis species, 3 primate species, 15 rodent species, 15 carnivorous species, 4 artiodactyl species with rare and precious species such as Pyganthris nemareus L., Panthera pardus, Selenarctos thibetanus, Antelope, deer, *Capreolus capreolus*, *Herpestes, Mustella*. One hundred forty (140) bird species are known to inhabit the park, including the noteworthy species such as *Pavo muticus imperator*, *Lophura diardi*, nightingale, *Motacilla flava* flava. Thirty-six (36) reptile species including *Gecko gecko* L., *Varanus nebulotus*, *Morelia, Bungarus*, *Ancistrodon conotortrix*, *Tropidomotus natrix* and 20 amphibian species, mostly toad and frog have also been identified.

The protected areas that are of concern to the NDTDP are the wetland protected areas found along the coastal zone of the Red River Delta. These protected areas are presented in the following sections. The source of information is the Sourcebook of Existing Protected Areas in Vietnam, 2nd edition.

4.5.4 Nghia Hung Proposed Nature Reserve

The site covers 12 km of coastline, bordered by Day River to the west and by Ninh Co River to the east. Landforms include sandy beaches, dunes and salt marsh. Aquaculture ponds are found to the west. Outside the main dyke, there is an intertidal area of about 3,400 hectares. Offshore, about 5 kms away are two small sandy islands covering 25 ha. One island support dunes while the other supports a salt marsh. Nghia Hung supports 13 different habitats and is one of the most diverse areas in the coastal zone of the Red River Delta

It supports a number of globally threatened or near-threatened waterbird species such as the Spotted Greenshank, Asian Dowitcher, Spoonbilled Sandpiper, Chinese Egret and Black faced Spoonbill among others. It qualifies as an Important Bird Area.

Figure 4-26. The imagery gives a bird's eye-view of the Ngiah Hung Proposed Nature Reserve in the Estuarine of the Day and Ninh Co Rivers.

4.5.5 Xuan Thuy National Park

This protected area is located in the province of Nam Dinh. It has a total area of about 7,100 hectares. It was decreed by Government as a protected area on 05 Sept 1994.

Xuan Thuy National Park is located in the coastal zone of the Red River Delta, at the mouth of the main channel of the Red River, known as Ba Lat River. Site consists of 3 islands. The largest is occupied by aquacultural ponds, the second contains mangrove and well as coastal marshes and a small aquaculture pond. The 3rd island is still accreting because of active deposition. Maximum elevation of the protected area is 3 m asl. It Supports 14 habitat types, both natural and man-made ones. Habitat types with highest biodiversity values are the undisturbed mudflats and natural mangroves, dominated by *Kandelia candel*.

This is an important winter staging area for migratory water birds. Eight species of globally threatened and near threatened birds regularly occur in the protected area. Xuan Thuy supports the largest wintering population of Black-faced Spoonbill in Vietnam. Xuan thuy qualifies as an Important Bird Area.

4.5.6 Tien Hai Nature Reserve

This protected area is located in the province of Thai Binh. The protected area occupies an area of about 12,500 hectares. It was decreed as a protected area on 05 September 1994. the nature reserve is located at the mouth of the Red River, immediately north of Xuan Thuy. It consists of 2 sandy islands, Vanh Island with an area of 2,000 ha and Thuy which has an area of 50 ha. Vanh Island is separated from mainland by a deep channel. The banks of Vanh are covered by mangrove, most of which is enclosed by ponds. It supports 12 habitat types, most important are sand dunes, reedbed and mangrove. Intertidal mudflats are important habitat for feeding shorebirds. This reserve forms the Northern extension of Xuan Thuy Nature Reserve.

Figure 4-27. Overview of the Xuan Thuy National Park and the Tien Hai Nature Reserve

4.5.7 Thai Thuy Proposed Nature Reserve

This proposed nature reserve is located in the province of Thai Binh and occupies an area of 13,696 hectares. It is bordered by Tra Ly River to the south and by the Thai Binh River to the north. The proposed reserve is bisected by the Diem Ho River. To the south of Thai Binh River mouth are extensive areas of mudflats. To the west are salt pans and adjacent to Tra Ly is a region of aquaculture ponds. It contains the largest remaining tract of old-growth mangrove forest in the Red River Delta. About 400 hectares of natural mangrove forest dominated by *Sonneratia caseolaris* remains at Thai Thuy. Most of the mangrove forest consists of plantation of *Kandelia candel*. The mangrove plantation is about 2,888 ha.

The proposed reserve supports 4 main habitat types and it supports several globally threatened and near threatened waterbird species over winter and on passage.

4.6 Natural Disasters and Environmental Incidents

<u>Storms and tropical Low Pressures</u>

According to statistics from 1980 to 1997, 26 storms have affected the provinces in the Northern Delta. The highest wind speed experienced during such condition was greater than 50m/s during the occurrence of Typhoon Wendy in 9 September 1968. During the of 1996 to 1999, the number of storms and tropical low pressures declined with 12 occurrences in 1996, 5 in 1997 and none in 1998 and 1999 as influenced by El Nino phenomenon The second storm in 1997 caused heavy rain and strong wind that affected almost all the provinces in the region. Wind was measured at 25 m/s with gusts of over 26 m/s to 35m/s. In 2007, 3 storms hit the coastal provinces of Ninh Bbin and Nam Dinh.

<u>Flood and Water-Logging</u>

Historical data shows that in the second half of the last century, floods of the Red River are more severe and with shorter return-periods. Floods in 1971 1945, 1969 and 1996 have the peaks of 14.8m, 13.22m and 13.38m, respectively. That is higher or equal to the usual flood level of 13.6m in Hanoi. The 1971 flood, with return period of 200-250 years and the 1945 flood with return period of 100 year are among the big floods. These floods are almost equivalent to 1,000 year floods with flow rates of rate of 45,000-51,000m3/s. This flow rate is 1.19-1.35 times the flow rate of the in 1971 flood as measured at Son Tay.

Most regions in the Northern Delta are protected by dikes but elevation of the dikes varies. When dikes are overtopped by floodwater, the areas must be drained by pumping. During the 4^{th} storm in 1996, although the wind is of grade 9 to 10 only, a storm surge occurred which almost overtopped the dikes of Hai Phong, Thai Binh, Nam Dinh. Overtopping and breaching of the dikes will have disastrous consequences on the economy of the region.

In 1998, heavy rain and rising water flew over and broke the dike of Dabac district, sweeping away many houses and schools at Tienyen (Quangninh). About 1000 meter of the sea dike was breached and damaged causing extreme traffic jams. Recently (1995-1999), flash floods frequently occurred at Tanlac district, (Hoabinh) with higher frequency and worse destruction. The regions of Nhovien and Nhoquan (Ninh Binh) have been damaged by flash floods of the Hoanglong River. Particularly, the flood in early October 2007 caused water logging over thousands of hectare and houses in districts of Nhoquan and Giavien Ninh Binh province.

Two provinces, Hanam and Nam Dinh, have very low elevations and are therefore prone to inundation. At present, the dike system and the Hoabinh hydroelectric dam have reduced the hazards of flooding in these provinces in the North Vietnam's Plain.

Sedimentation, Erosion and Land Slide

Natural processes and human activities have altered the conditions of the watersheds. Deforestation of the headwaters has shortened the concentration period of run-off, hastening erosion and sedimentation.

The Hoa Binh reservoir has basically changed the hydrological and hydraulic conditions of the river. Trapping of sediment in the reservoir has caused sediment starvation in river sections below the dam. As a consequence, erosion of the river bed is taking place. In Da River, depth of river bed erosion is 6.5m right behind the dike. An erosion depth of 4.5m has affected 5 km of the river. While river bed erosion with depth of 2.1 m has affected a distance of 11-12km. The erosion of the river bed has induced bank erosion, threatening the dike sections of Hoa Binh town.

Threats of erosion persist in Thinhland town where more than six million cubic meters of soil has been eroded. The state of erosion and landslide in the regions is as follows:

- ***Hung Yen Province:*** in the period of 1991-1998, the Red River caused landslide of 112 ha at Lamson ward (Hung Yen town). The Red River dike section at Maidong commune has suffered a rift of 190m in length, 0.5-0.18m in width. In the Luoc River dike, the rift is 600m long and 0.03-0.05m wide. In 1998, functional state bodies invested at least 1 billion dong to repair the rifts and prevent erosion in Hung Yen;

- ***Ninh Binh Province:*** Landslide occurred in the mountainous areas of Tamdiep, Nhoquan, Giavien, Thuy. Bank erosion is present in Van River in Ninh Binh town;
- ***Hai Duong Province:*** Break of Thanhong, Thanhha dikes in 1996;
- ***Riverside dike of the Thai Binh River*** is low, small with weak bases. Safety is threatened by incidents of long inundation at alarming degrees of 2 or 3.

Drought and Hot Temperature

The most recent drought occurred from March to late May 2003. Hoabinh hydroelectric plant ceased operations and thousands of hectares of crops were destroyed. The water shortage affected a large proportion of the population.

Earthquake

Earthquake hazard in the project site is low. The 1983 earthquake was measured at intensity 3-4 on the Richter scale and the April, 30, 2007 earthquake felt in Hanoi has an intensity of 3 based on the Richter scale.

4.7 Socio-Economic Conditions

The project site accounts for a major part of the Northern Delta which includes Quangninh and Vinh Phuc provinces to the northeast and the province Phu Tho to the northwest. This region is the center of economic, cultural and social development of northern Vietnam. This region has a population of 13 million representing 15.5% of Vietnam's total population. This region contributes 15% annually to the country's GDP. In recent years (2001 – 2007) these provinces have enjoyed high economic growth rate of 8-12% per year, according to reports by the provinces. As a result of industrialization and urbanization, a large area of farming land and forests has been converted into urban or residential land. Some information of economic growth of the provinces is outlined below.

4.7.1 Industrial Development

In the period of 2001 – 2006, the industrial growth of provinces in the study region was 15 – 30%, higher than the national average. But industrial growth was higher in Hanoi, and provinces of Quangninh, Haiphong, Hung Yen, Haiduong, Vinh Phuc which experienced growth rate of over 20% per year. The industrial GDP accounted for over 40%. Meanwhile, the economy of the provinces of Thai Binh, Ninh Binh, Ha Tay Nam Dinh, Phu Tho, Hanam are still generally agricultural based.

The favorable conditions for Industrialization has served as impetus for the development and expansion of industrial parks in cities, districts and towns of Campha, Halong, Uongbi, Dongtrieu (Quang Ninh povince), Thuy Nguyen, An Duong, Kien Thuy, An Hai (Hai Phong), Hai Duong city, Chilinh, Namsach, Camgiang (Haiduong province), Myhao, Vanlam (Hung Yen province), Dong Van, Phu Ly (Ha Nam province), Gia Vien, Tam Diep, Ninh Binh city (Ninh Binh province), Nam Dinh city (Nam Dinh province), Thai Binh city (Thai Binh province), Luong Son (Hoa Binh province), Viet Tri city (Phu Tho province), Vinh Yen city, Phuc Yen town (Vinh Phuc province), Ha Dong city, and Hoai Duc (Ha Tay province).

4.7.2 Urbanization

The project region has experienced rapid urban development during the last decade. The urban population increased to more than 35% as of 2006, higher than the nation's average of 24% for 1995. A number of towns have been upgraded to cities (including Thai Binh, Hoa Binh, Ninh Binh, Hai Duong, Ha Dong and Vinh Yen as of 1995).Urbanization creates favorable conditions for socio – economic growth but also imposes heavy pressures on the environment.

4.7.3 Transport

The main characteristics of the transport network in the Northern Region are given below.

Inland road

The existing road system links all communes to centers of districts and provinces. The main national roads include:

- National Road 2: linking Hanoi with the Northeast and the Northwest regions.
- National Road 5: linking Haiphong ports with Haiduong, Hung Yen and Hanoi city.
- National Road 18: linking Mongcai border gate with Halong city and Haiduong and Bacninh.
- National Road 10: linking coastal provinces, namely Quangninh, Haiphong, Thai Binh, Nam Dinh, and Ninh Binh provinces.
- National Road1: linking Southern provinces with Hanoi city.
- National Road 21: linking Hanam, Nam Dinh with coastal districts of Nam Dinh provinces.
- National Road 6: linking provinces in the Northwest region with Hanoi.

Railways

In the project area there are three railways: the North-South, the Hanoi – Haiphong and the Hanoi – Quangninh and Hanoi – Laocai.

Waterways

The Northern Delta is the place of the biggest ports in North Vietnam and also the hub of international transport toward other nations in the world.

The biggest ports include Cuaong, Cailan (Quangninh), Dinhvu, and Chuave (Haiphong). The system of waterways in the project area is relatively convenient, still waterway transport is not yet delopped due to sedimentations and shortcomings of technical infrastructure.

Airways

Two international airports are located in the study region. These are the Noibai (Hanoi) and Catbi (Haiphong) and some military airports.

4.7.3 Agriculture, Forestry and Fishery

Agriculture, forestry and fishery are among the economic activities in the project region. The agricultural areas in the Northern provinces are Hung Yen, Haiduong, Nam Dinh, Thai Binh, Ninh Binh, and Hanam. Major agricultural crops include rice, maize, vegetable and fruits. Cattle and poultry-raising are among the major agricultural industries of the region.

In the coastal provinces of Quangninh, Haiphong, Thai Binh, Nam Dinh, and Ninh Binh, aquaculture and capture fishery are well developed. In the period of 2001 – 2006, the growth rate of agriculture is 3 – 4% per year, and fishery 4 – 8% per year.

Forestry is an important economic sector in Ha Tay, Vinh Phuc, Phu Tho and some districts of Hai Phong, Ninh Binh, and Quang Ninh. Nevertheless, both the area and quality of forests (mountain forests and mangrove forests) are declining, indicating the general decline in quality of the environment.

4.7.4 Land uses along the Banks of Corridor 1

The most dominant land use in the Red River Delta is agriculture this is followed by built-up land use composed mainly of residential, commercial and industrial uses. **Figure 4-28** shows the overall land use map of the Red River Delta.

Red River Viet Tri to Dong An

The beginning of this segment is the Viet Tri port which is a major port and among the busiest ports along the Red River. A small ship yard is present right next to the port. Downstream of the port is a steel factory. A number of small ports and ship yards are present further downstream. The major ferry landings in this segment are the Son Tay and the Vinh Thinh Ferry Landing. A major brick making area is present in Son Tay. Agricultural use is the prevalent use in this segment. Dredging for construction material is noted in a number of locations along this segment. Dredged materials are offloaded in a number of ports. Coal is noted to be handled only in a few ports. The following photographs documents the land uses and activities along the river banks of Corridor 1.

Photo 4-8. The shipyard next to the Viet Tri Port	**Photo 4-9**. The ferry landing of VinhTinh, Vinh Puc Province
	
Photo 4-10. Clay manufacturing in Son Tay	**Photo 4-11**. One of the small ports along Red River.
	

Intense economic activities occur along this segment of Red River within Hanoi. Numerous large ports are present handling construction materials. Also, many small shipyards are present in the Hanoi part of Corridor 1.

Duong River Segment

The floodplains of Duong River are mostly used for agriculture. However, it is noted during the December 2007 survey that dredging is very prevalent in this part of Corridor 1. There are numerous small ports along Duong River where dredged materials are unloaded.

Photo 4-12. Residential houses along Duong R	**Photo 4-13**. Construction of the approach of the new bridge across Duong R.

Figure 4-28. Land Use Map of the Red River Delta.

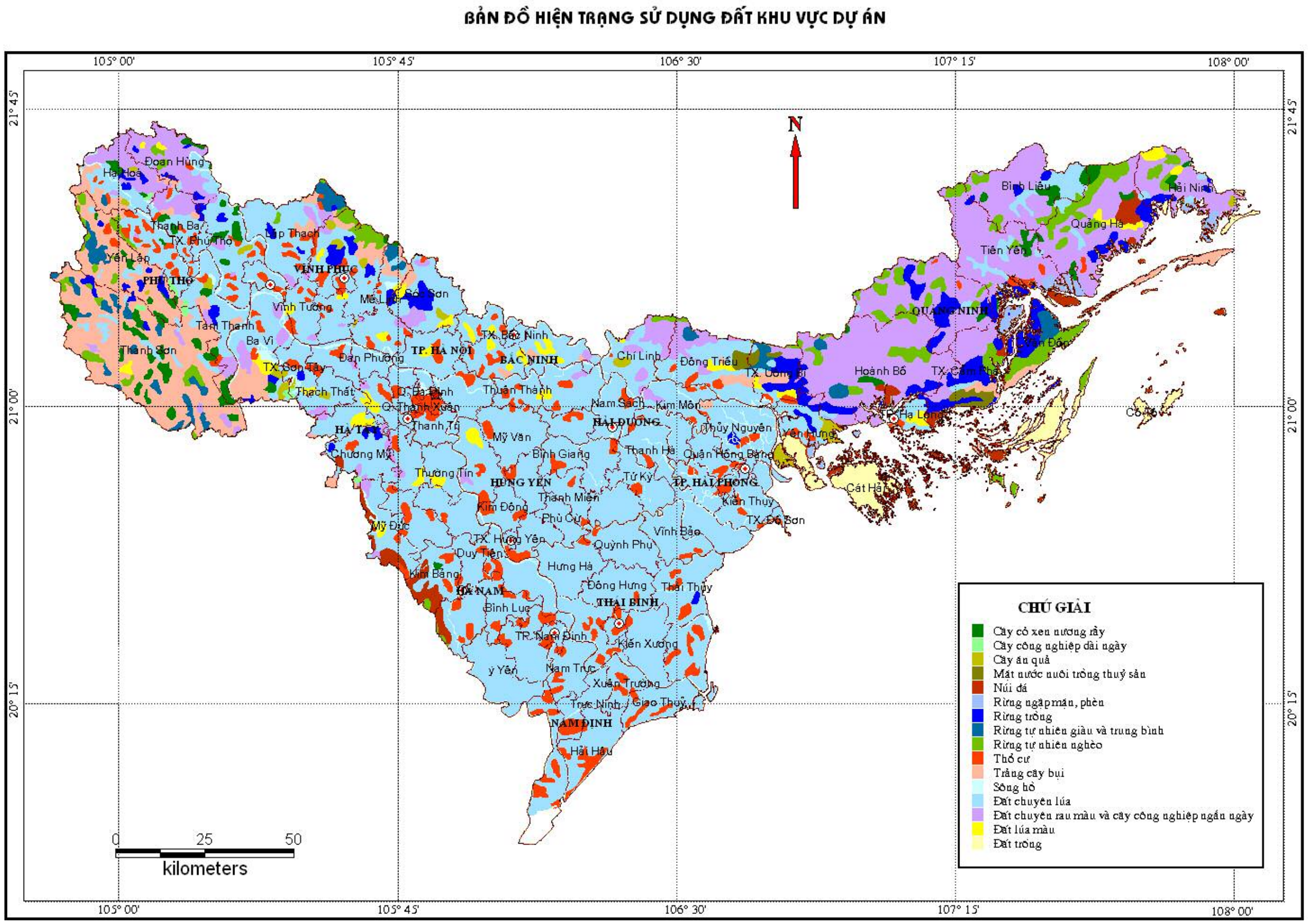


Photo 4-14. The only oil terminal existing in this part of Corridor 1.	Photo 4-15. Brick making a major industry in Gia Binh, Bac Ninh Province
	
Photo 4-16. Dredging in Duong River	**Photo 4-17**. One of the ports along Duong River
	

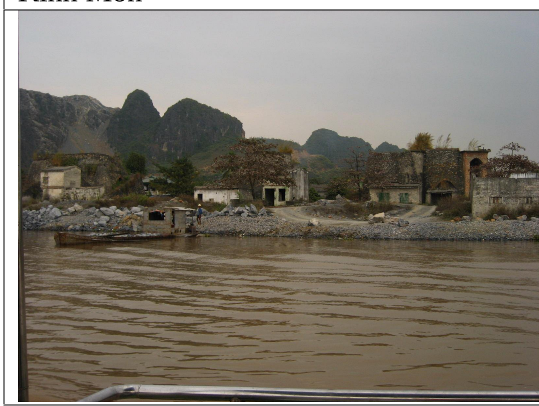
Brick making is a major industry located along the banks of Duong River in Bac Ninh. A long stretch of brick kilns line the Duong River bank in Gia Binh. A number of small shipyards have been noted along Duong River.

Kinh Thai - Han River Segment

An industrial area occupies the final section of the Kin Thay River. This is one of the major sources of construction materials in the Red River Delta. Products include concrete aggregates, lime, cement, dimension stones, etc. A cement plant and numerous lime kilns and brick kilns are located in this segment of Corridor 1. In addition, numerous small shipyards operate in the area as well. Air pollution because of fugitive dust from loading of construction materials, operations of the kilns and the cement is very noticeable. This is the busiest segment of Corridor 1 with coal barges delivering coal to the Pha Lai power plant making up a sizeable proportion of the river traffic. Numerous small shipyards and repair docks are scattered in this part of Corridor 1. This is the most congested part of Corridor 1. Houses along the river have not observed easement requirements and are located right on the water's edge.

Cam River Segment

The Cam River is the lowermost segment of Corridor 1. The industrial area of Hai Duong and Hai Phong forms one contiguous industrial zone along the southern bank of Cam River. Warehouses, oil depot, steel plant and other industries are located within this industrial zone. The port of Hai Phong is also located in this estuary.

Photo 4-18. Rock Quarry in Kinh Mon, Hai Duong.	**Photo 4-19**. Cement plant in Thuy Nguyen In Quang Ninh.
	
Photo 4-20. Rock aggregate producer in Kinh Mon	**Photo 4-21**. Limestone kilns in Kinh Mon.
	

4.7.5 Irrigation Use of River Water

Aside from fishing and transport, one of the major uses of the river water is for irrigation. A number of pumping stations have been established in different sections of the rivers of Corridor 1. **Figure 4-29** shows the location of pumping stations in the Red River Delta while **Photo 4-22** shows one of the stations.

4.7.6 Historical and Natural and Cultural Resources

Historic and natural and cultural resources are present in the region. The resources that are within the project site are summarized below.

Halong Bay is a unique karst landscape / seascape. It has 1,969 karst islands with caves and caverns and pocket beaches. It is a declared World Heritage and a World Biosphere Reserve by UNESCO.

Beaches and other tourist destinations in the region are found in Tra Co, Bai Chay, Doson, Cat Ba and Cat Hai.

Places of scenic beauty include the former capital of Hoa Lu, Van Long – Gia Vien, Tam Coc – Bich Dong (Ninh Binh), Kem Trong, Ngu Dong Son and Mt. Cam (Ha Nam).

Figure 4-29. Pumping stations located along the river of the Red River Delta

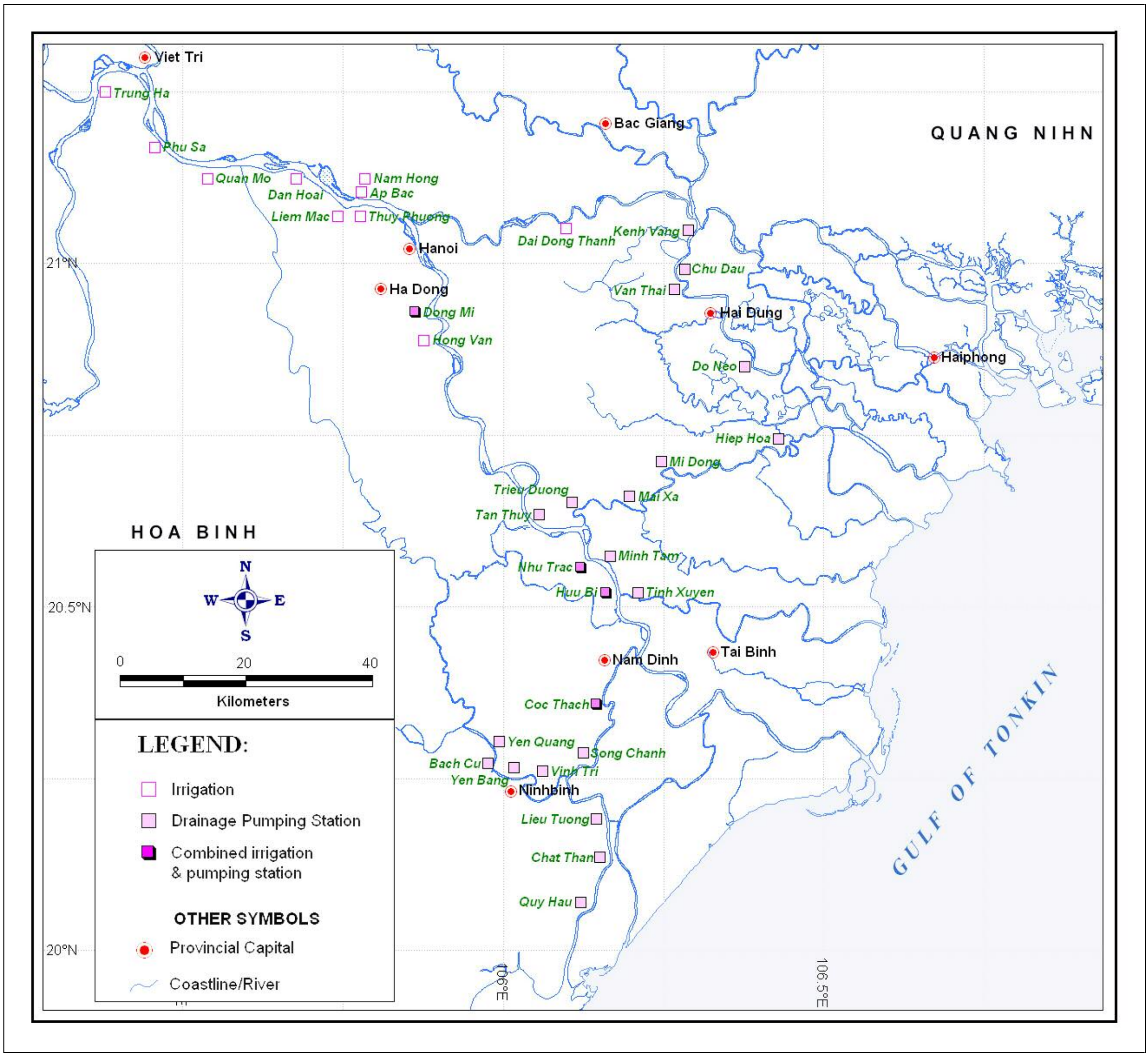


Photo 4-22. One of the pumping stations upstream of the Red River

4.7.7 Historical Heritages

There are a number of historical heritages in the study region. Among these are the Conson pagoda, Kiepbac temple (Haiduong), the ancient port town and Hien town, the temple of Pham Ngu Lao (Hung Yen), Keo pagoda (Thai Binh), relics of Saint Nguyen, Dichlong pagoda and cavern, the temple to King Dinh Tien Hoang, Loson pagoda, Hoalu cavern, Baidinh mount and pagoda, Phat Diem Stone Church (Ninh Binh). Alongside the coast of Hai Phong – Quang Ninh are historic sites and sites of traditional festivals such as the Bachdang gate, Yentu pagoda, Cuaong temple, etc. In almost all provinces there are heritage resources of ancient architectures and artifacts, pagodas, temples.

5 ENVIRONMENTAL IMPACTS PREDICTION AND ASSESSMENT

5.1 Environmental Impact Assessment Method

The proposed structure for defining the magnitude and significance of the impacts are as follows:

No Impact

An impact is assessed as "no impact" if it is physically removed in space or time from the environmental component or if the impact is so small as to be un-measurable (i.e. negligible).

Major Impact

An impact is assessed as "major" if it has the potential to significantly affect an environmental component. A major impact can be positive or negative. The following criteria will be used to determine whether a given impact is "major":

- spatial scale of the impact (site, local, regional, or national/international);
- time horizon of the impact (short term (0-12 months), medium (12-36 months), or long term (>3 years));
- magnitude of the change in the environmental component brought about by the activities (small, moderate, large);
- importance to local human populations;
- compliance with international, national, provincial, or district environmental protection laws, standards, and regulations; and
- compliance with WB guidelines, policies, and regulations.

Minor Impact

An impact is assessed as "minor" if it occurs but does not meet the criteria for a major impact as described above. A minor impact can be positive or negative.

Unknown Impact

An impact is assessed as "unknown" if the significance of the effect can not be predicted for any of the following reasons:

- the nature and location of the activity is uncertain;
- the occurrence of the environmental component within the impact area is uncertain;
- the time scale of the effect is unknown; or
- the spatial scale over which the effect may occur is unknown.

Finally, impacts are assessed based on the basic assumption that no intervention shall be implemented.

5.2 Summary of Improvement Works

The river works that will be done in the different segments of Corrridor 1 are enumerated in **Table 5-1**. The river works include removal of obstructions such as sunken vessels and rocks, dredging, bank protection, groin removal and groin construction.

Table 5-1. Summary of the Proposed works in Corridor 1.

Location	Dredging	Outcrop Cutting	Bank Protect	Groin Const	Groin Repair	Rock Removal	Wreck Removal	Groin Removal
Red River								
Km 53-54							☑	
Km 59-63	☑				☑		☑	
Duong River								
Km 0+500						☑		
Km 3+500						☑		
Km 7						☑		
Km 10						☑		
Km 11						☑		
Km 12						☑		
Km 14+300						☑		
Km 15+500						☑		
Km 22	☑			☑				
Km 26	☑			☑				
Km 31								☑
Km 30-32			☑					☑
Km 33-34	☑							
Km 50								☑
Km 53	☑			☑				
Km 56	☑							
Km 64	☑							
Km 65	☑			☑				
Kin Thay								
Km 0		☑	☑	☑				
Km 11+500	☑			☑				
Km 18		☑	☑					
Km 21	☑	☑	☑					
Km 19+500	☑							
Km 22+500	☑		☑	☑				
Km 24-25	☑	☑	☑					
Km 27	☑							
Km 33	☑			☑				
Km 34+500	☑			☑				
Km 37+500						☑		
Han River								
Km 0-1			☑					
Km 5	☑		☑					
Da Bach 1+500								Remove Old pier

The indicative extent, in area and distance of the improvement works is listed in **Table 5-2**. It is obvious that in terms of volume, dredging will have the most significant environmental impact.

Lifting of bridges, Duong and Ho Bridge in Duong River will also be undertaken to improve air clearance. The summary of bridge improvements that will be done in the Corridor 1 is listed in **Table 5-3**.

Table 5-2. Indicative Extent of Each Improvement Work on Corridor 1.

Activities / Works	Red River	Duong	Kinh Thay	Han R
Dredging & Disposal (km)	3	5.2	2.8	1
Volume Dredged Materials(cu m)	1,374,933.00	149,288	35,776	1,153,550.00
Bend Improvement	0		3 areas	0
Bank Protection		1 area	5 area	2 areas
Groin Construction	4 areas	4 areas	5 areas	
Removal of Obstructions (km)	0.221	0.225	0.008	0
Bridge Construction		1 bridges		

5.3 Impacts Screening Checklist

As an aid to impact prediction, a screening matrix was set up. The matrix lists the proposed activities and the various environmental components that will likely be affected. The matrix indicates the environmental component/s that will be affected by each of the proposed project activity.

Table 5-3. Impacts Screening Matrix

Environmental Components	Dredging & Disposal	Outcrop Cutting	Bank Protect	Groin Construct	Removal of Obstruct	Bridge Improve
Climate & Air Quality						
Air Quality	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)
Geology & Topography						
Topography / morphology	(shaded)	(shaded)	(shaded)	(shaded)		
Soils and Soils Quality	(shaded)	(shaded)				
Erosion & Deposition	(shaded)	(shaded)	(shaded)	(shaded)		
Sediment Transport	(shaded)	(shaded)		(shaded)		
Stream Sediment Quality	(shaded)	(shaded)				
Water Resources						
Hydrology		(shaded)	(shaded)	(shaded)		
Surface Water Quality	(shaded)	(shaded)	(shaded)		(shaded)	(shaded)
Groundwater						
Groundwater Quality	(shaded)					
Ecology & Biological Resources						
Important Terrestrial Habitat						
Protected Terrestrial Plants and Animals						
Aquatic Flora & Fauna	(shaded)	(shaded)		(shaded)	(shaded)	
Important Aquatic/Wetlands Habitats	(shaded)					
Socio-Cultural						
Livelihood	(shaded)	(shaded)	(shaded)			(shaded)
Land Use	(shaded)	(shaded)	(shaded)			(shaded)
Historic and Natural & Cultural Resources						
Occupational Health & Safety	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)
Public Health & Safety	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)	(shaded)

The description of the impacts of each of the activities is presented in the following sections.

5.4 Impacts of Dredging

Of the proposed improvement works, it is predicted that dredging and disposal of dredged materials will have the most significant impacts. These activities can have major impacts on the physical environment, biologic environment and socio-economic environment. The impacts are attributed to extraction of large volume of sediment over a long stretch of Corridor 1 and disposal of the dredged material will require a large area, possibly over a thousand hectares. As such, discussion of the impacts of dredging is given priority.

The following matrix lists the known impacts of dredging and the time and space relationship of the impacts. It shows that impacts associated with dredging are potentially significant at or near the activity and that severity of impact declines with distance.

Table 5-4. Time-Space relationship of Dredging Impacts[4]

	Near-field Environmental Effects (<1km)	**Far-field Environmental Effects (>1km)**
Short-term Environmental Effects (<1 week)	**Dredging** Turbidity Smothering/removal of organisms Reduced water quality	**Dredging** None generally expected
	Disposal Smothering of organisms Turbidity Reduced water quality Acute chemical toxicity	**Disposal** Offsite movements of chemicals by physical transport
Long-term Environmental Effects (>1 week)	**Dredging** Disturbance by shipping traffic Removal of contaminated sediment	**Dredging** None generally expected
	Disposal Altered substrate type Altered community structure Chronic chemical toxicity Bioaccumulation	**Disposal** Offsite movements of chemicals by physical transport and/or biota migration

5.4.1 Impacts on Aquatic Life

Dredging can affect aquatic life in a number of ways. The most direct impact is the removal of substrate including the benthic organisms and the smothering of sessile bottom dwelling organisms by dredged materials. The other source of impacts associated with dredging is the impact of suspended sediments on aquatic life. Numerous researches and experiments have been done in the past on the impacts of suspended sediments. DOER (2000) reviewed these studies and relates the findings to sediment suspension associated with dredging.

It is recognized that estuarine and coastal waters experiences conditions of high turbidity due to sediment resuspension caused by storms, tides and currents. It is expected therefore that organisms have behavioral and physiological mechanisms for dealing with this feature of their habitat. The same condition can be said for river habitats where fish and invertebrates display considerable adaptability to dredging, probably because the streams naturally have substantial seasonal and annual fluctuations (Moyle et al. 1982).

[4] Source: http://www.ukmarinesac.org.uk/activities/ports/ph5_2.htm)

These fluctuations, in the form of seasonal flushing flows, can greatly reduce the long term impact of dredging.

Because dredging-related suspended-sediment plumes may differ in scope, timing, duration, and intensity from natural conditions, dredging may create conditions not typically experienced by resident or transient species (DOER, 2000).

Studies show that the eggs and larvae of estuarine and coastal fish are some of the most sensitive to suspended-sediment exposures. Low suspended sediment concentrations sustained for several days could be fatal for the larvae of anadromous fish that occur in freshwater and brackish habitats at this life history stage

Generally, free swimming aquatic fauna like fishes are able to swim away from highly turbid waters. But for those that follow or linger in turbid water, feeding rates of certain species are reduced at a high turbidity level (120 NTU). This is presumably due to a decrease in the reactive distance of the fish to their planktonic prey (Hecht and van der Lingen 1992 in DOER 2000). Clogging of gills is also known to affect fish in waters with high concentration of suspended sediments.

As for crustacean species, laboratory studies showed that crustaceans are not affected by suspended sediments conditions normally associated with dredging. All mortalities observed in laboratory studies are associated with suspended sediment concentrations of over 10,000 mg/l (DOER 2000), conditions not normally caused by dredging.

5.4.2 Recovery of dredged areas

There are relatively few references on recovery of dredged areas in fresh water. But there is a wealth of information on studies on recovery/ re-colonization of dredged areas in estuaries. For the purposes of this study, experiences in the estuaries are used as references to appreciate the recovery period of dredged areas.

EPA's monitoring of recovery of dredging in a river in Alaska showed that substantial recovery of the diversity of macro-invertebrate occurred after one year (Prussian et al. 1999)

A review of dredging works in coastal areas world-wide showed that the rates of recovery of benthic communities following dredging in various habitats varied greatly (Nedwell & Elliot 1998; Newell, Seiderer & Hitchcock 1998 in http://www.ukmarinesac.org.uk/activities/ports/ ph5_2_2.htm#a1

Among the information available on recovery of riverine benthic communities after dredging are the reports by the USACE and USEPA according to the USACE, if the substratum is stable with moderate to low velocities, the area could colonize in less than 5 years.

The recovery time and habitat types are listed as follows:

Table 5-5. Recovery Period Observed in Various Dredging Areas

Location	Habitat Types	Recovery time
Coos Bay, Oregon	Disturbed Muds	4 weeks

Gulf of Cagaliari, Sardinia	Channel muds	6 months
Mobile Bay, Alabama	Channel muds	6 months
Goose Creek, Long Island	Lagoon muds	>11 months
Klaver Bank, North Sea	Sands-gravels	1-2 years
Chesapeake Bay	Muds-sands	18 months
Lowestoft, Norfolk	Gravels	>2 years
Dutch coastal waters	Sands	3 years
Boca Ciega Bay, Florida	Shells-sands	10 years

The general observation is that recovery rates were most rapid in highly disturbed sediments in estuaries that are dominated by opportunistic species. In general, recovery times increase in stable gravel and sand habitats dominated by long-lived components with complex biological interactions controlling community structure.

Experiences in other areas generally agree with the above observation. For instance, the study in polluted estuary in northeastern England showed that recovery of benthic communities will require more than 6 months. (M.P Quigley and J.A. Hall, 1999). A study of a small dredging area (2625 m^2) in a similar environment in the harbour of Ceuta in North Africa showed that about 6 months are required for the disturbed area to re-establish a sediment structure and a macrobenthic community similar to the undisturbed area (Jose M Guera-Garcia et al.2003).

5.4.3 Impact on Water Quality

Turbidity due to sediment resuspension is the primary impact of dredging on water quality. Increased turbidity and total filterable solids (TFS) can occur below the dredge. The turbidity is highest immediately downstream of the dredge but declines rapidly downstream of the dredge (USACE 1997).

The level of turbidity generated by dredging is partly dependent on the type of dredge used. Experience with hydraulic cutterhead shows that maximum concentrations generally remain less than 500 mg/L and bottom suspended-sediment plumes are limited to within 500 m of the dredge (Havis 1988; LaSalle 1990 in DOER 2000). Mechanical dredging on the other hand can cause much more severe condition.

Mechanical dredges which generate suspended-sediments through the impact of the bucket on the bottom and withdrawal from the bottom, washing of material out of the bucket as it moves through the water column and above the water surface, and additional loss when the barge is loaded (LaSalle 1990). A suspended- sediment plume associated with clamshell dredging at its maximum concentration (1,100 mg/L) may extend up to 1,000 m on the bottom (Havis 1988; LaSalle 1990; Collins 1995 in DOER 2000)

5.5 Impacts of Dredging on Corridor 1

<u>Impacts on Air Quality</u>

Impacts of the dredging on air quality will emanate from the operations of diesel fuelled engines. The project will have to comply with TCVN 5939-1995 for emissions of dredging equipment. This impact is rated negative, minor and of short term duration

Impacts on Topography / Morphology

Dredging will alter longitudinal profile of the river reslting to deepening of the channel. This will increase water flow, locally and induce erosion. This is a negative impact, minor due to its localized nature and maybe of term duration.

Impacts on Stream Sediment Quality

Resuspension of pollutants into the water column during dredging may case contamination of the stream sediments downstream of the dredging area. This risk is considered minimial since sediments of Corriodor 1 are generally uncontaminated based on the reslts of the sediment analysis. This impact is rated minor, negative and short term duration.

Impacts on Water Quality

Based on the proposed work, dredging will be most extensive in Red River and Han River. Of the total stretch of Corridor 1, Duong River and Kinh Thay are highly disturbed due to constant dredging. Aside from maintenance dredging, extraction of stream sediment for construction is on-going. As observed, water quality degradation occurs during dredging when overflow occurs when the barges hydraulically unload the dredged material to landing stages along the rivers.

As mentioned earlier, increased turbidity in the river due to dredging is confined within the immediate vicinity of the dredge. **Photo 5-1** shows the plume dispersion during dredging in the Red River. It can be noted in the photo that the plume does not spread laterally due to the current. It spreads out downstream of the dredge and is effectively diluted.

Photo 5-1. Dredging in Red River

Duration of the dredging of Corridor 1 will depend on the capacity of the cutter suction dredge that will be used. Assuming a weekly dredging rate of 75,000 cu meters, dredging of the entire length of Corridor can be completed with 36 weeks.

Use of cutter suction dredge and pumping spoils onto land disposal will minimize the impacts of suspended sediments. Assuming that no overflow is allowed during dredging, source of suspended will be limited to leakage and disturbance of the river bottom with the movement of cutter head. Further, impact on increased suspended sediment is mitigated by the natural factors of low clay and silt content of the river sediement. Grain size analysis of some samples from Corridor 1 showed that clay and silt makes up about 11% or less by volume and coarse sand makes up more than 55% of the sand fraction. Finally, as measured during the field survey, typical flow velocity of Corridor 1 is about 0.5 m/sec. Thus, leaked suspended solids will be dispersed and diluted effectively. If there will be severe increase in turbidity, this will be confined to a limited area right next to the dredge.

The stream sediments from the dredging area in Corridor 1 are generally compliant with the soil and sediment standard set by TCVN2709-2002. The hazard of re-suspension of contaminants in the water column during dredging is minimal.

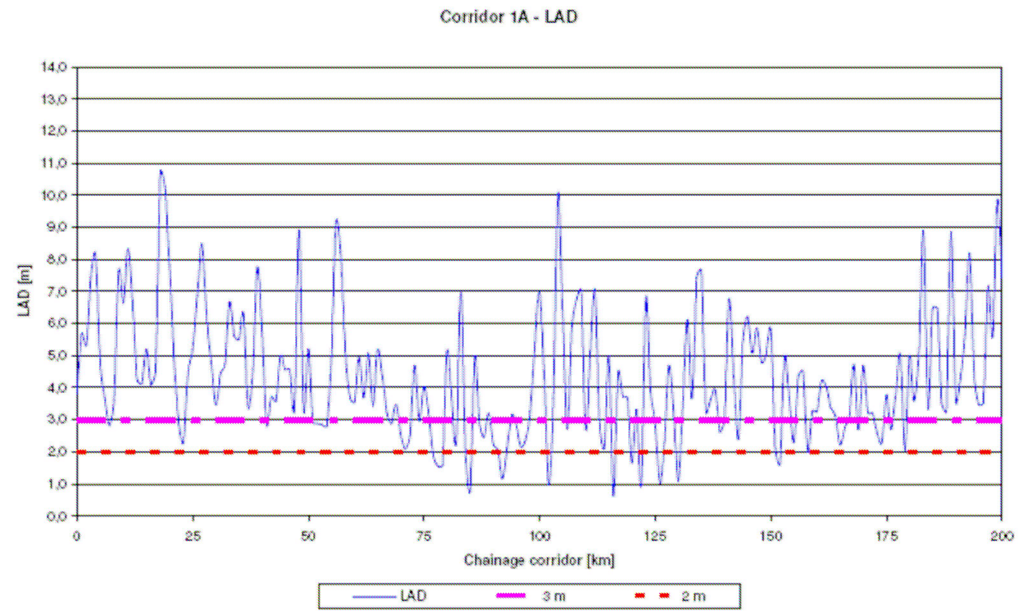
Further, the beneficial use of sediments is possible. However, monitoring of sediment during dredging should be done for proper spoils management. Slight exceedance of arsenic is noted among the collected stream sediments samples.

The impacts of dredging on water quality is rated negative, minor and of short term duration.

Impacts on Hydrologic Regime

The change in the longitudinal profile by dredging Corridor1 may have impacts on the hydrodynamics. Deepening can induce higher flow velocity, intrusion of saline water farther upstream. However, these impacts are predicted to be minor since deepening of the channels by dredging will be less than 4 meters to attain the least available depth and that dredging will only be done in selected areas and not in the entire length of Corridor 1. The following graph (**Figure 5-1**) shows the depth along part of Corridor 1 and it indicates the relative amount of dredging required to improve navigability of the rivers.

Figure 5-1. Chart of Least Available Depth in a Segment of Corridor 1



Impact on Erosion and Sedimentation

Deepening of the river channel may induce higher streamflow and cause bank erosion in Duong River and Kinh Thay. The impact is predicted to be minor since bank protection is present in critical parts of the rivers. **Photo 5-2** shows a section of the bank protection now in place along Duong River.

In addition, the construction of groins in some of the dredging areas will enhance bank protection.

Impact on Aquatic Life of Corridor 1

It is inferred that aquatic life is highly disturbed in the Duong and Kinh Thay River due to the prevalence of dredging. These rivers do not have any opportunity to fully recover if the estimated recovery period of dredged area of about 5 years is accurate. It was noted during the inspection of Corridor 1 that dredging is very prevalent in the segment of Duong R and Kinh Thay R. Judging from the volume of dredged materials stockpiled in landing stages and ports along the river banks of both rivers, dredging is continuously carried out. Inspite of this, it is reported that maintenance dredging of of Duong and Kinh Thay is being carried out.

Photo 5-2 Bank Protection in Duong River at About Km 0.

The persistent disturbance of the stream sediments in this river has likely affected the aquatic life in this section, particularly the benthic organisms. The benthic organisms play vital role in the food chain since they link the primary producers, such as phytoplankton, with the higher trophic levels, such as finfish, by consuming phytoplankton and then being consumed by larger organisms. This is probably one of the causes of the reported decline in fish catch in the Red River system.

The effects of dredging of Corridor 1 will be a cumulative impact on the aquatic ecosystem of Corridor 1.

Impact on protected Aquatic / Wetland Habitats

The dredging in Corridor 1 will not directly affect any protected areas. Wetland protected areas in the Red River Delta are mostly located in estuaries along the coastline. The protected wetlands such as Thai Thuy, Xian Thuy, Cat Ba and Vin Ha Long are distant from the dredging areas.

Impacts on Occupational and Public Health and Safety

During dredging operations the workers will be exposed to hazards of operating heavy equipment, noise, heat, ergonomic stress. They will also be exposed to water hazards, such as drowning.

Overall, one of the objectives of the NDTDP is to enhance public safety in water travel. But during the construction stage, dredging can pose hazards to river navigation. The dredge will be an obstruction in the river way. This is a concern in Kinh Thay River particularly in Duy Tan where the river channel is narrower and where barges load construction materials on both banks.

This impact is rated minor, negative, short to medium term duration.

Impacts of Cultural and Historical Resources

The dredging will not have direct impact on Cultural and historical resources of the Red River Delta. These known cultural and historically significant areas are located away from the work area of Corridor 1.

5.6 Impacts of Disposal of Dredged Sediments

The land space required to hold the dredged material has been computed based on piling height of 1.5 m and a bulking factor of 1.4. **Table 5-6** below enumerates the estimated land area needed to hold the spoils from various rivers of Corridor 1.

Table 5-6. Volume of Dredged Sediments and Required Land Area for Disposal

River	Volume of sediment to be dredged (x 1000 m^3)	Land area required (in hectares) assuming 1.5 m stockpile height and 1.4 bulking factor
Red River	1,375	128.3
Duong River	149	13.9
Kinh Thay River	36	3.3
Han River	1,153	107.6
Total	**2,713**	253.2

Based on the proposed work an estimated 2,713,000 m3 spoil will be dredged overall along Corridor 1, with dredging most extensive in the Kinh Tay River. The estimated storage required for this is 84.4 hectares, 48.0 hectares permanent storage and 36.4 hectares temporary. The 36.4 Ha will be temporary land use, with spoil being used for construction or fill, for instance as replacement fill in mined out quarries. The remainder, 48.0 Ha, will be permanent storage. As much as possible, marginal lands will be used as stockpile areas, although compensation will also be required for affected land users.

The breakdown for disposal of dredged material, based on the waterway engineering advice, is estimated to be:

a) 20% of dredged material would have pollutants like heavy metals and need to be permanently stockpiled on land, and secured within bunds to stop any side effects from leaching out of pollutants.

b) 10% of dredged material would simply be disposed in deep channels in the river

c) 40% of dredged material will be good material, of this 32% construction quality sand and 8% of lesser quality but still usable material in construction

d) 30% of dredged material would be good material, but not construction quality or taken by the construction industry. Of this, half (15%) is estimated to be used immediately as landfill (eg forming and backfilling guidance dams or backfilling old quarry sites adjacent to the river) and half (15%) is estimated to go to temporary storage

Impact on Air quality

Stockpiles of the spoils may generate dst dring the dry season. Haling and handling will also have the same impact on air quality. Mnimize the impact on local residents, stockpiles shold be located away from residences and areas where people congregate (e.g. ferry boat stations)

Operations of diesel fuelled engines (dredge, vehicles) dring project implementation will generate emissions. The project will have to comply with TCVN 5939-1995 for emissions of dredging equipment. This impact is rated minor, negative and of short duration.

Impact on Topography

Disposal of dredged material on land will have short to long term impact on topography. However, if dredged material is used, then the impact on topography will be temporary in nature. The land will be restored to its original condition after the sediments have been exhausted. This impact is rated negative, minor, short to long term duration.

Impact on Soils

The soil in the disposal site can be affected by the leaching of the dredged material. But the impact can be minor if the storage of sediment is only temporary. Further, the sediments, based on the analysis of samples are not contaminated. The dredged material can be used for beneficial purposes if it complies with TCVN 7209-2002 (see table below) and the Dutch Standards for Sediments.

Table 5-7. TCVN-7209-2002 -Standards for Soil and Sediment Quality Vietnam in mg/kg

Parameter	Industrial Use	Agricultural Use	Forestry	Settlement & Recreation	Commerce & Tourism
Arsenic	12	12	12	12	12
Cadmium	2	2	5	5	10
Copper	50	70	70	100	100
Lead	70	100	100	200	300
Zinc	200	700	200	300	300

Impact on Erosion & Sedimentation

The return to the river of the surplus water used in pumping the spoils in the disposal site can cause erosion. It was observed during the inspection of Corridor 1 that surplus dredge water that is returned to the waterway through unprotected canal is causing erosion along the bank. This impact is rated minor, negative and of short duration.

In addition, silted water may flow into low lying areas during hydraulic placing of spoils in sloping land. The silted water may smother growing crops on the low lying areas. This impact is rated minor, negative and of short duration.

Impact on Stream Sediment Quality

The dredging will remove contaminated stream sediments, if present. This will mitigate pollution of stream beds, but considering the relatively unpolluted state of the dredging areas, the expected environmental improvement will not be very significant. This impact is rated, positive, minor and possibly of long term duration.

Impact on Surface Water Quality

The return of the surplus dredge water (approximately 100 mg/l of suspended sediments) can cause water quality degradation through increased turdibity. But this impact is not expected to persist far downstream of discharge. The flowing water will effectively dilute the turbid run-off. This effect is not expected to persist beyond 100 meters downstream of point of discharge. This impact is rated minor, negative, short term.

Impact on Groundwater Quality

The groundwater maybe affected by lecahate from the contaminated spoils if containment is insufficient. This impact is rated minor, negative, maybe long term.

Impacts on Aquatic Fauna

Disposal on land will not have direct impact on aquatic life. The return of highly turbid surplus water into waterway is a possible source of impact on the aquatic life. This impact is considered negative, minor and short term duration.

Impacts on Protected Aquatic / Wetland Habitats

No direct impact on protected areas is predicted during the dredging of Corridor 1.

Impact on Land Use

The disposal of dredged material will have significant impact. For extremely contaminated sediments' containment, 50 hectares is needed. For clean spoils that will not be taken, estimated at 30% of total clean sediments, some 80 hectares will be needed. Since cultivation is pervasive, chances are agricultural land will be used for the purpose. This is a negative impact and in view of the social implication of the impact, the magnitude is rated moderate, long term.

Impact on Agricultural Productivity and livelihood

The temporary use of agricultural land as holding area for dredge material will preclude the cultivation of the land for as long as the area is utilized as a spoils holding area. This will result to loss of livelihood for land users. This impact is rated major, negative, of possibly short to long term duration.

Impact on Historic and Cultural Resources

The disposal of the dredged material will not have impacts on the historical and cultural resources.

5.7 Impact of Bend Improvement and Disposal of Spoils

Table 5-8 indicates the loss of agricultural land caused by River Bend Corrections, for Corridor 1. Except for km 186 (C1-C01), all the impacts are caused on the Kinh Thay River and located in Hai Duong Province.

Table 5-8. Agricultural Land Losses due to Bend Improvement

#	KM	Design Reference	Community	DPs	Population	Agricultural Land (m^2) Loss	DPs Losing more than 20% Agricultural Land
1	149	C1-KT05	Mac Ngan Hamlet, Dong Lac	16	69	7,969	4

			Commune, Chi Linh District				
2	151	C1-KT07	An Bai Hamlet, An Lac Commune, Chi Linh District	8	29	18,758	2
3	152	C1-KT08	Ninh Xa Hamlet, Le Ninh Commune, Kinh Mon District	18	69	7,947	0
4	186	C1-C01	Cam river	18	60	10,000	3
Total				**60**	**227**	**45,000**	**9**

Just as in dredging, the spoils of the outcrop cutting will be disposed in a land disposal site or used beneficially.

Impact on Air Quality

Impacts of the dredging on air quality will emanate from the operations of diesel fuelled engines. The project will have to comply with TCVN 5939-1995 for emissions of dredging equipment. This impact is rated negative, minor and of short term duration

Impact on Morphology

The bend improvement will result to change in river morphology. This activity will entail the excavation of inside bank to improve the bend radius. This is the desired impact. This is a positive, minor, long term impact.

Impact on soils and Soil Quality

The stockpiling of the spoils can affect soil quality on site if the spoils are contaminated and if the in situ soil has high adsorption capacity. This is a negative, minor, long term impact.

Impacts of Erosion and Sedimentation

During the excavation, the bare river banks will be exposed to flowing water. Loose sediments will be eroded away and deposited downstream of the working area. This impact will persist until the river banks have stabilized either through growth of vegetation or the completion of the river bank protection.

Impacts on Stream Sediment Quality

The impact on sediment quality is predicted to be minor. The soil type in the bend cutting area is uncontaminated and is not expected to cause significant change in the stream sediment at the work site.

Impacts on Waterflow

The bend improvement will not have significant impact on the river's morphology, hence impacts on waterflow is predicted to be minimal.

Impact on Surface Water Quality

Earthworks during the excavation of the river bend will affect water quality through increased suspended sediment load. Bare river bank will be exposed to water flow which can erode loose sediments and in the process release the clay and silt particles into the water column. This impact will persist until the banks have been stabilized. The extent of the impact will be confined to a limited area in the work site and downstream of the work site..

Impacts on Groundwater Quality

Quality of groundwater maybe affected if the spoils are contaminated and leachate of the spoils is allowed to infiltrate into the groundwater. The groundwater in the Red River Delta is shallow and hence susceptible to pollution from surface sources.

Impacts on Important Terrestrial Habitats

The bend cutting will not affect important species or protected terrestrial habitats. The river bend is presently cultivated and planted to mixed crops of cassava, banana, corn and other crops. **Photo 5-3** shows the general land use in the vicinity of the bend cutting areas in Kinh Thay River while **Photo 5-4** shows the banks of the outcrop cutting area.

Photo 5-3. The typical land use in the vicinity of the bend Improvement area in Km 155-km156 Kinh Thay River

Photo 5-4. Part of the bend improvement site in Km 0 Kinh Thay River. Cultivated land behind the bamboo grove.

Impacts on Aquatic Life

The excavation work to improve the bend will induce sedimentation which can smother benthic organisms near the work site. The turbidity that will be caused by the excavation may temporarily drive away motile organisms. This impact is negative, minor and of short duration which will persist only for the duration of the activity. This will be a cumulative impact on the overall ecology of Duong River which is inferred to be highly disturbed by prevalent dredging activities.

Impacts on Agricultural Productivity and livelihood.

Considering that the banks of Corridor 1 are mostly cultivated, the bend cutting and the disposal of the excavated material will affect agricultural lands. Tentative measurement indicated that more than 3.4 hectares of agricultural land will be permanently affected. It can be expected that about the same land area will be required for both temporary and permanent dsiposal. Because of the socio-economic implication of the impact, the impact is rated negative, moderate and possibly of long term to permanent duration.

The Google Earth Imagery (**Figure 5-2**) shows the existing land use in the proposed outcrop cutting area in Km 0 Kinh Thay.

Impacts on Historic and Cultural Resources

As far as can be determined, there are no historic and cultural resources in these sites. These sites are located on relatively active banks subjected to a series of erosion and deposition which would not have allowed any use in the historic past.

Impacts on Occupational Health

The excavation will utilize land based heavy equipment. The workers will be exposed to work related hazards posed by operating heavy equipment, exposed to possibly prolonged elevated noise levels and dusty condition. In addition, they will be working around water, hence they will also be exposed to water hazards such as drowning. This impact is rated negative, minor, short term duration.

Figure 5-2. Image of Vicinity of the Proposed Bend Improvement in Km 0 Kinh Thay.

The following Google Earth imagery shows the bend cutting site in Km 18, Kinh Thay River.

Figure 5-3. Imagery of the Proposed Outcrop Cutting Area in Km 18 Kinh Thay

Impacts on Public Health and Safety

The excavation work will be land based, as such it is not expected to interfere with boat traffic. Except for Km 0 Kinh Thay and Km 24-25 where boat crossings are located. The excavation activity can pose hazard to the boats when they land on the banks where work is being done.

No other threats to public health and safety are predicted considering that the work area is relatively remote from settlements. This impact is rated negative, minor, short term duration.

5.8 Impacts of Bank Protection

The objective of bank protection is to prevent bank erosion and scouring. Bank protection method that have been selected for Corridor 1 are Reno mattress for rural areas and concrete mattress for the urban areas.

Among the negative impacts of bank protection, particularly the impermeable type of bank protection is the displacement of fauna that dwells on the river banks. Also, use of impermeable bank protection prevents the exchange between groundwater and the river. However, this may not be significant since exchange can still occur at the river bed. Impairment of the aesthetics because of its unnatural appearance is another potential impact of bank protection.

Photo 5-5. Bank Protection Construction in a Segment of Corridor 1.

The photo above is from Kinh Thay River, Chi Linh, Province of Hai Duong. The photo shows the on-going construction of the bank protection. The construction is basically manual labor intensive and is land-based.

NDTDP is proposing bank protection in certain river sections like Duong R (1 site), Kinh Tahy R (5 sites) and Han R (2 sites). The detailed description of the impacts of bank protection is presented in the following sections:

<u>Impacts on Air Quality</u>

The Impact of the construction of the bank protection on ambient air quality will emanate from the operations of diesel fuelled heavy equipment, like excavators. The standard for motorized vehicle is contained in TCVN 6438-2001. This impact is rated minor, negative, short duration.

The other sorces of noise and dst is the constrction staging areas and the materials stockpiles areas. These will have to be located more than 200 meters away from residences and places where people congregate.

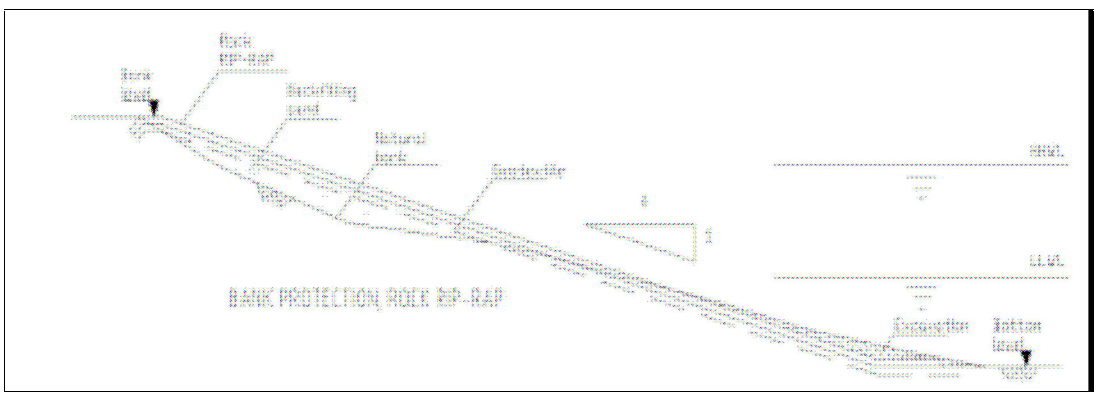
Impacts on morphology

The construction of the bank protection using rock rip rap as shown in **Figure 5-4** will require a slope ratio of 1:4. As such, bank trimming has to be done in order to attain this slope. In effect, the bank profile will change from an originally very steep bank to a sloping one. This is a permanent impact but of limited extent, rated negative, minor and long term duration.

Impacts on Erosion and Deposition

The benefical impact of bank protection structures is the control of bank erosion to prevent shallowing of the waterways. Additionally, the bank protection will also protect properties along the river bank. This is a positive impact, minor of long term duration. However, river bank protection has the potential to upset the natural process of bank erosion and deposition. This project under the NDTDP will have cumulative impact on reduction of sediment load of the rivers since it will increase the length of protected bank in the stretch of Corridor 1.

Figure 5-4. Profile of the proposed Bank Protection



Impact on Hydrology

Impervious bank protection may hinder the exchange between surface water and groundwater.

Impact on Surface Water Quality

The construction of the bank protection can affect water quality when work is done below water level. The water quality degradation will be mainly due to suspended sediment due to disturbance of the soil along the bank. This impact is minor since it will affect a limited area and will be short term.

Impact on Important Habitats

The construction of the bank protection will not have any direct impact on important habitats / protected areas. The protected areas along the coast of the Red River Delta, distantly located from the construction area.

Impact on Aquatic Flora and Fauna

The construction of the heavy and impervious bank protection can eliminate spawning areas along the river bank and it can also displace fauna that inhabits the water's edge. Impact is negative, minor, long term duration.

Impact on Agricultural productivity

The construction of the bank protection will require a slope of 1:4 (1m vertical for every 4m horizontal). In the case of Corridor 1, where the river bank height reaches 3 or 4m, the bank protection will likely occupy a land strip of about 12 – 16m. This strip will be graded and will be permanently occupied by the bank protection structure. With a length of 6,545m and a width of average 14m, land requirement is 91,630m^2 or 9.2Ha. This will be permanently acquired. Assuming construction site requirements of 0.5Ha at each location, there will be an additional need for temporary land acquisition of about 2.5Ha.

Impact on Land Use

The bank protection will permanently convert an agricultural strip of land along the river and will preclude the future use of this land for production. Considering the relatively limited land area that will be affected, this impact on land use is classified as minor, negative and long term duration.

Impact on Historical and Cultural Resources

The bank protection will not affect any historical or cultural resources. However, it will have negative impacts on the aesthetics because it will look unnatural. This impact is considered negative, long term, of minor significance.

5.9 Impacts of Groins

Groins are structures that are constructed along the channel bank to locally change river conditions, thereby creating flow acceleration and promoting scouring (H. Zhang, et la. 2005). Groins are an ideal means of obtaining navigable depths of water and given directions of flow with as few detrimental environmental impacts as possible. The construction of transverse dykes and training structures often has the effect of making other river engineering operations, e.g. dredging, unnecessary.

Impacts on Air Quality

The Impact of outcrop cutting on ambient air quality will emanate from the operations of diesel fuelled heavy equipment, like excavators. Heavy equipment and motor vehicles have to comply with TCVN 6438-2001. This impact is minor, negative and of short term duration.

Impacts on Topography/morphology

Groins affect the river morphology in two ways. Firstly, groins function as local obstructions. The direct result is local scour holes at the toes of all the groins. Secondly, a group of groins lead to the narrowing of the channel width. Due to this kind of narrowing, the longitudinal velocity in the main channel is intensified. As a result, significant degradation of the main channel takes place. In contrast to the erosion, deposition area is concentrated along the bank in the groin fields and the downstream area (H. Zhang et al 2005). The impact is rated positive since it is the desired effect, minor and long term duration.

Impacts on Soils

No impact on soils and soil quality is predicted.

Impacts on Erosion & Deposition

The construction of groins will alter the erosion and deposition in the specific segments of the rivers. A laboratory experiment showed that scouring occurs at the toes of groins with sediments being deposited in the groin field. This effect will occur only in the area of the groin field. This impact is rated positive since this is the desired effect to minimize maintenance dredging, minor and of long term duration.

Impacts on Sediment Transport

The groin prevents deposition by concentrating flow and increasing streamflow velocity, hence sediments will be transported farther downstream and will deposit when condition is favorable for deposition. This impact will prevail only in a relatively short section of Corridor 1. This impact is positive, minor, long term duration.

Impacts on Stream Sediment Quality

No direct impact predicted.

Impacts on Hydrology

The main purpose of groins is to modify flow characteristics in specific parts of the river. It concentrates the flow to increase streamflow velocity to induce scouring. The change in flow dynamics will depend on the design, orientation and type of groins that will be constructed. Impact is rated positive, minor, long term duration.

Impacts on Surface Water Quality

During construction, installation of the groins will have minor negative and short term impact on water quality. Pollution of surface water quality can come from discharge of waste water from construction, disturbance of river bed during construction which can re-suspend fine sediments. This is however confined to a relatively small area due to river flow and dilution.

Impacts on Groundwater

No direct impact on groundwater is predicted.

Impacts on Groundwater Quality

No direct impacts predicted.

Impacts on Important Terrestrial habitats

No direct impacts predicted.

Impacts on Protected terrestrial plants and animals

No direct impacts predicted.

Impacts on Protected Wetlands

No direct impacts predicted.

Impacts on Aquatic Plants & Animals

The construction of the groins will eliminate benthic communities in specific sites. But in the long term it is known to have beneficial impacts on aquatic life. There are studies indicating that stone groins provide a more favorable habitat for river micro-organisms and fish than does blanket revetment (McCollum R.A. et al. 1987).

Scientific design of groins may greatly improve the aquatic habitats through the effective control of the hydraulic parameters and sediment transport processes. For instance, Shields et al. (1995 in H. Zhang et al. 2005) documented significant increases in fish numbers, sizes, species and the area of aquatic habitats around groins after adding some complements to an existing experiment project. In the Yodo River basin, historically built groins are found to have formed satisfactory environments for the flora and fauna in the river system (H. Zhang, et al., 2005)

Scouring that occurs at the toes of groins is believed to have beneficial effects on aquatic organisms. Live-bed scour condition does not occur as frequently as clear-water scour condition in most alluvial rivers, but it has obvious and long-lasting impact on the channel characteristics and riverine ecosystem. This is due to the facts that under live-bed scour condition (i) flowing water transports large amounts of nutrients on which the aquatic inhabitants feed; (ii) there is a great change of the water depth, velocity and shear stress distribution which has a potential effect on the habitat suitability and (iii) there is a significant change of bed forms, substrate and space availability which influences the benthic invertebrates, fish and macrophytes. .

For a highly disturbed river section, the overall impact of groins is major, positive and long term.

Impacts on Agricultural Productivity & LIvelihood

No direct impact predicted.

Impacts on Land Use

No direct impact is predicted.

Impacts on Historical and Cultural Resources

No Direct impact is predicted.

Impacts on Occupational Health

Physical hazards involved during the operation phase include noise, temperature, vibration, ergonomic stress and occupational accident and injuries. Noise is generated from the machines of the plant facilities and motor vehicles. Workers will be exposed to the heat of running equipment, machines and vehicles. Moving machine and vehicles expose workers to vibration.

Impacts on Public Health and Safety

Impacts on public health and safety are considered minor, negative and short term duration. Public maybe exposed to certain health and safety hazards during construction. Workers may carry and transmit certain diseases to the local people. Also, non-workers may wander into the construction site and maybe exposed to hazards of operating heavy equipment, noise and vibration.

The presence of the work vessel for the duration of the activity will constitute a navigational obstruction. This impact is low magnitude due to the short duration of the impact and that the river channel is wide with width reaching about 1 km and river traffic in this section of Corridor 1 is relatively light as compared to the downstream sections.

5.10 Impacts of Removal of Obstructions

Impacts on Air Quality

Impacts on air quality will emanate from the operations of vehicles and heavy equipment that will be used in the construction of the groins. Impact is minor, negative and short duration.

Impacts on Hydrology

Impact on water movement is predicted to be minor. Impact predicted to be very localized but could be long term.

Impacts on Surface Water Quality

Minor impact on surface water quality. Retrieval operations may stir up sediments and cause turbid water condition.

Impacts on Aquatic Plants & Animals

Minor negative impact since the rocks and sunken vessels may have served as shelters for fish and removal will deprive fish of shelters. However, fish and other motile organisms can move away to areas for sheltering.

Impacts on Occupational Health

Physical hazards involved during the operation phase include noise, temperature, vibration, ergonomic stress and occupational accident and injuries. Noise is generated from the machines of the plant facilities and motor vehicles. Workers will be exposed to the heat of running equiuyjjpment, machines and vehicles. Moving machine and vehicle expose workers to vibration.

In addition, since work will be around water, workers are exposed to hazards like drowning.

Impacts on Public Health and Safety

Impacts on public health and safety are considered minor, negative and short term duration. Public maybe exposed to certain health and safety hazards during construction. Workers may carry and transmit certain diseases to the local people. Also, non-workers may wander into the construction site and maybe exposed to hazards of operating heavy equipment, noise and vibration.

The presence of a work vessel during construction may constitute a navigational obstruction. This impact is low magnitude due to the short duration of the impact and that the river channel is wide with width reaching about 1 km and river traffic in this section of Corridor 1 is relatively light as compared to the downstream sections.

5.11 Impacts of the Raising of Duong Bridge

Impacts on Traffic

The lifting of the Duong Bridge will not have significant impacts on the environmental components but will however have significant short term impacts on socio-economics, e.g. transport and accessibility. Duong Bridge is the access into Hanoi for those coming from Bac Ninh and Bac Giang. It is also a major route of agricultural products (mainly fruits) from Bac Giang.

Partial closure of Duong Bridge will cause traffic problems and will delay travel of people and goods into Hanoi. Traffic can be diverted to Phu Dong Bridge if Duong Bridge will be totally closed during improvement. This will lengthen travel time from Hanoi to Bac Ninh and Bac Giang.

Impacts on Noise and Air Quality

There are receptors at both approaches of the Duong Bridge. The construction will generate nuisance noise and emissions from operations of construction equipment. This is a negative, short term, minor impact.

Impacts on Occupational Health

Physical hazards involved during the operation phase include noise, temperature, vibration, ergonomic stress and occupational accident and injuries. Noise is generated from the machines of the plant facilities and motor vehicles. Workers will be exposed to the heat of running equipment, machines and vehicles. Moving machine and vehicle expose workers to vibration.

Impacts on Public Health and Safety

Impacts on public health and safety are considered minor, negative and short term duration. Public maybe exposed to certain health and safety hazards during construction. Workers may carry and transmit certain diseases to the local people. Also, non-workers may wander into the construction site and maybe exposed to hazards of operating heavy equipment, noise and vibration.

5.12 Impacts of the Operations Stage

The use of the Corridor 1 for navigation will have impacts on the following environmental components:

Impacts on Air Quality

Vessels are diesel fuelled and generates emissions consisting of TSP, CO, NO_2, CO_2, hydrocarbons. This is a minor negative impact, but long term duration.

Impacts on Erosion and Deposition

The barges and other vessels will generate wakes. The wakes and waves generated by moving water vessels may cause bank erosion. The result of a study done on wave heights caused by moving water vessels is shown in **Table 5-9**. The following table was taken from the Coastal Engineering Manual and gives an indication of the influence of vessel characteristics and speed of travel on the maximum wake height (Hm). Two values of wave height are provided, the first measured 30m from the vessel and the second 150m away. This is a minor negative impact, but long term duration

Impacts on Water Quality

Discharge of oily bilge water and wash water from the vessels causes water quality degradation. The presence of oil in ports of Corridor 1 indicates the possible contribution of vessels in oil pollution of the waterway. This impact ranges from minor to moderate and could be of long term duration. In addition disposal of cargo residue can also cause localized degradation of water quality. Disposal of solid waste in the river will also contribute to degradation of water quality and impairment of the aesthetic quality of the river.

Table 5-9. Influence of vessel characteristics and travel speed on wake height.

Vessel	m/s	30m	150
Cabin Cruiser			
length-7.0m	3,1	.2	.1
beam-2.5m	5.1	.4	.2
Draft-0.5m			
Coast Guard Cutter			
length-12.2m	3.1	.2	.3
beam-4.0m	5.1	.5	.3
Draft-1.1m 7.2	7.2	.7	
Tub Boat			
length-13.7m	3.1	.2	.1
beam-4.0m	5.1	.5	.3
Draft-1.8m			

Note: The above data are from tests conducted at water depths ranging from 11.9 to 12.8m.
Source: J. Murphy, G. Morgan and O. Power 2006

Propeller wash, specifically in shallow riverways, can cause resupension of sediments in the water column.

Impacts on Protected Areas

The coastal navigation lane from Hai Phong to Quang Ninh goes through the portion of the Cat Ba and Halong Bay. The following photograph shows heavy boat traffic in the bay. Note the coal barge amidst boats carrying tourists. The coal barge is from Quang Ninh and will likely deliver coal to one of the thermal power plants.

Discharge of oily water and the disposal of wastes overboard may possible affect the water quality within the protected areas. Aside from impacts on water quality, impacts on marine life, such actions also affect the aesthetic quality of a tourist destination like Halong Bay.

Figure 5-4. Mixed Boat Traffic of Cargo Vessels and Tourist Boats in Halong Bay

6 Analysis of Alternatives

6.1 Alternative No.1 -"No Waterways Improvement"

"No new action" is always an alternative and often it compares favorably in a purely economic analysis. However, there can also be significant non-economic impacts from such an approach which makes a straightforward evaluation more difficult. The "No Improvement" alternative will mainly involve continuing the current activities.

Corridor 1 can still be used without improvement. However, the limitations to navigation in terms of capacity will continue to prevail. The "no project option" means that periodic excavation of the river channel needs to be carried out for safe navigation. One major concern with the "No Project Option" is how well can the present situation enhance safety of the river navigation, mitigate environmental impacts and enhance river transport in support of the economic development of the Northern Delta.

Environmental Impacts: "No new action" preserves the existing status quo of environmental impact versus benefit, whatever that balance might be. Degradation of river's water quality will continue, bank erosion and sedimentation will proceed at present rates. Periodic minor disruption will result from maintenance dredging and disposal/filling. However, negative impacts from all the activities associated with the proposed waterways improvement activities will avoided.

However, "No New Action" will mean foregoing the economic and environmental benefits that are expected to be derived from an improved waterway in Corridor 1.

6.2 Alternatives for Waterways Improvement

Major bottlenecks and safety hazards along the three corridors under consideration consist of bridges with too narrow span or too low vertical clearance, narrow sections, sharp bends etc. Other constraints are bank erosion and sedimentation. Bank erosion, which is often triggered by the destruction of the natural vegetation, is sometimes destabilizing the roads and houses parallel to the canals. Sedimentation is a problem at specific locations, often in areas with brackish water or areas with a sudden decrease in flow velocity. Below a general description of the main improvement works are given followed by the proposed mitigating measures.

The basic options for improvement works waterways improvements for meeting the navigation requirements (mainly during low waters), consist in general of measures aiming at:

- Waterway deepening;
- Waterway widening;
- Waterway realignment;
- Slope stabilization;
- Groins;
- Providing aids to navigation;
- Other measures.

The abovementioned waterway improvements measures are briefly discussed below.

6.2.1 Waterway deepening

Waterway deepening in the canals can be achieved by dredging. When considering dredging, the deposition of the excavated material, on land or in the water should be given due consideration. To maintain the waterway some maintenance dredging will be required, especially in waterways where the flow velocities are limited. The actual locations where deepening of the waterway is foreseen in case it is earmarked for improvement, is depends on the LAD requirements.

6.2.2 Waterway widening

When upgrading the canals to the required classification, widening of some waterways will be required. Of the waterways comprising the corridors, width restrictions can be found in some canals as well as in some rivers. In the rivers limitations in width are mostly in river bends which need widening to ensure safe navigation. In specific cases, e.g. where very high costs are involved, a smaller width should be acceptable, but sailing speed will be restricted and proper channel marking, to ensure safe navigation. In general widening of waterways requires dredging.

6.2.3 Waterway realignment (e.g. bend improvement)

Re-alignment of existing waterways will generally involve considerable dredging and lead to high costs. Realignments should therefore be avoided if one is to avoid these high costs, unless there is a justification from an environmental, social and/or economic point of view.

The main reasons can be given for choosing major re-alignments are the following: Bends in the waterways have a radius that is too small to facilitate safe navigation for the envisaged water transport. In specific cases, e.g. where very high costs for realignment are involved, one should consider accepting a smaller bend radius, but imposing sailing speed restrictions and proper channel marking, to ensure safe navigation. Very high costs are associated with relocating families and/or facilities where widening is required.

6.2.4 Slope stabilization

In certain cases the navigability of the waterways can be endangered by bank erosion, as bank erosion (widening) could signify reduction in water depth. Furthermore some waterway banks will need to be stabilized after improvement of the waterway as:

- Existing banks and their protection have been removed and therefore require protection;
- Increased loading of the banks due to increases in navigation intensity as well as increases in vessel sizes, causing erosion.

6.2.5 Groins

In some cases the rivers are meandering. In case this meandering comes too close to the bank, erosion can occur. In addition the meandering river can cause problems for navigation. To improve navigation in a meandering river groins are a good solution because they:

- Increase the navigable depth by concentrating the flow;
- Avoid meandering of the river;

- Influence flow directions.

Providing aids to navigation Aids to navigation can improve safety for navigation as well as improving time available for navigation (night navigation). Along the waterways comprising the corridors aids to navigation are limited and considerable improvements can be made.

6.2.6 Other measures

In addition to the abovementioned measures other measures could be taken to improve navigation viz.:

- Prevent encroachment on the waterways;
- Provide mooring areas to prevent vessels from mooring in the waterway;
- Remove obstructions in the navigation channels; and
- Improvements of aids to navigation shall also be done.

6.3 Types of Bank Protection

Typically, eroding river banks are stabilized in a limited number of ways, according to the standards as set by MARD. A very common type of bank stabilization above the water line is the application of concrete or masonry grids, filled up with a rockfill revetment of neatly placed and secured stones. This type of stabilization work is called 'Tsu Phan' in Vietnamese. Securing is done by wedging small stones into the remaining pores. This rockfill layer is provided with an underlying filter layer of crushed gravel. The use of a geotextile, as separation between gravel layer and soil, was observed at some places, but was absent at other places. At lower levels of the bank, rubble is dumped to fill up the slope to the desired angle and /or gabion or bamboo packed stone sausages ('dragons') are applied. Before placing the stabilization, the slope above the waterline is re-adjusted to the desired slope angle (usually around 1: 2.5) by removing or replenishing the soil.

There are quite some advantages to this method, such as easy construction without measuring equipment after the grids have been installed. Another advantage is that the rockfill revetment is enclosed by the concrete or masonry squares. Along some river stretches drainage ditches are made first, neatly positioned and providing a reference position for the subsequent construction of the grids. Apart from some incidental subsidence this type of bank protection seems to be a fairly reliable means of protection.

Another type of slope protection is a partly open system that allows vegetation to grow through, e.g. a Vetiver grass test section. Continuous layers of rockfill, without concrete or masonry grids, are applied on occasion. Vegetation growth may be that abundant after some time that such a protection is hardly visible anymore in due time.

The application of a limited number of groins, meant as bank protection, can be observed as well. Sometimes they act as a flow shelter for protruding points, e.g. landings for ships to protect economic assets. In some cases, however, they seem to serve as a means for protection of eroding river banks. The usefulness of the latter type of groins can be doubted, as they generally are relatively short, sometimes too low and very costly. Moreover, the spacing between the groins is often too large, with the consequence that additional bank protection may be required between the groins.

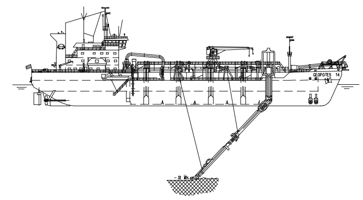
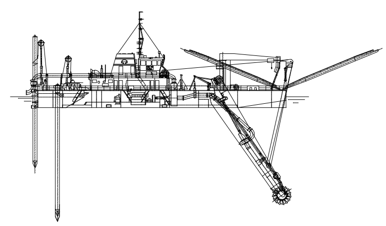
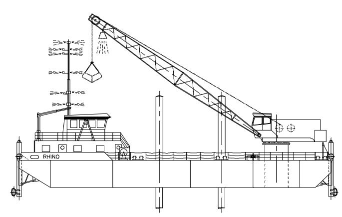
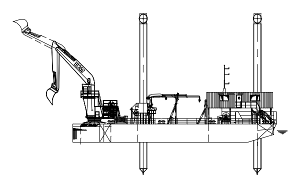
When protecting the river bank locally, the recommended choice between groins and revetments leads easily to revetments. Reasons are:

- Revetments are much cheaper for larger water depths;
- Groin systems have a negative impact on flood levels (since their height should at
- least reach the floodplain level to be effective as bank protection);
- Groin systems cause much more morphological impact, since they actively constrict the river width) and may enhance bank attack downstream of each groin if the spacing is too large;
- The most heavily eroded parts in the Red River system are the banks on the outer bends; Constructing groins there constrict even more the already limited navigation width.

6.4 Dredging Methods and Associated Operations

Various dredging methods were analyzed with respect to suitability in the various rivers of the Northern Delta. The various types of dredgers are described in the following table.

Table 6-1. Types of Dredgers

Type	Description
Trailing suction hopper dredge A trailing suction hopper dredger (TSHD) trails its suction pipe when working, and loads the dredge spoil into hoppers in the vessel. When the hoppers are full the dredger proceeds to a disposal area and either dumps the material through doors in the hull or pumps the material out of the hoppers.	
Cutter suction dredger A cutter-suction dredger's (CSD) suction tube has a cutter head at the suction inlet, to loosen the earth and transport it to the suction mouth. The cutter can also be used for hard surface materials like gravel or rock. The dredged soil is usually sucked up by a wear resistant centrifugal pump and discharged through a pipe line or to a barge.	
Grab/Clamshell dredger A grab dredger picks up seabed material with a clam shell grab, which hangs from an onboard crane, or is carried by a hydraulic arm, or is mounted like on a dragline. Most of these dredges are crane barges with spuds.	
Backhoe dredger A backhoe/dipper dredge has a backhoe like on some excavators. A crude but usable backhoe dredger can be made by mounting a land-type backhoe excavator on a pontoon.	
Bucket dredger	A bucket dredger is a dredger equipped with a bucket dredge, which is a device that picks up sediment by mechanical means, often with many circulating buckets attached to a wheel or chain.

Currently, the common dredging method used by Vietnamese contractors in maintaining inland waterways is the cutter suction dredgers. These dredgers are able to operate during wet and dry season provided river current velocity is below 2.5m/s. Under this condition, the dredge can operate efficiently.

In actual operations other types of dredgers are used in combination with the cutter suction dredge depending on the condition of the area to be dredged. In areas where widening or bend cutting has to be done, top soil layer may contain large pieces of materials that cannot be handled by the suction dredge. In such case the grab/clamshell dredger is used to remove the large materials. The cutter suction is then utilized for the removal of bulk of the soil and sediments. The grab/clamshell dredger is also suitable for works in restricted location like areas close to bridge foundations. But clamshell dredger is not suitable for large scale dredging requirement because of its low capacity and the need for double handling of dredged materials during disposal.

6.4.1 Transport of Dredged Materials

There are a number of means of transporting dredged materials to the storage/disposal area. The methods are conveyance through a pipeline, by barge or through the use of hopper dredges.

Pipeline

A floating or submerged pipeline is laid from the dredger to the disposal or reclamation area. At the disposal site the pipeline is connected to a spreading pontoon or an onshore pipeline system. The maximum length of the pipeline depends on the mixture concentration, particle size, installed pump power and pipeline diameter. A floating pipeline is an obstruction to other traffic. Optionally a sunken pipeline can be used in order to avoid traffic interference. Floating pipelines are vulnerable to climatic conditions. Depending on local circumstances the economic maximum lengths of pipelines are some 5 km. Wear and tear has to be taken into account due to the abrasing effect of the soil- water mixture.

Barges

The dredger at the borrow area disposes the soil into barges. The barges are either self propelled hopper barges or towed hopper barges. During the hydraulic filling of the barges a percentage of losses, especially of the fine fraction of the dredged material can be expected.

Hopper dredger

The dredger at the borrow area has his own hopper aboard and can transport the sand itself without double handling. Factors that have an impact on the suitability of the different types of equipment for the transport of sand are:

- available water depth
- sensitivity to currents and waves
- interference with nautical traffic
- distance between borrow area and disposal or reclamation site
- environmental impact

6.4.2 Unloading and placing

The materials can be disposed by either one of the following methods:

Direct placing

Direct placing is placing straight from the means of transport into a disposal or reclamation area. This could be carried out with a dredger with pumps onboard that have usually sufficient power to pump the soil water mixture over a distance ranging from 1 to 4 km.

Alternatively, a dredger can cast the material aside to areas next to the dredging area. In case of transport with barges the unloading of the vessels is carried out with a barge suction dredger. This equipment, stationary at the mooring place fluidizes the sand in the hopper by means of water-jetting. The barge then pumps the water-sand mixture into the designated place through a pipeline. Turbidity caused by return water and overflow losses are common for this option. Barges and hopper dredger can also dump the material at a suitable dump location.

Indirect placing

This is the placing from the means of transport into the works by double handling and used in case of a reclamation. The sand is temporarily stored in an underwater stockpile area close to the reclamation area. The barges or trailing hopper suction dredgers dump the sand into the stockpile with sufficient depth. A (cutter) suction dredger will then remove the sand from the stockpile and will pump it ashore. The dumping of the sand in the underwater stockpile causes turbidity and losses of especially the fine fraction of the sand can be expected. Factors that have an effect on the suitability of the different types of equipment for the placing of the sand:

- available water depth;
- sensitivity to currents and waves;
- interference with nautical traffic;
- distance between point of delivery and designated location

6.4.3 Disposal of dredged material

There are various options for disposal of dredged material from inland waterways. Several are listed below, viz.:

- open and contained disposal at sea or in the waterway;
- agitation dredging;
- open and contained disposal on land.

Open and contained disposal at sea is not considered to be feasible options as the distance between the dredging area in the waterway and the open sea is very large and would imply high transportation costs. Furthermore, the material to be dredged contains pyritic soil and large scale dumping of this type of material at sea would be environmentally unacceptable.

Open and contained disposal in the waterway are not considered to be feasible options as the dimensions of the waterway are not sufficient to permit large scale dumping of the material in the waterway. Material could be dumped in the Bassac and Mekong rivers as these are sufficiently deep to place material however, large scale dumping of pyritic material in these rivers is also environmentally unacceptable.

Agitation dredging is not a feasible option for disposing of dredged material from the waterways under consideration. The flow velocities in the canals are limited and subject to tides, and therefore material agitated into suspension would most likely not easily be carried out to sea or the major rivers, without settling down beforehand. Furthermore the enormous turbidity created by agitation dredging may cause problems to aquatic life in the waterways.

Open disposal of dredged material on land is not recommended as surplus dredge water used to hydraulically transport the dredge material through the pipeline would drain to low lying areas. These low lying areas are often used for agriculture and the acidity of the surplus dredge water could negatively affect this. In addition, the material is very fine grained which means it will spread over very large areas during the reclamation process.

Considering the above, there remains only one option for material disposal and that is contained disposal on land. When the transportation distance is kept short by disposal on the adjacent canal bank, costs can be kept low. The material will be contained between bunds, meaning the process of dewatering the disposal area and the distribution of material over the land can be controlled. This is essential when disposing this material in an environmentally friendly way.

A contained clay disposal area comprises a perimeter dyke which can be previously constructed by draglines from material excavated from the disposal site. The ditch created by the excavation of material will form the drainage ditch for the disposal area which is located on the outside of the perimeter dyke.

The disposal area is normally divided into a number of sub-containment areas by a suitable arrangement of internal bunds. These sub-containment areas are filled in sequence during the dredging operation. This is required as once a sub-containment area is filled the surplus dredge water can not be discharged directly to the waterway as suspended sediments have not had sufficient time to settle. One day should be sufficient for suspended sediments to settle and then the surplus dredge water can be drained from the area.

The thickness of dredged material deposited in a continuous operation is usually limited to about 1.5 m as dewatering of this fine grained clay becomes increasingly difficult and time consuming as the thickness increases.

Following the experiences at the Inland Waterways and Port Modernization Project for acid sulphate soils the dykes will be covered with PVC membrane to ensure drainage does not occur through the dyke walls and a lime layer will be used to cover the material.

The suitability of a discharge area is determined by environmental, social and economic factors. In respect of the techno-economic aspects of a reclamation area it can be concluded, that in general waste land and agricultural areas with yearly crops are most suitable as (temporary) disposal areas. The costs for the use of this land can usually be limited to crop compensation for the land users but experiences at the Inland Waterways and Port Modernization Project show that this can cause delay and problems with obtaining the land when the people consider the compensation too low. At this project the compensation for roads was approximately four times higher than for waterways, which was difficult to explain to the people. Therefore the assumed costs for compensation are chosen in line with the road compensations.

On the other hand disposal areas can have socio-economic benefits. In low-lying areas with frequent flooding, the dredged soils may be used as landfill material which will raise the land of the people by approximately 1.5 m. Further people may sell the dredged material as building or landfill material. In this way disposal of dredging materials creates better living conditions for the poor and may induce urban economic development.

Further the Inland Waterways and Port Modernization Project experienced problems with finding large disposal areas because the land is divided and it is needed to negotiate with all the different land owners. While it was estimated that 20 disposal areas would be required, at the end of the project approximately 500 disposal areas were used, covering the same total area. Therefore at this moment the suitable areas for disposal are not identified in detail.

Most stretches of the waterways are characterized by the presence of a road at one side of the canal, while along the roads and canals most houses are located. Behind the houses usually the agricultural fields are located, which can be, (and in fact are already often used during maintenance dredging campaigns), as reclamation area.

Densely populated areas and high investment agricultural areas should be avoided as much as possible. Dredging in large villages or towns, or at locations near extensive coconut plantations will require consideration of alternative disposal techniques. At these locations the use of grab dredgers and barges for transport will be a more feasible option.

7 Environmental Management Plan

7.1 Background

Presented in the early parts of this chapter is the discussion on the management of the environmental impacts of the proposed activities in Corridor 1. This discussion is followed in section 7.4.4 by the actual Environmental Management Plan for the entire corridor in matrix form, which will be used throughout project implementation, starting with the detailed engineering design stage, through construction and into the operations and maintenance stages. This chapter also contains a Dredge Management Framework in section 7.4.3, which sets out the processes to be followed for preparation of the Dredge Material Disposal Plan (DMDP) and describes the required contains of the DMDP. The DMDP is required to ensure the approximately 2.7 million cubic meters of spoil material that will be dredged from Corridor 1 is disposed of in an environmentally and socially sustainable way. The DMDP is in effect a critical part of the EMP and both are crossed referenced. Finally, at the end of this chapter, a Construction Management Plan (CMP) is included, which is also referenced in the EMP. The CMP is produced to ensure enough specificity and guidance is given for the management of the common environmental impacts associated with all aspects of construction.

7.1.1 Mitigating the Impacts of Dredging

Mitigation of Impacts of Dredging - Selection of Dredging Method

The level of turbidity generated by dredging is partly dependent on the type of dredge used. To minimize turbidity, hydraulic cutterhead suction dredge will be used. Experience with hydraulic cutterhead shows that maximum concentrations generally remain less than 500 mg/L and bottom suspended-sediment plumes are limited to within 500 m of the dredge (Havis 1988; LaSalle 1990 in DOER 2000). Mechanical dredging on the other hand can cause much more severe condition.

Mechanical dredges which generate suspended-sediments through the impact of the bucket on the bottom and withdrawal from the bottom, washing of material out of the bucket as it moves through the water column and above the water surface, and additional loss when the barge is loaded. A suspended- sediment plume associated with clamshell dredging at its maximum concentration (1,100 mg/L) may extend up to 1,000 m on the bottom (Havis 1988; LaSalle 1990; Collins 1995 in DOER 2000). Since clamshell is required for working in tight areas it cannot be avoided, it should be used selectively.

Implementation of this environmental management will be assured by including this requirement in the Project Implementation Plan and in the Tender Documents.

Timing of Dredging Activities – Mitigation of Impacts on Aquatic Life

For protection of Corridor 1's aquatic life, timing of dredging will consider the known seasonal biologic processes. The seasonality of the known biologic processes is enumerated in the chart below. Most of the potentially environment sensitive processes takes place during the flood season. To mitigate possible impacts on aquatic life, dredging will be carried out between October to June or July, avoiding the peak of the flood season. However, shold there be a need to carry out dredging during the peak flood season, it is recommended that work be done inland rather than in Han River. Being close to the sea, Han R is part of the estuary and is expected to be more biologically active than the upper reaches of the Red River during that time of the year.

7.1.2 Mitigating the Impacts of Spoils Disposal

Managing the Spoils

As part of environmental management, a dredge material disposal plan needs to be prepared by the detailed engineering design consultant. The plan will contain, among others, containment plan, lists of possible diposal sites, permanent & temporary, persons or projects that may have demand for fill materials or construction materials; private land stages that are willing to accommodate or taken on clean sediments. The process to be followed for the preparation of this plan and the conatins of this plan are presented in the Dredge Management Framework which can be found later in this chapter (see 7.4.3.).

Management of dredged material shall be dependent upon the quality of the material. There are various options for disposal of dredged material and the recommended methods for particular quality of spoils are listed in **Table 7-1**.

Other options such as open and contained sea disposal, river disposal, agitation dredging and open land disposal have been considered. Open and contained disposal at sea is not considered to be feasible options as the distance between the dredging area in the waterway and the open sea is very large and would imply high transportation costs. Open and contained disposal in the waterway will be utilized to dispose about 10% of the dredge in deep water channels.

Agitation dredging is not a feasible option for disposing of dredged material from the waterways under consideration. The flow velocities are limited and subject to tides, and therefore material agitated into suspension would most likely not easily be carried out to sea or the major rivers, without settling down beforehand. Furthermore the enormous turbidity created by agitation dredging may cause problems to aquatic life in the waterways.

Table 7-1. Management of dredged materials according to quality[5]

Highly Contaminated	Moderately Contaminated	Lightly Contaminated	Clean Sediments
Landfill at controlled sites (silts and clays)	Land reclamation (capped)	Land Reclamation	Land Reclamation
	Land Fill (capped)	Land Improvement	Landfill (capped)
	Replacement Fill (e.g. mines) (silt and sands)	Habitat Creation (capped)	Land improvement (sand and silt)
		Construction (cleaned sands)	Habitat creation
		Beach Nourishment (sand)	Saltmarsh protection / regeneration
		Inter-tidal mudflats (silts, sand)	Construction (sand)

[5] Source: http://statistics.defra.gov.uk/esg/evaluation/materials/chapter7.pdf

Sea defence	Beach Nourisment
Coastal Protection	Inter Tidal Mudflats (silt, sand, clay)
	Sea Defence
	Coastal Protection

Open disposal of dredged material on land is not recommended as surplus dredge water used to hydraulically transport the dredge material through the pipeline would drain to low lying areas. The low-lying areas are often used for agriculture and the acidity of the surplus dredge water could negatively affect this. In addition, the material is very fine grained which means it will spread over very large areas during the reclamation process.

Polluted spoils will be disposed. When the transportation distance is kept short by disposal on the adjacent canal bank, costs can be kept low. The material will be contained between bunds, so the process of dewatering the disposal area and the distribution of material over the land can be controlled.

At this moment, some areas have been recommended to be considered as disposal sites. Among the sites recommended are the islands in the river and mined out clay and rock quarries. The possiblility of using these sites will be investigated during the detailed design stage.

As presented in **Table 7.1**, contaminated sediments can be utilized as replacement fills in mined out quarries. There are major clay mines in Son Tay and in Gia Binh and Que Vo in the province of Bach Ninh which can be investigated for possible sites for replacement fill. Based on the number of kilns noted during the river trip last 01 December, there are large mined out clay quarries in this locality. The condition in these areas is shown in the following Google Earth imagery. **Photo 7-1** shows the bank of Kinh Thay R in Gia Binh where a large brick making industry is present. The brick factories are lined along the river bank. It is presumed that the clay quarries are very close to the kilns and hence close to the river.

In addition, there are rock quarries near the banks of Kinh Thay in Hai Duong and Quang Ninh.

For clean sands, use for construction is the most beneficial use particularly in the stretch of Duong River and Kinh Thay where dredging for construction material is very prevalent. Considering the volume of the sediment to be dredged, it is presumed that a temporary holding area shall be required.

The areas to be considered for temporary storage of sediments should be near the waterway and accessible by land. The various landing stages along Duong R and Kinh Thay R can take up some of the spoils and the rest could be stockpiled in other suitable areas. Outside of these land stages, some of the islands can possibly serve as temporary holding areas. Among the recommended areas is shown in the photo below. This is in Nghia Chi, Tien Du, Province of Bac Ninh. Another possible temporary repository is the island in Dao Vien, Que Vo in BAc Ninh. This has a land area of about 77 hectares as measured from the Google Earth imagery.

Photo 7-1 The photo shows the brick manufacturing areas along the banks of Kinh Thay in Gia Binh and Que Vo in the province of Bac Ninh

Photo 7-2. Possible temporary holding area for spoils, Nghia Chi, Tein Du, Province of Bac Ninh.

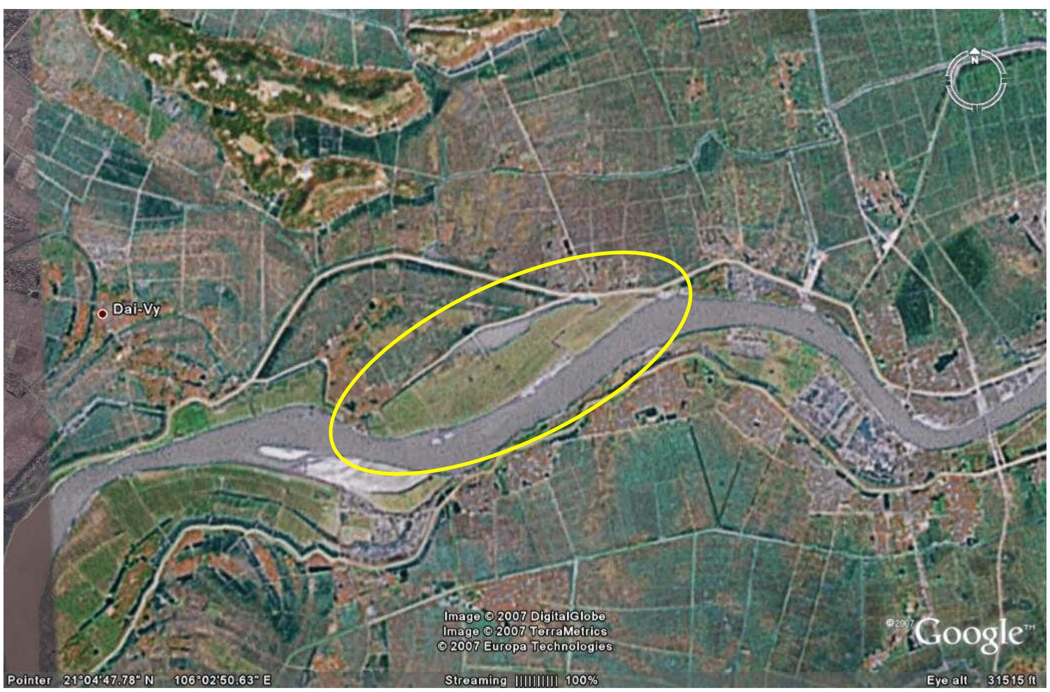
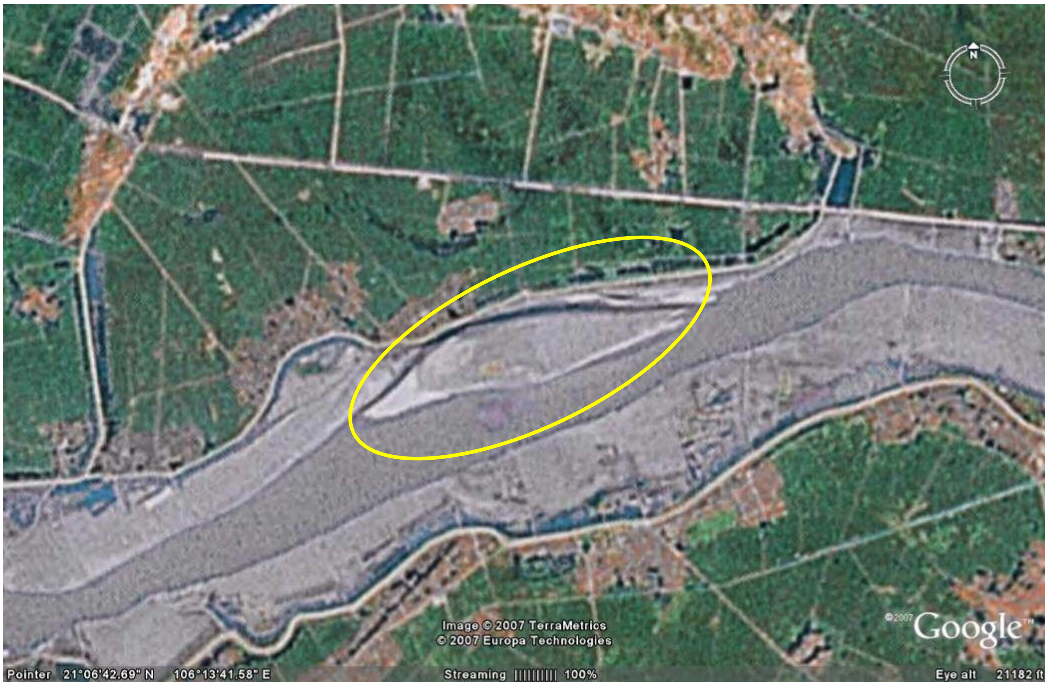


Photo 7-3 Another possible location of a temporary holding area is this island in Dao Vien, Que Vo, province of Bac Ninh.



The suitability of a discharge area is determined by environmental, social and economic factors. In respect of the technical and economic aspects of a selecting disposal sites area it can be said that in general marginal land and agricultural areas with yearly crops are most suitable as (temporary) disposal areas. The costs for the use of this land can be limited to crop compensation for the land users. But experiences at the Inland Waterways and Port Modernization Project show that this can cause delay and problems with obtaining the land when the people consider the compensation too low.

On the other hand disposal areas can have socioeconomic benefits, considering that the stream sediments to be dredged are generally compliant with soil and sediment quality standards. One beneficial use is that soils may be used as landfill material to raise elevations of flood prone areas. Furthermore, dredged material can be sold as building or landfill material. In this way disposal of dredging materials creates better living conditions for the poor and may induce urban economic development.

Containment of Spoils

A contained disposal area comprises of a perimeter dyke, which can be previously constructed by draglines from material excavated from the disposal site. The ditch created by the excavation of material will form the drainage ditch for the disposal area, which is located on the outside of the perimeter dyke.

The disposal area should be divided by bunds into a number of compartments. These compartments are filled in sequence during the dredging operation. Surplus water used for pumping the spoils should be contained for at least a day to allow fine sediments to settle.

The thickness of dredged material deposited in a continuous operation is usually limited to about 1.5 m as dewatering of this fine-grained clay becomes increasingly difficult and time consuming as the thickness increases. Following the experiences at the Inland Waterways and Port Modernization Project for acid sulphate soils and contaminated soils the containment areas should be lined with PVC membrane or clay lining to prevent seepage into the groundwater or through the containment walls.

These disposal areas can pose threats to public health before consolidation of the sediments. It is therefore important that sufficient measures are taken to prevent the exposure of local population to the spoils area.

Changes in bulk density of the soil will vary at different stages of the dredging, transport and placement processes. The alteration in density is caused by the formation of additional voids in the soils, which fill with water when it is disturbed. This usually means that the volume of the disposed material on the disposal site is higher than the in-situ dredged volume. This increase can be expressed as a percentage of the in-situ volume or as a ratio of the two volumes. The latter is known as the bulking factor. When hydraulic excavation and placement techniques are adopted, bulking can be much higher (1.30 to 1.50).

In order to determine the dimensions of the disposal sites an average bulking factor of 1.40 will be applied. The total required area of the disposal sites would be determined using the calculated dredging quantities plus tolerances, multiplied by the bulking factor, whilst using a fill height of 1.5m. For instance, a dredging volume of 1 million m^3 will require a 93 ha if the 1.5 m stacking height is followed and bulking factor is applied.

It is estimated that 20% of dredged material would have pollutants like heavy metals and need to be permanently stockpiled on land, and secured within bunds to stop any side effects from leaching out of pollutants. Given an estimated spoils volume of 2.7million cu m, 20% of this is 540,000 cu m and with an assmed containment cost of US$ 2.00 per cu m, total cost of containment will be US$1.08 million. It is anticipated that this cost can be substantially reduced if contaminated spoils are used as replacement fills for mined out quarries.

7.1.3 Environmental Management of Work Site

The environmental management of the work sites shall be the responsibility of the contractor nder the supervision of the PMU-W or its consultants. The Contractor shall regularly inspect the work sites for compliance with constructon management plan.

Mitigation of Impacts on Air Quality

The construction work will require the use of motorized vehicles and heavy equipment for construction. These are mostly diesel fuelled which emits CO, NO_2, SO_2, hydrocarbon, lead and particulate matter. The contractor will have to ensure that all the equipment supplied for the project complies with the Vietnamese Government standard for vehicle emission (TCVN 5939-2005). Prior to deployment, the equipment owner will have to submit service records of the equipment and results of emission testing.

Work will be done mostly during the dry season and hence it is expected that bare areas will be exposed resulting to dusty condition. Dust suppression should be done especially if there are human receptors near the construction area.

Selection of alignment of temporary access roads should take into consideration the presence of residences. As much as feasible, temporary access roads should be in places that are unpopulated or sparsely populated.

All vehicles transporting construction materials (sand, clay, cement, stones) should be covered to prevent dust dispersion. Installation and maintenance of mufflers on vehicles are necessary.

Concrete mixing plants and asphalt plants should be located over 200m from boundary of dense residential sites. Plant emission will have to comply with the Vietnam Standard for Air Emission (TCVN-5939-2005). Otherwise, plant will have to to install emission control equipment.

Spoils stockpile area should also be located away from residential areas to protect them from dust that may be generated by materials stockpile.

Compliance with air quality management should be one of the criteria for selecting equipment supplier and contractor. This condition should be stated in the Bid Document. As for staging areas, this should be specifically identified in the construction plan. This is the responsibility of the contractor.

Mitigation of Potential Impacts on Water Quality

Possible sources of pollutants from construction camps are wastewater from the workers' accommodation and contamination from spilled lubricants and fuel from equipment repair yard and fuel depot. To prevent contamination from these sources the workers' quarters should be provided with sealed septic tanks. While the equipment repair yard and the fuel depot should be provided with impervious flooring, containment wall and floor sump to collect oily wash water and to allow separation of solids.

These details should be contained in the construction plan to be prepared by the contractor.

Management of Construction Waste

Construction site should practice segregation and waste minimization. All materials that can be re-used and recycled should be segregated and sold. Residual wastes that cannot be recycled or re-used should be collected and disposed of in the municipal or city landfill. Hazardous wastes (spent solvents or used lubricants) should be disposed of in authorized disposal facilities. Contractor should coordinate with provincial people's committee for authrorization to use sanitary landfill.

This is the responsibility of the Contractor. This should be contained in the construction EMP to be prepared by the contractor.

Restoration of Land Occupied by Construction Camp / Staging Area

The use of the construction camp/staging area is only temporary, hence, at the end of construction period, the land will be returned to the landholder who can then resume the former productive use of the land. As such, the contractor should remove all equipment, structures, rubbish and obstructions and restore the land to its condition prior to use for construction. This condition will have to be included in the construction EMP that will be prepared by the Contractor.

7.1.4 Health and Safety Aspects

Occupational Health

Workers will be exposed to ergonomic stress, hazards of operating heavy equipment, exposed to heat and high noise level. Further, the workers will be exposed to overhead conditions, such as working underwater in flowing and low visibility water condition. They will also be exposed to hazards of heavy lifting. To protect and keep workers safe, the following shall be implemented:

- Workers shall be given orientation on safety procedures on job site;
- They shall be provided with personal protection equipment such as hard hat, safety shoes, ear plugs, masks when necessary, gloves and goggles;
- A first aid station with a trained emergency first responder shall be provided in the construction site;
- A safety officer shall be designated to enforce safety regulations in the construction site;
- Workers shall be provided with ample clean water;
- Hygiene facilities shall be available in construction site;
- An emergency warning system shall be instituted to protect workers from site emergencies and natural hazards.
- Evacuation plan for extreme emergency conditions shall be formulated.

Public Health and Safety

Protection of public health and safety should not be neglected. For this purpose the following shall be adopted:

- Construction site shall be off-limits to non-workers, warning signs shall be prominently posted along the site periphery;
- Disposal sites of contaminated spoils shall also be off-limits to people. An IEC will be implemented to inform the host community and warning signs will be posted.
- Health screening will be done for workers to prevent spread of disease to the host community;
- Use of illegal drugs shall be strictly prohibited in the construction site to prevent spread of HIV disease and other possible social problems.

For navigational safety, the dredging work should be announced in the Notice to Mariners so vessels will be forewarned of the presence of the dredger. The dredger should have the necessary navigational lights and signals. Fog is known to occur in the Red River delta and the dredger's crew should be aware of this.

The implementation of programs to protect occupational health and safety as well as public health and safety is the reponsbility of the Contractor.

7.1.5 Management of Impacts Due to Lifting of Duong Bridge

Traffic Impacts Management

A traffic management plan that will be implemented during the construction of Duong River should be prepared. The contractor shall be responsible for preparing the traffic management plan. The plan shall be approved by the PMU-W and by the Provincial Peoples' Committee and provincial road authority. The plan should contain rerouting plan and recommended alternative routes. It should also contain an IEC program so that the traveling public can be amply warned of the construction so that they can avoid the Duong Bridge or make other travel plans.

Partial closure of the bridge, if technically feasible, should be considered as a means for mitigating impacts on traffic. Alternative bridges to cross Duong River are quite distant.

Provision of temporary ferry crossing is another mitigating measure that can be implemented. This will provide motorists an alternative means of crossing Duong River while it is being lifted / constructed.

Impacts on Noise and Air Quality

To protect the people living near the approaches of Duong Bridge from nuisance noise and emissions caused by the construction, the following measures should be adopted: Construction activities that generate loud noise should only be done during daylight hours; workshops and staging areas and materials stockpile areas should be located at least 200 meters from residential areas.

Occupational and Public Health and Safety

See Section 7.1.3

7.1.6 Management of Social Impacts

The implementation of the waterways improvement in Corridor 1 will surely require acquisition of land, whether on a temporary or permanent basis. Recovery of land will have to be undertaken. With lands intensively used for agriculture, land users will be affected. However, it is not anticipated that works in Corridor 1 will physically displace residences.

Mitigation of Loss of Agricultural Land and Its Consequences

The NDTDP will have the potential to affect agricultural areas that are planted to rice maize, vegetable or orchards. Built-up areas or areas of historical and cultural significance occupy only a minimal proportion of the land area. Altogether there are an estimated 250 DPs (1,115 population) affected by permanent and temporary acquisition of about 108 hectares of primarily agricultural land.To mitigate the loss in income of the project affected households (PAHs) and social consequences of land acquisition, a proper Resettlement Plan (RP) will be prepared and implemented by the PMU-W. The suggested contents of RP are as follows.

Principles of RP

The legal framework governing land acquisition, compensation and resettlement in Vietnam consist of the following:

a. The Constitution of Vietnam, issued in 1993, confirms the right of citizens to own house and to protect the ownership of the house. Article 18 prescribes that the State shall entrust land to organizations and private individuals for stable and lasting use. Further, it stipulates that these organizations and individuals are responsible for the protection, enrichment, rational exploitation and economical use of the land. They may transfer the right to use the land entrusted to them by the State, as determined by law.

b. The Civil Code contains provisions on Property and Ownership Right in the Article 172 throughout Article 284.

c. The Land Law (No.13/2003/QH11), promulgated on December 10, 2003 by the State President as contained in order No.23/2003/L-CTN, prescribes land management and use. It supersedes the previously issued ordinances and decrees of the previous Land Law issued n 1993. The revision is also aimed at responding to the needs of the emerging land market. This law took effect in July 1, 2004. The amended Law on Land consists of 6 Chapters, 146 Articles providing for: the right of state to land and state management on land; regimes of land use; rights and obligations of land users; administrative procedures on land management and utilization and other provision inspections, detailing with dispute, complaint and denunciation and settlement of breaches on land.

d. The Decision No. 181/2004/ND-CP dated October 29, 2004 which contains the Government on guidelines in the implementation of the Law Land.

e. “Land recovery” is the term equivalent to land acquisition in Vietnamese legal framework on land. Article 4 of the new Land Law defines “Land Recovery” as the State’s action based on an administrative decisions to retrieve land use right or recover land already assigned to organization, commune, ward or township People’ Committees for management according to the provision of this Law.

The Land Recovery Process

The State shall recover land, pay compensations, clear ground after the land use planning and/or after plans are publicized or when the investment projects have been approved by competent State agencies.
The State Agencies shall notify land holders of the State’s intent to recover the land at least ninety days before actual recovery. The State agency will have to inform the affected people within this time frame the reason for recovery, the overall schemes for compensations, ground clearance and resettlement.

After the decision on land recovery and schemes for compensations, ground clearance and resettlement, have been agreed on and approved by the competent State agencies and made public, the land holder must abide by the decisions on land recovery.

In case the persons with land to be recovered refuse to abide by the land recovery decisions, the People’s Committee shall issue orders for coercive execution of the decision. The person subject to coercive land recovery must abide by the decisions on coercion and have the right to lodge their complaints.

Compensation Principle

General rules of compensation are laid down in Article 42 and 43. The articles state that persons with land to be recovered shall be compensated with the assignment of new land with the same use. If there is no land to compensate the affected landholder, a monetary compensation shall be paid based on the land use right value at the time of issuance of the recovery decisions.

In case land being recovered is used by households or individual landholders for production and the government cannot provide suitable land compensation, aside from pecuniary compensation, the State shall provide support in the form of training to allow the affected individuals to engaged in alternative gainful activities.

The State may recover land without compensation in cases where land users deliberately refuse to fulfill their obligations towards the State.

Recovery of Cemeteries and Graveyard

Article 43 stipulates that recovery of land for cemeteries and graveyard will not be compensated. Further, the law states in Article 101 that cemetery or graveyards must be planned and located in areas far from population centers but convenient for burial and visits, hygienic and economical. The provincial/municipal People's Committees shall prescribe the land limits and management regimes for the construction of tombs, monuments, steles in cemeteries, graveyards.

Procedure for Land Use Right

Procedure of land use right transfer is described in Article 127. The land use right transfer dossiers shall be filled at the land use right registries. For households and individuals in rural areas, such dossiers shall be filled at the People's Committees of commune.
The land use right transfer dossiers comprise the land use right transfer contract and the land use right certificate.

The land use right transfer contracts must be certified by the State notary public. The land use right transfer contracts of households or individuals shall be certified by the State notary public or authenticated by the People's Committee of communes, wards or townships where the land exists.

Within fifteen days of the receipt of the complete and valid dossiers, the land use right registries shall have to verify the dossiers. Thereafter transfer them to the land management agencies of the People's Committee who are mandated to grant the land use right certificate. To complete the transfer, land users must fulfill their financial obligations. The financial obligations are determined according to the cadastral data. The land use right registries shall send the cadastral data to the tax offices for determination of the financial obligations. The land use right certificates shall be issued within 5 workings days after all financial obligations have been settled.

Other Legal Documents needed in Preparation of RP

a. Decision No. 188/2004/ND-CP dated January 16, 2004 of the Government on methodology in determination of land price.

b. Decision No. 197/2004/ND-CP dated December 2, 2004 of the Government on compensation and subsidy allowances in land acquisition

c. Circular No. 166/2004/TT-BTC of the Ministry of Finance on guidelines in implementation of the Decision No. 197/2004/ND-CP.

The PMU-W will closely cooperate with the People Committees of the provinces where the project is located to prepare and implement a proper RP. This is to avoid the negative impacts on livihood due to land acquisition. A detail RP will be immediately prepared after the project has been approved by the Government.

WB Policy on Land Acquisition and Resettlement

The basic guiding principle of the WB Policy on Involuntary Resettlement is that:

"Involuntary resettlement and loss of means of livelihood are avoided where feasible, exploring all viable alternatives. When, after such examination, it is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected. People to be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by the project proponents, etc. in timely manner. The project proponents, etc. must make efforts to enable the people affected by the project, to improve their standard of living, income opportunities and production levels, or at least to restore them to pre-project levels. Measures to achieve this may include: providing land and monetary compensation for losses to cover land and property losses), supporting the means for an alternative sustainable livelihood, and providing the expenses for relocation sites; and Appropriate participation by the people affected and their community must be promoted in planning, implementation and monitoring of involuntary resettlement plans and measures against the loss of their means of livelihood".

Mitigation of Hazards Due to the War Residues

The PMU-W will cooperate with an experienced unit of the Engineering Corp of the Ministry of Defense to invest and remove all residual material (bombs, mines) before commencement of construction activity. Because the field, where will be an area of the NDTDP is used for food crop cultivation in a long time (over 30 years) from the war, residual explosive materials may not occur on topsoil layer, if they may exist, they may be found only at the deeper layer. Duration of removal of residual explosive materials may be some months, if the PMU-W will decide to conduct this measure.

Mitigation of Physical Cultural Resources

In some isolated cases, the physical re-location of some graves and burial sites will be required. This will be planned closely with the resettlement process in the detailed design phase.

Mitigation of Loss in Housing, Historical, Religious, Technical Facilities

The project implementation may result to loss in housing, religious, cultural and technical facilities. This is a significant adverse impact of the project. Therefore, countermeasures for this issue are necessary.

The PMU-W will prepare a proper RP, in which measures for relocation of the existing houses, religious, cultural and technical facilities will be discussed in detail. The policy in grave relocation should respect the local traditional creed.

Mitigation of Impact on Ethnic Minority

There is very small number of households of ethnic minority in the communes within the project region. Phase I of the project will not affect ethnic minorities. Because the locations of Phase II sub projects are unknown at this time, they are not likely to affect etchnic minority communities as these are traditionally found in upland areas away from actual river deltas. For this reason mitigation is not necessary at the moment. The Indigenous People Planning Framework will be followed in the unlikely event that ethnic minorities are affected by future project activities.

Mitigation of potential Conflict with the Regional Master Plan

The project is consistent and in accordance with the Master Development Plan of National Transport System as well as the Provincial Master Plan. No negative impact is expected. Therefore, no mitigation measure is necessary.

Integrating Environmental Management Concerns in Tender Document

The project management unit (PMU-W) of MOT in collaboration with the Consultant should prepare a Tender Document, incorporating the requirements for pollution prevention and control in accordance with the Vietnamese Standards for the maintenance of environmental quality during all phases of the project implementation.

7.2 The Environmental Management Plan

The section contains Table 7.2 which is the Environmental Management Plan (EMP) itself, in the form required by the World Bank Environmental Assessment OP4.01. Tables 7.3 and 7.4 further below are the EMPs of the Construction related issues only. Therefore, tables 7.2, 7.3 and 7.4 are to be read in conjunction with one another.

7.3 Environmental Management Plan for Bridge Lifting

Mitigation of Impacts of Bridge Lifting

An intensive public information campaign has to be implemented prior to the actual improvement work. The public has to be informed of the planned works on the bridges and the recommended alternate routes for Duong Bridge. For Ho Bridge, partial closure of the bridge is recommended. However, if total closure to vehicular traffic needs to be done, ferryboats should be deployed as an alternative means for vehicles and people to cross Duong River in this section. Implementation of the mitigation is the responsibility of VIWA through PM as the

To prevent vehicular accidents, conspicuous road signs and guides shall be installed to warn motorists.

Environmental Monitoring

Monitoring of the Duong Bridge works should be done in order to assess the need for additional means to alleviate the traffic congestion. Queuing time and number of affected vehicles need to be monitored. Sufficiency of the ferry boats in Ho River crossing should be monitored and assessed to that it can be determined if additional ferry boats need to be deployed.

Monitoring shall be done by PMU-W Environmental Staff.

7.4 Environmental management plan for Operations

7.4.1 Mitigating measures

Impacts on Air quality

Vessels plying the Corridor 1 should comply with existing standards on emission set by the Government of Vietnam. Issuance of Certificate of seaworthiness for river vessels should include compliance with emissions standards as one of the criteria.

Impacts on re-suspension of sediments due to propeller wash

Re-suspension of sediments due to propeller wash occurs when the influence of the wash reaches the stream bed. This happens in shallow water. To mitigate this impact, vessels should stay within the navigational channel and avoid going into shallow water.

Impacts on Bank Erosion Due to Boat Wakes

Control of bank erosion is one of the objectives of the water ways improvement project of the NDTDP. However, there will still be unprotected banks along Corridor 1 which will be prone to erosion. To minimize bank erosion due to boat wakes, restrictions in vessel speed can be imposed in certain sections using aids to navigation.

Impacts on Water Quality

Pollution of waterways can occur with disposal of oily bilge water, solid waste and cargo residue by cargo vessels. To mitigate this impact, ports within the NDTDP region should be provided with environmental reception facilities such as bilge water reception facility, sewage reception facility, bins for solid waste, bins for oily wastes / hazardous waste and bins for cargo residues.

Boats should be required to utilize the port waste reception facilities and report the usage to port authorities prior to leaving port.

Strict implementation of relevant environmental regulations on violations of environmental laws should be enforced by the government.

Safe Navigation in Busy Sea Lane, Halong Bay

Navigational lanes need to be clearly demarcated in Halong and Cat Ba to separate sight seeing boats from the cargo barges. Vessels should have running lights when navigating in the night. They should also be equipped with horns to warn other vessels during low visibility conditions which sometimes prevail in northern delta.

7.4.2 Monitoring

Air Quality

Vessels plying the Corridor 1 should be tested for emissions at least once year. This should be a pre-condition to the issuance of certificate of seaworthiness. The emissions tests can be done by an environmental center with capability for emissions testing.

Water Quality

Random sampling of bilge water of boats should be done. Sampling should be done by ports authority and reported to PMU-W. Bilge water should be analyzed for mineral oil, Pb, Cr, As, Hg, Cr, Fe, Al.

Compliance with imposed speed limits

Monitoring of vessels compliance with imposed speed limits should be done in segments of the river that are highly susceptible to bank erosion.

Monitoring of Maintenance Dredging

Water Quality

Water quality monitoring should be done once before maintenance dredging commences and once after the completion of the dredging work.

Sediment Quality

As in monitoring during construction, similar monitoring protocols should be observed. Stream Sediment quality should be analyzed prior to maintenance dredging and once after completion of the maintenance dredging.

Biological monitoring

Monitoring for plankton and benthic communities shall be done after dredging to assess recovery of the affected. Estimate of cost will depend on the monitoring program during operations.

for Construction related issues is in Tables 7.6 and 7.7)

Activities to be carried out in Corridor 1	Environmental Impacts	Mitigation			Monitoring		
		Measures	When	By Whom	Monitoring Indicators	When	By Whom
Groins	Change in hydrology may induce erosion, scouring and sediment transport, thereby affecting water quality and morphology of the river.	- Adjustments and correction of the geometry/side slopes/gradient of and spacing between groins so as to moderate flow velocities and eddy currents between groins. This will lead to less erosion risk to river banks, less intense scouring at the toe of the groins and along the river bed, which will in turn lead to less re-suspension of sediments and less turbidity.	- During maintenance /operations	- Engineering design by PMU-W	- Flow velocities, turbidity levels, particulate size of suspended solids	- During maintenance/operations. The exact details will be determined by the engineering design consultant. See sec. 7.2.2 of the EA report	- VIWA
	Spoil Disposal required.	- Prepare Dredge Material Disposal Plan (DMDP)	During Detailed Design Stage	Detailed Engineering Design Consultant.	DMDP becomes part of dredging works bidding/contract documents for each work package	Before launch of bid process and before award of contracts.	PMU-W
		- Implement DMDP	During dredging	Civil Works Contractor	Implementation of measures in DMDP	During Dredging	Civil Works Contractor Supervision Consultant, DoNRE and PMU-W
	Land/soil pollution from contaminated spoil.	48ha of land required for permanent storage to be secured with bunds prevent run-off from pollutant leachate.	Before temporary or permanent stockpiling on land.	Bunds designed by detailed design engineering consultant	Amount of seepage and constituent in leachate are within design and acceptable limits and standards.	Required intervals during operations with increased frequency during raining season or receipt of wet spoil. The exact details will be determined by the engineering design consultant. See sec. 7.2.2 of the EA report	Dredging Contractor. DoNRE. Supervision Consultant PMU-W

Table 7.3: Construction Environmental Management Plan, Part 1, Quarry Management

Environmental Issues of Potential Significant Concern	Management Measures to be implemented by the Civil Work Contractors during Construction	Monitoring		
		Monitoring Indicators	**When**	**Whom**
Quarry Management	It is assumed that contractors may either source their quarry material from existing licensed operators or that they may operate their own quarries. The measures below apply in the latter case, i.e when contractors operate their won quarries.	Source of quantities of material.	Weekly	Civil Works Contractors, Supervision Consultant, DoNRE
	Generally, quarries areas will be licensed and developed so that areas of disturbance are kept to a minimum, with suitable erosion and sediment controls, greatest possible separation distances between the areas of dust and noise generating activities and villages/local communities, sites selected that are as far away from watercourses as possible and general public safety in mind. Quarries will be rehabilitated after use. These measures are to be included in Quarry Management Plan to be prepared by the Contractor. These plans will be simple general arrangement drawings indicating these measures.	Measures in the Quarry Management Plan	Weekly, but daily during periods of intense activity.	Civil Works Contractors, Supervision Consultant, DoNRE

- Clearing and Disposal of Vegetation	Clearing of large trees and shrubs will be restricted to that area required for the ultimate quarry operation. Clearing of vegetative ground cover will also be restricted to that area for test material excavation, internal access road development, establishment of the crushing plant and other required site infrastructure. Topsoil will be cleared and stockpiled on site for site rehabilitation.	Demarcation of areas/trees approved to be maintained.	Before, during and after clearance.	Civil Works Contractors, Supervision Consultant, DoNRE
- Erosion and Sediment Control - Stability	Maintenance of as much of the natural vegetative cover as possible, laying of geo textile material to cover exposed slopes and strategic location of excavated sedimentation tanks.	Visual observation of these measures.	Weekly, but daily during periods of intense activity.	Civil Works Contractors, Supervision Consultant, DoNRE

- Air quality	The risk of quarry face instability and failure will be managed through appropriate measures such as installation of slope drainage measures and benching of slopes.	Visual observation of these measures and presence or absence of fault lines.	Weekly, increased to daily during rain storms.	Civil Works Contractors, Supervision Consultant, DoNRE
- Noise Control	Dust suppression measures will be implemented on exposed areas during dry and windy conditions or when visual observation indicates excessive dust generation. These measures will include watering of exposed surfaces and crusher operation and covering of stockpiles.	Ambient air quality conditions thru measurements or visual inspection.	Daily or hourly as required.	Civil Works Contractors, Supervision Consultant,
-Protection of Physical Cultural Property	Blasting activities to be carried out only between the hours of 06.00 and 18.00. Construction staff working in vicinity of activities generating noise levels greater than 80db, or any worker, who request protection, will be provided with hearing protection. Training will be provided to construction workers in relation to need for noise protection.	Noise emission levels	Constantly during periods of intense activity.	Civil Works Contractors, Supervision Consultant, DoNRE

	Known sites with physical cultural property as defined by World Bank OP4.11 will be avoided. With regards chance finds of PCR during quarrying activities, work would stop immediately and the local authorities and the client VIWA/PMU-WS will be informed as per the chance clause finds in the civil works contract.	Number of times chance clause is invoked. Proximity of site to know areas of cultural significance.	Monthly, during operations of the site. Before site is chosen	Civil Works Contractors, Supervision Consultant, DoNRE Local PPC's.

Table 7.4: Construction Management Plan, Part 2, for Use at all Construction Sites[6]

Environmental Issues of Potential Significant Concern	Management Measures to be implemented by the Civil Work Contractors during Construction	Monitoring		
		Monitoring Indicators	When	Whom
Water Quality Management	Careful placement of rock material for groin construction, to be done at times of relatively	Turbidity levels	Constantly	Civil Works

[6] All construction related mitigation measures and there monitoring will be undertaken by the civil works contractor during construction, and will be supervised by the supervising engineering consultant. The local office the DoNRE will also perform their usual monitoring functions.

	low tidal currents where possible, material properly sieved to ensure suitable particle sizes are selected where possible. Discard as much loose material from material mix before placement in river.	following visual observation of suspended solids and plume in the water.	during construction.	Contractors, Supervision Consultant, DoNRE
Emission and Dust Control	The first principle is to minimize dust generation. All construction vehicles will be confined to designated routes where possible.	Number of vehicles using alternate routes	Daily	Civil Works Contractors, Supervision Consultant
	Dump trucks with loads to be covered. Stock piles of aggregates to be covered during a prevailing wind storm.	Availability on site and use of cover material	Daily	Civil Works Contractors, Supervision Consultant
	Watering of exposed areas to be covered during wind storms, if excessively dry, during periods of heavy traffic use on unsealed roads and in response to complaints by local communities and other external parties.	Availability water bouzers on sites.	Daily	Civil Works Contractors, Supervision Consultant

Noise Control	All equipment and construction vehicles should be well maintained and in good mechanical condition and where practical, fitted with appropriate silencers, mufflers or acoustic covers. If complains are received about excessive noise levels in the vicinity of local villages and residential areas, the contractor will consult with the supervising engineer to identify additional mitigation measures, e.g. additional shielding, change in equipment type, restriction of construction hours, etc. Contractors to maintain a Public Complaints register on site.	Service logs.	Monthly	Civil Works Contractors, Supervision Consultant

7.5 Dredge Material Disposal Management Framework

7.5.1. Background

This framework sets out the processes to be followed for the preparation of the Dredge Material Disposal Plan, its approval and subsequent implementation and monitoring. This plan is required to ensure that the approximately 2.7million cubic meters of spoil that would be dredged from Corridor 1 is disposed of in an environmentally sustainable way.

7.5.2. Process for Preparing and Approving Dredge Management Plans.

i) A Dredge Material Disposal Plan is required for all activities in Corridor 1 requiring dredging.

ii) As part of the detailed engineering design process, the Dredge Material Disposal Plan (DMDP) for Corridor 1 will be prepared by the Engineering Design Consultant.

iii) The DMDP is then to be included as part of the civil works bidding documents for selection of the dredging contractor according to the works procurement packages for Corridor 1. Since the works along the entire length of the Corridor will be divided into several works contracts, one DMDP will be prepared for each works package.

iv) The potential contractors bidding for the dredging works will be required to either accept or modify the DMDP during the bidding process.

v) Before the selection and award of the civil works contracts, the DMDP's will be submitted to the VIWA and PMU-W for review and approval.

vi) The civil works contractors will not be allowed to start dredging before all entitlements to project affected persons are paid and received in full by them incases where land acquisition is involved.

7.5.3 Contents of the Dredge Material Disposal Plan

The DMDP will be structured as follows;

- Chapter 1 – Background
- Chapter 2- Description of the Dredging Methodology including brief descriptions of the dredger to be used, times and duration.
- Chapter 3 – Dredging Material, Quantity and Quality.
  Describe the physical characteristics of the dredged spoil material, the quantity and the quality. Discuss the severity of contaminants.
- Chapter 4 – Evaluation of Disposal Options.
  Discuss the disposal options considered including a brief analysis of these alternatives and the choices made. Some of the options considered in the EA processes are for uses of the spoil as construction material where

appropriate; disposal of good quality spoils in deep river channels without temporary stockpiling on land where possible, and use as fill material for rehabilitating closed mines/quarries

- Chapter 5 – Recommended Disposal Plan.

Discuss and present in matrix form the recommended Disposal Plan. Present details of where each category of spoil will be disposed of, the design measures necessary to operate that choice (land or deep river channel), the key details of how this would be done, such as what transporting method would be used, whether there is need for temporary stockpiling and what measures would be needed to operate and maintain the site. Include details and arrangements for monitoring implementation of these measures and the institutional requirements necessary to ensure these are implemented. Also, include a detailed cost budget for implementing this plan.

7.5.4. Institutional and Monitoring Arrangements

Following approval by VIWA and PMU-W, the DMDP will be implemented by the civil works contractors and monitored by the supervising engineering consultant and the DoNRE with jurisdiction of the various locations.

7.6 Environmental Monitoring

7.6.1 Institutional Responsibilities for Environmental Monitoring and Reporting

At present, in Vietnam, the Department of Environmental Protection (VEPA) within MONRE is responsible for the national-wide environmental monitoring. A National Monitoring System set up by the former MOSTE in 1994, involved the various environmental research centres. These centres carry out monitoring of air and water quality and solid wastes in the selected areas and submit reports to NEPA. Annually, MONRE prepares "Annual Report on the State of Environment of Vietnam" based on environmental monitoring and socio-economic data. This report is presented to the Government. According to the Law and Government Decision, projects and/or companies which may have environmental problems may carry out appropriate monitoring programs during the project construction and operation under the arrangement of "*internal monitoring*".

At provincial level, Department of Natural Resources and Environment (DONRE) is responsible for environmental management, including environmental monitoring which is referred to as *external monitoring*.

For the NDTDP, the PMU-W is responsible for undertaking internal environmental monitoring during pre-construction, construction and operation stages. The results of the internal environmental monitoring are regularly submitted to the Ministry of Transport, DONREs of the related provinces or MONRE for review.

Organization of Environmental Monitoring for NDTDP

Two types of environmental monitoring are to be implemented in the NDTDP. These are the site audit and environmental quality monitoring.

Site Audit

Site audit mainly involves the evaluation of the implementation and effectiveness of the mitigation measures. This is conducted by the PMU or its contractor during the pre-construction, construction and operation stages.

Environmental Quality Monitoring

The environmental quality monitoring involves the testing, analysis and evaluation of selected environmental indicators. Environmental quality and compliance with set standards are assessed by comparing results of monitoring data with relevant Vietnamese Standards for the Environment

Agencies Involved in Environmental Monitoring Programs

The organizations involved in environmental monitoring are:

- Independent Monitoring Consultant (IMC).
- Contractors
- Governmental Environmental Management Agencies (DONREs).

The independent monitoring consultant (IMC) will be engaged by the Project Management Unit of MOT. The role of the IMC is to monitor the implementation of the EMP. The IMC will submit its environmental monitoring report every 3 months to MOT and WB.

General responsibilities of the IMC are:

a. *Conduct observation at the project area and assess the following aspects:*

- Status of implementation of safety measures (signboards, restricted zone, fences, isolation etc.) in the construction phase.
- Status of installation of sanitary facilities at worker camps and construction sites.
- Status of waste management in the construction phase and operation phase.
- Public consultation in environmental problems produced by the project.

b. *Conduct field sampling and submit samples to the laboratory for analysis*

7.6.2 Environmental Quality Monitoring

Air Quality Monitoring

Due to the low concentrations of pollutants in the ambient air of the project sites of NDTDP, air quality monitoring will be limited to sites where there are human communities (receptors) near the construction site.

Method and parameters to be monitored

Monitoring will be limited to noise and suspended particulate matter (dust). The occurrence of nuisance noise and increased TSP in the atmosphere will be occasional rather than a continuous event, such that instrumental monitoring may not detect exceedance. As such alternative method shall be key informant interview. Key informants from the nearby communities shall be identified and these people shall be interviewed on a regular basis to complaints on construction nisance sch as noise and dust. This monitoring is the responsibility of the contractors and is part of its constrction supervision

Acitivity	*Location*	*Freqency*
Dredging and Disposal	Spoils disposal sites	Weekly interview of KI
Bank Protection	Materials storage area Construction site	Weekly interview of KI
Groynes	Materials storage area Construction site	Weekly interview of KI
Bend Improvement	Spoils disposal sites Work site	Weekly interview of KI
Removal of obstacles	NA	NA
Lifting of Dong Bridge	Work site	Weekly interview of KI
Aids to Navigation	NA	NA

Topography and Morphology

The primary areas for monitoring of river morphology are the areas immediately downstream of dredged areas, groins, bank protection and bend improvement sites. Although changes in hydrodynamics are being modeled, the results of the computer modeling should be validated, thus, monitoring of river bank erosion and deposition should be done after the structures have been completed. Secondly, this monitoring is essential in protecting properties bordering the areas where river works improvements have been undertaken.

Bank erosion and occurrence of deposition should be monitored at areas immediately downstream of the dredging areas, groins, bank protection and outcrop cutting sites. Monitoring should be done annually.

Recommended monitoring methods are varied depending on the rate of erosion or sedimentation:

- For places where rates are in the order of centimeters, monitoring of bank erosion can be done by driving graduated steel stakes into the scarps along the river bank. The rate of erosion can be measured by the length of the steel stake exposed over a certain period of time. For deposition areas, chains or ropes with float at the end can be installed, tied up to a steel stake driven on the river bed, annual floodplain or point bar deposit. During flood condition when deposition is likely to happen, the line will float and the amount of deposition can be measured by the length of the line that is buried.
- However for areas with very big rates of erosion / deposition (in the order of meters or tens of meters), there are other appropriate methods.
- One method is by measuring the position of the river bank with respect to a fix and stable reference point, maybe a road, dike, house, etc. This can be done with a measuring tape and a compass to keep the bearing of measuring line constant. The same method can be used for measuring the accretion in the depositional area. A survey quality GPS will do the work quickly and accurately.

- The other method that can be used for monitoring large rates of erosion and sedimentation is the use of temporal remote sensing data. This however, will entail more cost than the other methods mentioned.
- The monitoring should be done on an annual basis, until such time that it can be confidently concluded that the river work has caused very minimal change in erosion and deposition process.

Interpretation of the bank erosion and sedimentation will yield impacts of the project on erosion, sedimentation and sediment transport.

Acitivity	***Location***	***Frequency***
Dredging and Disposal	All dredging areas	Yearly
Bank Protection	Banks downstream of bank protection areas	Yearly
Groynes	Groyne field and upstream of groyne field	Yearly
Bend Improvement	Downstream of improved bends	Yearly
Removal of obstacles	NA	
Lifting of Dong Bridge	NA	
Aids to Navigation	NA	

This monitoring is the responsibility of PMu-W as part of its regular function in the environmental management of the Northern Delta Inland Waterways.

Soils and Soil Quality

Monitoring of soils quality shall be done in areas that will be used as temporary spoils disposal sites. The purpose of the monitoring is to detect the possible impacts of spoils leachate on the soil of the disposal site. Timing and frequency of sampling shall be one sampling before the use as disposal site, then annual sampling until such time the spoils have all been removed. Final sampling shouldbe done before land is turned over to land holder.

One composite sample for every 4 hectares of disposal site should be collected. With a projected requirement of about 50 hectares of disposal site for contaminated spoils from Corridor 1, this will require about 11 samples a year. With a unit cost of VND490,000 this translates to an annual cost of about VND 5,390,000.

Parameters for monitoring are pH, Al, Fe, As, Cd, Pb, Cr and Hg.

Three samples should be collected from each sampling stations but only one sample should be submitted to the laboratory analysis. The two samples are check samples in case there is a need to check results of the initial analysis, such as when high concentrations of heavy metals are detected. One check sample should be submitted to the laboratory for analysis. This procedure of taking duplicate samples will save time and money when there is need to validate laboratory results.

This monitoring shall be done by the IMC with chemical analysis done by an environmental chemistry laboratory.

Monitoring for Morphological Impacts – I.e erosion and sedimentation

The monitoring for possible impacts of the improvement works on erosion and sedimentation can be done through ocular inspection, field mapping and photo documentation techniques. The locaton and frequency of sampling are as follows:

Acitivity	*Location*	*Schedule & Frequuency*
Dredging	Red R	While dredging in progress
	Dong	While dredging in progress
	Kinh Thai	While dredging in progress
	Han R	While dredging in progress
Bend Improvement	Mac Ngan Hamlet, Dong Lac Commune, Chi Linh District	While dredging in progress
	An Bai Hamlet, An Lac Commune, Chi Linh District	While dredging in progress
	Ninh Xa Hamlet, Le Ninh Commune, Kinh Mon District	While dredging in progress

The indicators that can be used are erosion (retreat of banks), deposition (shoals, shallowing and advancing bank),

Monitoring of the morphology of banks and coast prior to work implementation is the responsibility of the Contractor. The survey shold be done as part of the detailed design. But after completion of the work, succeeding monitoring is the responsibility of PM-W as part of waterways environmental management. No additional cost necessary

Stream Sediment Quality Monitoring

Monitoring of sediment shall be done while dredging is ongoing to monitor sediment quality so spoils can be disposed of accordingly. The recommended number of samples for monitoring is as follows:

Table 7-5. Recommended number of samples based on volume of spoils (after EPA Victoria)

Volume of Spoils in cubic m	*No of Sediment Samples*
Upto 25,000	3
25,000 to 100,000	4-6
100,000 to 500,000	6-10
500,000 to 2,000,000	10-20
For each 1,000,000 above 2,000,000	Additional 10

.

The number of sediment samples to be collected from the different work areas of Corridor 1 is enumerated as follows:

Acitivity	*Location*	*No of Samples*	*Schedule & Frequuency*
Dredging	Red R	***15 samples***	While dredging in progress
	Dong	***8 samples***	While dredging in progress
	Kinh Thai	***5 samples***	While dredging in progress
	Han R	***15 samples***	While dredging in progress
Bend Improvement	Mac Ngan Hamlet, Dong Lac Commune, Chi Linh District	***6 samples***	While dredging in progress
	An Bai Hamlet, An Lac Commune, Chi Linh District	***8 samples***	While dredging in progress
	Ninh Xa Hamlet, Le Ninh Commune, Kinh Mon District	***8 samples***	While dredging in progress

Parameters to be monitored are pH, Al, Fe, As, Cd, Pb, Cr and Hg. Cost of analysis per sample is VND490,000. For 65 samples, total cost of analysis is VND3,185,000.

The monitoring shall be done by the IMC and analysis by an environmental laboratory.

<u>Surface Water Quality Monitoring</u>

Monitoring of surface water quality shall be done during dredging. The sampling location, the number of sampling stations and frequency / timing of monitoring is listed in the following matrix.

Activities	*Sampling Location*	*No of stations*	*Frequency / Timing*
Dredging and Disposal (18 sites)	a. One station upstream of dredge b. One station downstream of active dredging areas;	36	a. Once before dredging b. 2 samplings, spread over the active dredging period; c. Once after completion
Bank Protection (6 locations)	a. One station upstream of dredge b. One station downstream of active dredging areas;	12	a. Once before dredging b. 2 samplings, spread over the active dredging period; c. Once after completion
Groynes (13 groyne fields)	a. One station upstream of dredge b. One station downstream of active dredging areas;	26	a. Once before dredging b. 2 samplings, spread over the active dredging period;

			c. Once after completion
Bend Improvement (3 sites)	a. One station upstream of dredge b. One station downstream of active dredging areas;	6	a. Once before dredging b. 2 samplings, spread over the active dredging period; c. Once after completion
Removal of obstacles	NA		
Lifting of Dong Bridge	NA		
Aids to Navigation	NA		

Parameters to be monitored are:

Table 7-6. Parameters for Monitoring

Temperature	NO_3^-
pH	Total N
C	Total P
Salinity	Zn
Turbidity	Cr
SS	Cd
DO	Oil
Fe	As
BOD_5	Phenol
NH_4^+	Total Coliform

The cost of analysis per sample is VND1,780,000. Three hundred twenty (320) samples are antipcated to be collected for the duration of dredging and other waterways works in Corridor 1. Total estimated cost of water quality monitoring is VND569.6 million.

Monitoring shall be done by the independent monitoring consultant and analysis by an environmental laboratory.

Groundwater Quality Monitoring

Groundwater quality monitoring will be undertaken in disposal sites of contaminated sediments. Monitoring shall be done annually during the dry season.

It is assumed that 20% of the total sediments that will be dredged will be contaminated and will require containment. It is estimated that a land area of abot 50 hectares will be reqired for containment of contaminated sediments. It is ssumed that the 50 hectares will be divided into about 5 to 10 sites. Assuming that one monitoring well will be installed for every site, a maximum of 10 monitoring wells will be required. With the shallow groundwater, each well be about 10 m deep. Parameters to be monitored are:

Table 7-7. Parameters for Monitoring of Groundwater Quality

Temperature	NO_3^-
pH	Total N
C	Total P
Salinity	Zn
Turbidity	Cr
SS	Cd
DO	Oil

Fe BOD_5 NH_4^+	As Phenol Total Coliform

The cost of installing the monitoring well will be part of the development cost of the containment strctres. The yearly cost of monitoring grond water is VND17.8 million.

The monitoring shall be done by the PMu-W as part of the environmental management of the Northern Delta inland waterways.

Monitoring of Aquatic Flora & Fauna

The monitoring of plankton, zooplankton and benthic organisms is to monitor the change and the recovery of the dredged areas. Hence and extended monitoring of 3 years after completiong of all works.

The location / no of stations and the timing of the monitoring are listed in the following matrix.

Activities	*No of stations*	*Frequency / Timing*
Dredging and Disposal	18	Once before dredging and yearly for 3 years
Bank Protection	NA	
Groynes	13	Once before and yearly for 3 years
Bend Improvement (3 sites)	3	Once before and yearly for 3 years
Removal of obstacles	NA	
Lifting of Dong Bridge	NA	
Aids to Navigation	NA	

There will be a total of 34 stations and 4 sampling episodes. The cost of biological analysis is VND960,000 per sample. This brings the total cost of biological monitoring to approximately VND131 million.

The monitoring is to be implemented by the IMC.

Monitoring for Social Impacts - Monitoring of Resettlement Plan (RP)

Regular monitoring of RP implementation will be conducted by PMU and by the International Donor (WB), as well as by an independent external monitoring agency.

Internal Monitoring

The Resettlement Department of PMU-W, with the assistance of supervision consultant teams, will be responsible for internal monitoring of RP implementation.

Monitoring Indicators

The main monitoring indicators are:

- Payment of compensation to PAPs in various categories, according to the compensation policy described in the RP,
- Public information dissemination and consultation procedures
- Adherence to grievance procedures,
- Resettlement site location, design, site construction and plot allocation
- House construction, technical assistance, payment of subsistence and shifting allowances as described in the RP,
- Employment generation through project implementation and priority of PAP for the options offered,
- Provision of training and credit availability,
- Co-ordination and completion of resettlement activities and commencement of civil works.

Staff for Conducting Internal Monitoring

The staff of PMU-W will carry out the internal monitoring activities. They will collect information every month from the Provincial Resettlement Committees (PRCs) and District Resettlement Committees DRCs. A database of resettlement, monitoring information about the project will be maintained and updated every month.

Reporting

PMU-W will submit to WB and Governmental authority a monitoring report on the progress of implementation of the RP every six month.

Monitoring for Land Use Change

The change in land use due to disposal of spoils will be monitored. The original land use shall be described and the resulting changes, after emplacement of spoils will be noted. For temporary spoils holding area, monitoring of land use after spoils have been removed should be done. The objective of the monitoring is to document the changes and the restoration of the land use after removal of spoils. This will have to be done in all the disposal sites.

This activity should be part of the regular monitoring work of the environmental section of PMU-Environmental section.

Monitoring for Impacts on Occupational Health & Safety

The monitoring for occupational health and safety should be done regularly. The monitoring should cover:

- Compliance by contractor with occupational health and safety plan:
- Adherence by workers with the safety guidelines
- Use of PPE by workers, including floatation devices by those working in water
- Presence of emergency first responder
- Availability of first aid station in construction site;
- Reported number of accidents or incidents involving lost time
- The monitoring shall be implemented by PMU-W environmental staff.

7.7 Capacity Building in Environmental Management

Environmental management of inland waterway projects is a relatively new task for Vietnam Transport Sector. As such, it is essential that a capacity building for environmental management be undertaken prior to project implementation. Staff who will be involved in the implementation of the EMP should undergo training. The objective of the training is to familiarize the management staff with environmental management and procedures for environmental monitoring and reporting. The training can be conducted by one of the environmental centers involved in environmental impact assessment and environmental management.

The training will include the following components:

a. *Training for PMU-W staffs*

The training will cover, among others, the following subject matters:

- The Environmental Management Program for Corridor 1.
- The implementation of the Dredge Management Framework.
- Preparation and Approval of the Dredge Material Disposal Plan.
- The Construction Management Plan.
- Environmental issues related with waterways improvement and operation.
- Environmental Regulations and Standards of Vietnam
- Environmental monitoring methods and procedures.
- Environmental Reporting – report preparation, interpretation of laboratory results

b. *Training for Construction Engineers*

The following training programs will be provided for engineers of the contractors:

- Labour Safety: Regular training on safety issues related to the riverworks and dredging;
- Environmental management Plan of the Project: Orientation of engineering staff on the environmental management plan for NDTDP Corriodr 1.
- Monitoring and reporting of EMP: The training will include the methodology for site observation and reporting of monitoring results.

Cost for the training activities is estimated in **Table 7-5**.

Table 7-8. Indicative Estimated Cost for Training Activities

No	Training	Items	Estimation	Cost (VND)
1	Training for PMU staffs (in the Pre-Construction phase)	3 above mentioned topics of training	20 people * 3 days * document preparation	25,000,000 (lump - sum)
2	Safety training (in the Construction phase)	Consultant's manpower requirement	1/2 man-month (local expert)	8,000,000
		Perdiem for 40 participants	40 people x 1days x 300,000 VND/day	18,000,000
		Other expenditures: classroom, stationery...	lump-sum	5,000,000
3	Training on environmental protection related to inlandwater (in the Construction phase)	Consultant's manpower requirement	1/2 man-month	8,000,000
		Perdiem for 40 participants	40 people x 1days x 300,000 VND/day	12,000,000
		Other expenditures: classroom, stationery...	lump-sum	5,000,000
4	Training on environmental monitoring and reporting (in the Construction phase)	Consultant's manpower requirement	1/2 man-month	8,000,000
		Perdiem for 30 participants	30 people x 1days x 300,000 VND/day	9,000,000
		Other expenditures: classroom, stationery...	lump-sum	5,000,000
	Total			97,000,000

7.8 EMP Costs

The costs of implementing the EMP will comprise three areas, which are;

- **The cost of the mitigation measures themselves –** these costs will be calculated by the detailed design engineering consultant and are not to be included in the total cost of the EMP stated here below.
- **The cost for the Capacity Building and Institutional Support –** these costs relate only to that which is required for implementation of the EMP. These costs are calculated in table 7.8 above and are estimated at VND97m, which is approximately US$6500 (six thousand five hundred dollars).
- **The cost for monitoring –** these costs would cover items like professional/consultant fees, travel costs to monitoring sites, laboratory fees, fees paid to local agencies such as DoNRE, purchase of equipment, report writing, etc. These costs are estimated at US$200,000 (two hundred thousand dollars) total over the construction period.

Therefore, the total cost of implementing the EMP as defined above is US$206,500 (two hundred and six thousand, five hundred dollars).

The costs of implementing the EMP beyond the construction period will be calculated by the detail design engineering consultant to ensure suitable budgeting by VIWA.

7.9 Stakeholders' Responsibilities

The responsibilities and participation of the different stakeholders are enumerated in the following table:

Party	Responsibilities
Ministry of Transport (MOT)	MOT is Project owner, responsible for project management including overall environmental management. To carry out overall environment management, within MOT an Environment Management Section will be set up. The Section is in charge of guiding and supervising implementation of the EMP for this project and other project.
Project Management Unit (PMU-W)	PMU within MOT is responsible for project implementation. PMU-W responsibilities include: - Overall planning, management and monitoring of the environmental management. - Ensuring that all environmental protection and mitigation measures of environmental impacts are carried out in accordance with policies regulations on environment and other relevant laws. - Coordinating with provincial people Committees in environmental management activities. - Organizing training courses for local staff and contractor's teams on mitigation measures and safety methods (professional experts on environment shall be involved). - Carrying out internal monitoring and supervising independent monitoring, which will be contracted with other consulting services of the project. - Supervising and providing budget for monitoring activities. - Reporting on environmental information to MOT and WB. - Implement changes or adjustments according to MONRE recommendation to protect the environment according to Vietnam's standards, laws, and regulations.
Consultants	The consultant should conduct several project tasks, including: - Preliminary survey and design. - Preparation of feasibility study. - Preparation of RP and EIA report. - Preparation of bidding documents. - Carry out some EMP tasks (environmental monitoring etc.) and assist PMU-W with environmental issues during construction.
Contractors	The Contractors will be selected by PMU-W. Their responsibilities include construction / dredging works and comply with environmental management plan and guidelines stipulated in the EIA and EMP. This includes: - Implement mitigation measures; - Ensuring safety of construction workers and local people during construction. - Following Vietnam and WB policies on environmental protection during construction.
Independent Monitoring Consultant (IMC)	Independent monitoring consultant for the EMP implementation will be engaged by PMU-W to conduct the monitoring programs in 3 stages of the project. The budget for the IMC will be provided by PMU.
Ministry of	MONRE is responsible for state management on environmental issues. As

Party	Responsibilities
Natural Resources and Environment (MONRE)	part of this responsibility, MONRE will review the EIA report. During EMP implementation, MONRE requires DONREs of the related provinces to act as external regulators. Their duties will include: - Monitoring the implementation of mitigation measures for construction and operation stages. - Assess effectiveness of recommended mitigating measures in minimizing the adverse impacts.
People's Committees of 10 provinces	At provincial level the PCs will mandate the DONREs to coordinate with the MONRE on the supervision of the implementation of the environmental management plans during and after construction phase.
Project Affected Households (PAHs)	PAHs will directly participate in the PMU-W's survey programs on affected households. Through these surveys they will: 1) have the opportunity to express their requirements and concerns to the above institutions; 2) provide input to the method and units of compensation. After compensation is complete, PAHs are responsible for cooperating with the contractors to clear relevant sites in a timely manner. In order to ensure that PAHs are well informed on the project, local authorities will provide PAHs with basic knowledge on project-related activities, and the negative and positive impacts on the natural/social environment. PAHs will be able to have a role in monitoring the environmental effects of the project and the EMP performance of the contractor. PAHs will also be consulted during the project in relation to relevant environment issues. PAHs will be allowed to bring legal action to an appropriate court if the PAH considers its claim for participation or information is ignored, groundlessly refused, or if information provided by local authorities is inadequate.

8. PUBLIC DISCLOSURE

8.1 Consultations with Affected Stakeholders

During the project preparatory phase, project's information and public consultation were conducted in all the project's affected provinces.

The methods of project information and public consultation included participatory rapid appraisals and stakeholder's consultation, using techniques of site and household visits, public meetings, group and focus group discussions and the household socio-economic survey.

The public meetings and consultation were widely organized in most of the affected hamlets of the Corridor 1. The local authorities, leaders of different administrative levels and local DPs were informed of the project proposal, its objectives and proposed activities. They were also informed of the WB's and the NDTDP's proposed resettlement policy. The DPs were extensively consulted, and actively participated in discussions on their development needs and priorities, about their perception toward project objectives. Consultations with different stakeholders on market prices of land and movable properties were also carried out. Severely affected farmers and business DPs were consulted on their priorities and possible measures to reduce negative impacts.

The local authorities are consulted on their agreement and commitments to follow the project resettlement policy described in the RP and RPF, reflecting both the Government and WB resettlement objectives and principles.

The public consultations with DPs were widely organized in 4 most affected communes/towns of the Corridor 1. In each of the consulted communes/wards, 1 to 3 public meetings and discussions at hamlet/village level were held. The DPs were extensively consulted, and they actively participated in discussions on their development needs and priorities, and their perception toward project objectives. DPs were consulted on project's potential impacts and possible measures to reduce potential negative impacts, and improve benefits for them and their communities.

The stakeholders' consultation with local authorities were organized in Hai Duong province; at the commune's/ward's level – with 4 communes/wards. The local authorities expressed their special concerns on the subproject's potential temporary impacts on public properties during its implementation, during the land acquisition process and civil works. As the proposed widening of the Waterway Corridor 1 will mostly be done on its right bank, which is located in the flood-prone area of the Delta, local authorities at all levels as well as DPs are specially concerned about the inundation risk in the flood season. They proposed that the project should take appropriate mitigation measures, including a timely rehabilitation of flood protection dikes, sluices, pumping facilities, either temporary or permanent, to protect local people, their crops and assets from possible flooding. They also proposed that the project should restore relevant public infrastructure before starting civil works to avoid possible inconveniences on local daily living and economic activities.

All the consulted DPs expressed their full support for the project's investment, expecting that it would improve conditions for trading and fostering the socio-economic development of their communities, and for communication, thus contributing to improving public awareness among the local population. Their main concerns were focused on fair compensation and its transparency. Many questions on different aspects related to the project's compensation rates, rehabilitation assistance packages were raised by the DPs and were extensively discussed. Focus group discussions were organized with severely affected DPs, including severely affected farmers, to consult on their preference towards rehabilitation measures. The severely affected farmers expressed their preference for cash option to rehabilitate their income generating capacity by themselves. In addition, there is no agricultural land available to provide compensation by land.

As the subcomponent impacts, both direct and indirect, would be widespread and severe, the people participated in the public information dissemination and consultations including local authorities at the provincial, district and commune's levels and DPs, have expressed their desire to have their special interests to be involved in stakeholders consultation activities. They considered the latter to be especially important. In their opinions, a good information dissemination and extensive discussions between all concerned parties on related environmental impacts on local properties and on the people and their communities could contribute to exploring all alternatives, appropriate and effective mitigation/rehabilitation measures to assist affected people and their communities in restoring their living standards and local public conditions. They strongly supported that the stakeholder consultation process should be continued in the project's implementation stage, and close cooperation between concerned parties should be given special attention for successful land acquisition.

Table 8-1: Place and time of consultations

No	Province	District	Commune	Hamlet	Date	Duration	No of DP
1	HaiDuong	ChiLinh	DongLac	MacNgan	23/11/2007	10.00 am – 12.00 pm	16
2			AnLac	AnBai	23/11/2007	7.00 am – 10.00am	8
3		KimMon	LeLinh	NinhXa	24/11/2007	8.00 am – 10.00 am	16
4				TienXa	24/11/2007	2.00 pm – 4.00 pm	12
5		ChiLinh	NhanHue	ChiLinh	21/12/2007	8.00 am - 10.00 am	35
Total	1	2	4	5			87

8.2 Consultation With Transport Officials / Port Operators

Extensive public consultation has been conducted throughout the various phases of the feasibility study to gauge the perception of key stakeholders. The primary focus of consultations with ports operators include the Provincial Department of Transport Officials and various Officials, Provincial Department of Transport Officials and port authorities from the following provinces:

Hung Yen

- Mr. Quan: Director of Hung Yen PDOT

- Mr. Nha: Vice Director of Hung Yen PDOT
- Mr. Nu: Chief of Planning and Technical Department.

Nam Dinh

- Mr Khinh: Vice Director of Nam Dinh PDOT
- Mr Mich: Chief of Planning and Technical Department

Ninh Binh

- Vice Director of Ninh Binh PDOT
- Mr Khanh: Chief of Planning and Technical Department

Hai Duong

- Mr Thang, Vice Director of Hai Duong PDOT
- Mr Phuong, Chief of Planning and Technical Department
- Mr Hiep, Deputy Chief of Traffic Management Department

Vinh Phuc

- Mr Minh, Vice Director of Vinh Phuc PDOT
- Mr Luong, Chief of Planning and Traffic Management Department

Phu Tho

- Mr Long, Officer of Planning Department PDOT

Viet Tri Port

- Mr Khanh, Director of Viet Tri Port
- Mr Chinh, Vice Director of Viet Tri Port
- Mr Thang, Deputy Director of Business Development

8.3 Formal Consultations / Workshops

Formal consultations have also been conducted for the NDTDP. The method used for the consultation is workshop. Three formal workshops have been conducted and these are the Inception Workshop (August 2007), the Interim Workshop, (December 2007) and the Final Workshop (28 January 2008). It is during these workshops that key stakeholders are consulted and updated of the progress of the feasibility study. At the same, these workshops offered opportunities for the key stakeholders to examine and contribute to the work's progress. The workshops were attended by the Ministry of Transport, Vietnam Inland Waterways Administration (VIWA), the port administrators, representatives of the academe and civil society, the World Bank, the consultants and others.

Photo 8-1. NDTDP Final Workshop, January 28, 2008, Melia Hotel.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The feasibility study was successflly concluded with with the final selection of sub-projects that meet the project objectives. The identified sub-projects complied with the technical, economic, social environmental, regional development and institutional sustainability criteria. The sub-projects shall be implemented into two phases, Phase 1 and Phase 2. The distribution of the sub-projects by phasing is as follows:
:

Phase 1 investment package
- Corridor 1 Improvement
  - Dredging
  - Groynes
  - Bank protection
  - Bend improvement
  - Lifting of Dong Bridge
  - Removal of obstructions
  - Aids to Naviation

Phase 2 Investment Package
- Corridor 3 Improvement
- River Moth Improvement
- Port and Landing Stages
- Ferry Boat stages

The adverse impacts of the different activities that will be undertaken to improve Corridor 1 have been predicted and assessed with a high degree of confidence. The initial apprehensions on the possible presence of highly contaminated stream sediments and its undesirable implication on environmental management has been assuaged with the collection and compilation of comprehensive environmental baseline information on the Red River Delta. Significant environmental impacts have been identified and corresponding mitigations and monitoring have been recommended. The need for capability enhancement has been determined and a training program is proposed.

As it is major impacts of the project are associated with dredging and disposal of spoils and not mainly due to the quality but the quantity of the spoils that need to be managed. Options for environmentally sound management of the spoils have been identified and are under consideration for implementation.

Consultations with the stakeholders in Corridor 1, including those who will be directly affected have been condcted dring the sb-project preparation. They have been informed of the project and its possible consequences on the stakeholders. The stakeholders are generally in favor of the project, recognizing its wider socio-economic benefits. They are confident in the fact that the affected families will be compensated and that they will be granted all entitlements as provided by the GoV's resettlement policy. The consulted people willingly participated knowing that there are critical isses that will affect them and that it is important that their voices be heard dring the decision making process.

At this point, it should be recognized that the impact assessment was based on feasibility stdy and that project details could change during the detailed design stage. Under this sitation, the EIA needs to be revisited and updated.

9.2 Recommendations

Due to the regional spatial coverage of the improvements of Corridor 1, the implementation of the environmental management will require the collaboration of numerous stakeholders, from national level down to commune level. In view of this situation, there is the need for sustained dialoge between the project owners and its representative, the consultants, the people's committee, the affected persons and the host community.

Enhancement of the capability of PMU-W in environmental management is a priority item in the implementation of Corridor 1 improvement. Training has to be synchronized with the project implementation. This will allow the PMU-W to have hands on training and be ready to implement the waterways environmental management upon NDTDP's completion.

While mitigating measures have been recommended, monitoring is a key component of environmental management. For monitoring to be effective, a practical system for compiling and analyzing the environmental monitoring data should be put in place.

10. REFERENCES

Aaron M. Prussian, Todd V. Royer, and G. Wayne Minshall, 1999. 1999 EPA Suction Dredge Study On The Fortymile River, Resurrection Creek, And Chatanika River, Alaska

Army Dredging Operations and Environmental Research (DOER) 2000. Assessment of Potential Impacts of Dredging Operations due to Sediment Re-suspension Http://Www.Tpub.Com/Content/Armydoe/Doere9/Doere90001.Htm

Army Engineer Waterways Experiment Station Vicksburg Ms Environmental Lab 1997 Http://Stinet.Dtic.Mil/Oai/Oai?Verb=Getrecord&Metadataprefix=Html&Identifier=ADA331100

Binnie & Partners, Snowy Mountains Engineering Corp Ltd. AACM International Pty Ltd. and Delft Hydraulics, 1995. Red River Delta Master Plan. UNEP, Government of Vietnam, MOSTE.

Birdlife International, World Bank, Royal Netherlands Embassy and the Ministry of Agriculture and Rural Development (MARD) 2004. Sourcebook of Existing and Proposed Protected Areas in Vietnam, 2nd Ed.

David Dudgeon, 2000. The Ecology of Tropical Asian Rivers and Streams in Relation to Biodiversity Conservation Annual Rev. Ecol. Syst. 2000. 31:239-63

David Hill and Michele Beachler The Effects of Boat Propeller Wash on Shallow Lakes Civil & Environmental Engineering Penn State University

EPA Victoria, 1996. Environmental Guidelines for Major Construction Sites: Best Practices EPA Publication, Http:// www.epa.vic.gov.au

Haskoning Consulting Engineers and Architects and Delft Hydraulics, 1998. Red River Waterways Project Vietnam TA No. 2615-VIE. Gov Socialist Republic of Vietnam, MOT, VIWA.

Haskoning Nederland BV Coastal And Rivers, 2003. Day River-Ninh Co River Mouth Improvement Project – Vietnam. Ministry of Transportation, PMU Waterways

http://www.Vietnam.Re.Kr/Asaprogram/Asaboard/Download.Php?Bn=Bulleting&F_Name=Airpollution.Do

International Bank for Reconstruction and Development, Environment Dept. 1991. Environmental Assessment Sourcebook, Vol. II Sectoral Guidelines

International Finance Corp. 2007. Environmental, Health, and Safety Guidelines Coal Processing, World Bank Group

International Finance Corp. 2007. Environmental, Health, and Safety Guidelines Ports, Harbors and Terminals, World Bank Group

J. Murphy, G. Morgan and O. Power 2006. Literature Review on the Impacts of Boat Wash

José M. Guerra-García, Juan Corzo, J. Carlos García-Gómez (2003) Short-Term Benthic Recolonization after Dredging in the Harbour of Ceuta, North Africa Marine Ecology 24 (3), 217–229.

Long Guang Hua, Lin Gang, Hu Dasheng, Li Xiuzhen, Liu Jianhong 2005. The Reproductive Biology of Barbel Chub Chinese Journal of Zoology, Vol. 40, No. 5, Pp. 28-36

M.P Quigley And J.A. Hall, 1999. Recovery of Macrobenthic Communities after Maintenance Dredging in the Blyth Estuary, North-East England Aquatic Conservation: Marine and Freshwater Ecosystems, **Volume 9, Issue 1 , Pages 63 - 73**

Mccollum,Randy A. ; O'Neal,Wayne C. ; Glover,Edwin 1987. Bank Protection, Bass Location Willamette River, Oregon. Hydraulic Model Investigation. ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRAULICS LAB, Defense Technical Information Center

Miller, Andrew C. ; Payne, Barry S 1991. Impacts of Commercial Navigation Traffic on Freshwater Mussels at the W. H. Zimmer Station, 1991 Studies. Phase 2, Defense Information Technology Center

NH12B Feasibility Study Report – Feasbility Study Report Tam Diep-Nho Quan

On the Heritage of Ireland's Inland Waterways http://www.heritagecouncil.Ie/publications/boatwash/boatwash_review.pdf

Royal Haskoning, SMEC and Center Of VAPO 2007. Northern Delta Transport Development Project. Consultancy Services for Feasibility Study and Preliminary Engineering Design. Inception Report, MOT, VIWA, PMU-Waterways

Sterling, E.J. M.M Hurley and Le Duc Minh. 2006. Vietnam: A Natural History. Yale Press, 448p.

Susumu Tanabe, Yoshiki Saito, Quang Lan Vu, Till J.J. Hanebuth, Quang Lan Ngo and Akihisa Kitamura, 2006. Holocene evolution of the Song Hong (Red River) delta system, northern Vietnam **Sedimentary Geology**, Vol. 187, Issues 1-2, 15, pp 29-61

Tran Duc Thanh, Yuosiki Saito, Dinh Van Huy, Nguyen Huu Cu and Do Dien Chien (Undated), Coastal Erosion in Red River Delta: Current Status and Response, Hai Phong Institute of Oceanology And MRE, Geological Survey of Japan.

UNEP, 2006. Viet Tri Paper Greenhouse Gas Emission Reduction from Industry in Asia and the Pacific" (GERIAP), Energy Efficiency Guide For Industry In Asia– Www.Energyefficiencyasia.Org

USACE, 2002. Dredged Material Management Plan and Environmental Impact Assessment Mcnary Reservoir and Lower Snake River.Reservoirs, USEPA.

Van Maren, D.S. 2004. Morphodynamics of a cyclic prograding delta: The Red River Delta Vietnam. University of Utrecht.

Vu Trung Tang, Nguyen Xuan Huan , Vu Ngoc Thanh, Bac Bo Delta Estuarine Area Http://Coombs.Anu.Edu.Au/~Vern/Bac-Bo/Estuary.Html

Watling K and Dear, S.E. 2006. Managing Acid Sulfate Soils, Natural Resources and Water, Queensland Government, http://www.nrw.qld.gov.au/factsheets/pdf/162.pdf

WWF (http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0141_full.html)

H. Zhang, H. Nakagawa, Y. Muto & Y. Baba 2005. Flow and Sediment Transport around groins under Live-Bed Scour Condition, Proceedings of the International

Symposium on Fluvial and Coastal Disasters (ISFCD), December 1-2, 2005, Kyoto (CD-ROM, No.2)

Zhen Li, Yoshiki Saito, Eiji Matsumotoa, Yongji Wangc, Susumu Tanabed and Quang Lan Vu, 2006, Climate change and human impact on the Song Hong (Red River) Delta, Vietnam, during the Holocene Quaternary International Vol 144, no 1, p 4-28

11 APPENDICES

11.1 List of Vegetation, NDTDP Project Areas

11.2 List of Fish in the Red River Delta

11.3 List of Phytoplankton, Zooplankton & Benthos

11.4 List of Samples and Location

11.5 Analytical Methods

11.6 Results of Laboratory Analysis

11.7 TCVN Standards

Appendix 1. List of Vegetation –NDTDP- Project Area,November 2007

No	Location	English Name	Latin Name
1	**Location 1:** Lo river at Cao Phong, Triệu Đề - Lập Thạch – Vĩnh Phúc Province (VT1) **Coordinate** $21^0$19'47,4" $105^0$26'35,2"	Corn	*Zea mays* L.
		bamboo	*Bambusa arundinacea*
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Weed	*Saccharnm spontaneum* L.
		China tree	*Melia azdarach*
		Datura	*Datura motel* L.
		Manioc	*Manihot esculenta* crantz
		Kudzu	*Pueraria Montana*
		Brush	
2	**Location 2:** Lo river at Việt Trì – Phú Thọ Province (VT 2 Port) **Coordinate:** $21^0$17'56,3"$105^0$26'36,6"	Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Burweed	*Sida* sp.
		Ecalyptus	*Eucalyptus* sp
		Khaya Senegal	
		Brush	
3	**Location 2:** Lo river at Việt Trì Lake – Phú Thọ Province (VT 2 lake) **Coordinate**: $21^0$18'07,8" $105^0$26'05,5"	Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Wild cotton	*Gossyplium* sp
		Sensitive plant	*Mimosa pudiea*
		Wild pineapple	*Pandanus* sp
		Brush	
4	**Location 3**: Lo river at Vĩnh Tường – Vĩnh Phúc Province (VT 3) **Coordinate:** $21^0$15'08,6"	Corn	*Zea mays* L.
		Manioc	*Manihot esculenta* crantz
		Bamboo	*Bambusa arundinacea*

No	Location	English Name	Latin Name
	105⁰26'56,8"	Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
5	**Location 4:** Red River at Vĩnh Tường Ferry – Vĩnh Tường – Vĩnh Phúc Province (VT 4) **Coordinate:** $21^0$09'36,5" $105^0$30'53,9"	Bamboo	*Bambusa arundinacea*
		Corn	*Zea mays* L.
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		China tree	*Melia azdarach*
		Ecalyptus	*Eucalyptus* sp
		Mulberry	*Morus alloa* L.
		Banana	*Musa paradisiacal* L.
6	**Location 5:** Red river at Chu Phan Ferry – Vĩnh Phúc Province (VT 5) **Coodinate:** $21^0$09'34,3" $105^0$38'49,1"	Sweet-potato	*Ipomoea batas* (L.) poir
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Corn	*Zea mays* L.
		Banana	*Musa paradisiacal* L.
		Bamboo	*Bambusa arundinacea*
		Brush	
7	**Location 6:** Red river at Liên Hà, Đan Phượng, Vĩnh Phúc Province (VT 6) **Coordinate:** $21^0$09'52,9" $105^0$38'02,8"	Banana	*Musa paradisiacal* L.
			Canavalia sp
		Corn	*Zea mays* L.
		Apple	*Rhamnacea*
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Manioc	*Manihot esculunta* crantz

No	Location	English Name	Latin Name
		pumpship	*Cucurlita dactylon* (L.) pers.
		Cockscomb	*Celosia agentea* L.
			Muntingia calabura
8	**Location 7**: Đuống river at Phù Đổng – Sài Đồng – Hà Nội City (VT 7) **Coordinate**: $21^0$02'41,2" $105^0$57'34,0"	Corn	*Zea mays* L.
		Banana	*Musa paradisiacal* L.
		Manioc	*Manihot esculenta* crantz
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
9	**Location** 8: Đuống river at Làn Small village, Trung Mầu Commune – Gia Lâm District – Hà Nội City (VT 8) **Coordinate:** $21^0$04'02,0" $105^0$59'48,5"	Corn	*Zea mays* L.
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Fern	*Polypodiophyta*
10	**Location 9:** Đuống river at Đại La – Gia Bình – Bắc Ninh Province (VT 9) **Coordinate:** $21^0$06'00,2" $106^0$12'06,1"	China tree	*Melia azdarach*
		Corn	*Zea mays* L.
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Fern	*Polypodiophyta*
		Bamboo	*Bambusa arundinacea*
		Sensitive plant	*Mimosa pudiea*
11	**Location 10:** Đuống river - Kênh Vang port – Hải Dương Province (VT 10) **Coordinate:** $21^0$06'58,0" $106^0$14'43,7"	Bamboo	*Bambusa arundinacea*
		Banana	*Musa paradisiacal* L.
		Corn	*Zea mays* L.
		Sensitive plant	*Mimosa pudiea*
		Papaw	*Caryca papaya* L.
		Soybean	*Canavalia sga*
			Muntingia calabura

No	Location	English Name	Latin Name
			Khaya Senegal
12	**Location 11:** Kinh Thay river at Nam Tân – Nam Sách – Hưng Yên Province (VT 11)	Bermuda grass	*Cynodon dactylon* (L.) Pers.
	Coordinate:	Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
	$21^0$04’56,9”	Weed	*Saccharnm spontaneum* L.
	$106^0$19’19,9”	Corn	*Zea mays* L.
		Bamboo	*Bambusa arundinacea*
		Banana	*Musa paradisiacal* L.
		Mulberry	*Morus alloa* L.
			Khaya Senegal
		Sensitive plant	*Mimosa pudiea*
		Brush	
13	**Location 12:** Thai Binh river at Cống Câu port – Hải Dương City (VT 12		*Ficus hispida*
	Coordinate:	Bermuda grass	*Cynodon dactylon* (L.) Pers.
	20^0’54’46,2” $106^0$20’34,9”	Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Water hyacinth	*Eichornia crassipes*
		Apple	*Rhamnacea*
		Brush	
14	**Location 13:** Kinh Thay river at Hiệp Sơn – Kinh Môn – Hải Dương (VT 13)	Banana	*Musa paradisiacal* L.
	Coordinate:	Corn	*Zea mays* L.
	20^0’59’28,3”	Ecalyptus	*Eucalyptus* sp
	$106^0$23’21,2”	Guava	*Psidium guajava*
		Longan	*Dimocarpus longan*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Water hyacinth	*Eichornia crassipes*
15	**Location 14:** Lach Tray river at Trường Thọ	Corn	*Zea mays* L.

No	Location	English Name	Latin Name
	- An Lão – Hải Phòng City (VT 14) **Coordinate:** 20^{0}'50'50,8" 106^{0}33'52,0"	Ecalyptus	*Eucalyptus* sp
		Guava	*Psidium guajava*
		Longan	*Dimocarpus longan*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Water hyacinth	*Eichornia crassipes*
16	**Location 15:** Lach Tray river at Liễu Giai Small Village – An Lão – Hải Phòng City (VT 15) **Coordinate:** 20^{0}'51'26,0" 106^{0}32'47,6"	Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
		Apple	*Rhamnacea*
		Banana	*Musa paradisiacal* L.
		Mango	*Mangifera indica*
		Malabar almond	*Terminalia Catappa* L
		Guava	*Psidium guajava*
			Muntingia calabura
		Water hyacinth	*Eichornia crassipes*
17	**Location 16**: Red river at Ha Noi Port – Ha Noi City (VT 16) **Coordinate:** 20^{0}00'28,0" 105^{0}52'13,2"		*Coloeasia* sp
			Ficus hispida
		Casuarina	*Casuarina equisetifolia*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
18	**Location 17:** Red river at Hồng Vân Port – Văn Giang – Hưng Yên Province (VT 17) Coordinate: 20^{0}48'44,0" 105^{0}54'54,8"	Eucalyptus	*Eucalyptus* sp
		Malabar almond	*Terminalia Catappa* L
		Sensitive plant	*Mimosa pudiea*
		fig	*Ficus racemosa*

No	Location	English Name	Latin Name
			Ficus hispida
		China tree	*Melia azdarach*
		Corn	*Zea mays* L.
		Banana	*Musa paradisiacal* L.
		Bamboo	*Bambusa arundinacea*
19	**Location 18:** Red river at Tân Châu Ferry – Hưng Yên Province (VT 18) **Coordinate:** 20^{0}'48'44,0" 105^{0}54'54,8"	China tree	*Melia azdarach*
		Apple	*Rhamnacea*
		Banana	*Musa paradisiacal* L.
		Corn	*Zea mays* L.
		Ecalyptus	*Eucalyptus* sp
			Khaya Senegal
			Muntingia calabura
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
20	**Location 19:** Red river at Cao xá – Hưng Yên Province (VT 19) **Coordinate:** 20^{0}'40'53,8" 106^{0}02'13,1"	Corn	*Zea mays* L.
		China tree	*Melia azdarach*
		Sweet-potato	*Ipomoea batas* (L.) poir
		Longan	*Dimocarpus longan*
		Banana	*Musa paradisiacal* L.
		Brush	
		Catus	*Eupluorbia antia*
		Wild pineapple	*Pandanus* sp
		Ecalyptus	*Eucalyptus* sp
		Malabar almond	*Terminalia Catappa* L
		Sensitive plant	*Mimosa pudiea*
21	**Location 20:** Red river Be small village – Quảng Châu Commune – Hưng Yên Town – Hưng Yên Province (VT 20)	Mulberry	*Morus alloa* L.
		Banana	*Musa paradisiacal* L.
		Corn	*Zea mays* L.

No	Location	English Name	Latin Name
	Coordinate: 20⁰'37'08,7" 106⁰02'59,6"	Fern	*Polypodiophyta*
			Coloeasia sp
		Ecalyptus	*Eucalyptus* sp
		China tree	*Melia azdarach*
		Wild pineapple	*Pandanus* sp
		Sweet-potato	*Ipomoea batas* (L.) poir
		Wild pineapple	*Pandanus* sp
		Ecalyptus	*Eucalyptus* sp
		Malabar almond	*Terminalia Catappa* L
		Sensitive plant	*Mimosa pudiea*
22	**Location 21:** Luoc river at An Khê –Quỳnh Phụ - Thái Bình Province (VT 21) **Coordinate:** 20⁰'42'53,1" 106⁰23'41,1"	Banana	*Musa paradisiacal* L.
		Corn	*Zea mays* L.
		Bamboo	*Bambusa arundinacea*
		China tree	*Melia azdarach*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
23	**Location 22:** Luoc river at Đò Quế - xã Quỳnh Hoa –Quỳnh Phụ - Thái Bình Province (VT 22) **Coordinate:** 20⁰'41'55,5" 106⁰19'15,0"	Banana	*Musa paradisiacal* L.
		Bamboo	*Bambusa arundinacea*
		China tree	*Melia azdarach*
		Corn	*Zea mays* L.
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
			Muntingia calabura
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
24	**Location 23:** Luoc river at Việt Yên – Điệp nông	Corn	*Zea mays* L.

No	Location	English Name	Latin Name
	– Hưng Hà - Thái Bình Province (VT 23) **Coordinate:** 20⁰'39'37,9" 106⁰14'04,5"	Ecalyptus	*Eucalyptus* sp
		Bamboo	*Bambusa arundinacea*
		Sugar cane	*Saccharum officianarum* L.
		China tree	*Melia azdarach*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
25	**Location 24:** Tra Ly river at Thái Bình Port – Thái Bình Province (VT 24) **Coordinate:** 20⁰'27'31,9" 106⁰20'34,8"	Apple	*Rhamnacea*
		fig	*Ficus racemosa*
		Ecalyptus	*Eucalyptus* sp
		Brush	
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon aciculatus* (Rety.) Trin.
26	**Location 25:** Red river at old ferry of Tân Đệ bridge - Nam Định Province (VT 25) **Coordinate:** 20⁰'26'26,9" 106⁰12'53,8"	China tree	*Melia azdarach*
		Banana	*Musa paradisiacal* L.
		Flamboyant	*Delmin regia*
		Indian taro	*Alocasia odora* (Rosela) C.Kocle
		Papaya	*Carica papaya* L.
		Bamboo	*Bambusa arundinacea*
		Bamboo	*Bambusa arundinacea*
		Ecalyptus	*Eucalyptus* sp
			Amaranthus
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon aciculatus* (Rety.) Trin.
		Weed	*Saccharum spontaneum* L.
27	**Location 26:** Red river at Nam Phong	Corn	*Zea mays* L.

No	Location	English Name	Latin Name
	Confluence – Nam Định Province (VT 26) **Coordinate:** 20⁰'25'49,1" 106⁰12'16,2"	Sensitive plant	*Mimosa pudica*
		Wild pineapple	*Pandanus* sp
			Ficus hispida
			Coloeasia sp
		Banana	*Musa paradisiacal* L.
		Perilla	*Perilla frutescen*
		Ecalyptus	*Eucalyptus* sp
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
28	**Location 27:** Day river at Ngô Đồng – Xuân Thủy – Nam Định Province (VT 27) **Coordinate:** 20⁰'17'55,4" 106⁰25'51,5"	Casuarina	*Casuarina equisetifolia*
		Wild pineapple	*Pandanus* sp
		Bamboo	*Bambusa arundinacea*
		Apple	*Rhamnacea*
		China tree	*Melia azdarach*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
29	**Location 28:** Day river at Đình Quang Port – Ninh Bình Province (VT 28) **Coordinate:** 20⁰'15'03,3" 106⁰00'06,1"	Wild pineapple	*Pandanus* sp
		Water hyacinth	*Eichornia crassipes*
		Ecalyptus	*Eucalyptus* sp
		Brush	*Khaya Senegal*
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
30	**Location 29:** Day river at Quần Liêu small village - Nghĩa Hưng – Nam Định Province	Bamboo	*Bambusa arundinacea*
		China tree	*Melia azdarach*

No	Location	English Name	Latin Name
	(VT 29) **Coordinate:** 20^{0}'11'27,3" 106^{0}11'47,3"	fig	*Ficus racemosa*
			Ficus hispida
			Khaya Senegal
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
31	**Location 30:** Ninh Co river at Quần Khu small village - Nghĩa Sơn – nghĩa Hưng – Nam Định Province (VT 30) **Coordinate:** 20^{0}'11'33,4" 106^{0}11'00,6"	Tropical fruit similar to lichee	*Baccourea ramiflcra* lour
		Bamboo	*Bambusa arundinacea*
		China tree	*Melia azdarach*
		Sargasso	*Paederig cousi*
			Momordica coclim clinemis (Lour) Spreng
		Banana	*Musa paradisiacal* L.
		Casuarina	*Casuarina equiseti folia*
		Loopah	*Liyfa cylindrica*
		Pomelo	*Citrus grandis* (L.) oslo
		Longan	*Dimocarpus longan*
32	**Location 31:** Lach Tray river at Bát Trang – An Lão – Hải Phòng City (VT 31) **Coordinate:** 20^{0}'51'09,7" 106^{0}30'05,0"	Corn	*Zea mays* L.
		Banana	*Musa paradisiacal* L.
		Bamboo	*Bambusa arundinacea*
		Longan	*Dimocarpus longan*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
33	**Location 32:** Lach Tray river at Trung lập – Vĩnh Bảo – Hải Phòng City (VT 32) Coordinate:	Ecalyptus	*Eucalyptus* sp
		Catus	*Eupluorbia antia*
		Banana	*Musa paradisiacal* L.

No	Location	English Name	Latin Name
	20^{0}'43'28,2" 106^{0}27'53,1"	Corn	*Zea mays* L.
		Bamboo	*Bambusa arundinacea*
		Water hyacinth	*Eichornia crassipes*
		Sensitive plant	*Mimosa pudiea*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.
34	**Location 33:** Luoc river at Quỳnh Lâm Ferry – Quỳnh Lâm – Quỳnh Phụ - Thái Bình province (VT 33) Coordinate: 20^{0}'41'56,8" 106^{0}16'07,1"	Banana	*Musa paradisiacal* L.
		Corn	*Zea mays* L.
		Bamboo	*Bambusa arundinacea*
		Malabar almond	*Terminalia Catappa* L
		Spinach	*Ipomoea aqua*
		Guava	*Psidium guajcus*
		Manioc	*Manihot esculunta* crantz
		Kudzu	*Pueraria Montana*
		Brush	
		Bermuda grass	*Cynodon dactylon* (L.) Pers.
		Chrysopogon	*Chrysopogon acculatus* (Rety.) Trin.
		Weed	*Saccharnm spontaneum* L.

Notes: - Latin names of the recorded vegetation species provided by Dr. Nguyen Khac Khoi, professor and senior botanist of the Vietnam Academy of Natural Sciences and Technology

Appendix 2. Fish of the Red River and Thaibinh River Basins

Adapted from Phan Mach, Institute of Ecology and Biological Resources, Dec. 2007

N	Vienamese Name	Scientific Names	Nhuệ River	Cầu River	Red River	Thái -bình River	Note
	Bộ cá Trích	**Clupeiformes**					
	Họ cá lành canh	**Engraulidae**					
1	Cá lành canh	*Coilia grayii* Richardson	+	+	+	+	Economic
	C¸ Mßi cê hoa	*Clupanodon thrissa* (Linnaeus, 1758) **Red Book (V)**			+	+	Economic
	Họ cá Ngần	**Salangidae**					
2	Cá Ngần to	*Salanx chinensis* (Osbeck)	+	+	+	+	
	Bộ cá Chép Mỡ	**Characiformes**					
	Ho Characid	**Charracidae**					
3	Cá chim trắng nước ngọt	*Colosoma brachypomum* **	+	+	+	+	
	Bộ cá Chép	**Cypriniformes**					
	Họ Chép	**Cyprinidae**					
4	Cá Mại	*Rasbora cephalotaenia* (Bleeker, 1852)		+	+	+	
5	Cá Cháo	*Opsariichthys bidens* Gunther, 1873		+	+	+	
6	Cá Lòng tong	*Opsariichthys hieni* Tu		+	+	+	
7	Cá Trắm đen	*Mylopharyngodon piceus* (Rich.)	+	+	+	+	
8	Cá Trắm cỏ (trắm trắng)	*Ctenopharyngodon idellus* (C&V)* *	+	+	+	+	
9	Cá Măng	*Elopichthys bambusa* (Rich)		+			
10	Cá Nhồng Măng	*Luciobrama macrocephalus* (Lac.)		+	+	+	
11	Cá Trắm đen	*Mylopharyngodon piceus* (Rich)		+	+	+	
12	Cá Chày	*Squaliobarbus curriculus* (Rich., 1846) **Red Book (T)**	+	+	+	+	
13	Cá Ngão gù	*Culter flavipinnis* Tirant, 1883	+	+	+	+	
14	Cá Thiểu	*Cultrichthys erythropterus* (Basilewsky)	+	+	+	+	
15	Cá Mương	*Hemiculter leucisculus* (Bas., 1853)	+	+	+	+	Economic
16	Cá Dầu hồ	*Toxabramis hotayensi* Hao *nov. sp*		+	+		
17	Cá vền dài	*Megalobrama terminalis* (Richardson,1846)	+	+	+	+	Economic

N	Vienamese Name	Scientific Names	Nhuệ River	Cầu River	Red River	Thái -bình River	Note
18	Cá vền	*M. skolkovii* Dybowsky,1872		+	+	+	
19	Cá dầu mỏng	*Pseudohemiculter dispar (*Peters,1880*)*		+	+	+	
20	Cá Mại bạc	*Rasborinus formosae* Oshima, 1920 (Metzia)		+	+	+	
21	Cá Mại sọc	*R. lineatus* Pellegrin, 1907 (Metzia)	+	+	+	+	
	Cá Mại	*R. cephalotaenia steineri* (N&P*)*	+				
22	Cá mần	*Xenocypris davidi* Bleeker, 1871		+			
23	Cá Nhàng bạc	*Xenocypris argentea* Gunther,1868		+	+	+	
24	Cá Đục ngộ	*Hemibarbus medius* Yue, 1995		+			
25	Cá Đục chấm râu	*Microphysogobio labeoides* (N.& P., 1927)		+	+	+	
26	Cá Đục chấm mõm ngắn	*M. yunanensis* (Yao & Young, 1977)		+			
27	Cá Đục đanh chấm mõm dài	*M. vietnamica* Yen,1978		+			
28	Cá Đục đanh đốm	*Saurogobio dabryi* Bleeker,1871		+			
29	Cá Đục trắng	*Squalidus chankaensis* (Dybowsky, 1827)		+			
30	Cá Đục râu	*Gobiobotia kolleri* (Ban. & Nal., 1966)		+			
31	Cá Thè be râu	*Acheilognathus barbatulus* (Gun., 1873)		+	+	+	
32	Cá Thè be thường	*A. tonkinensis* (Vaillant, 1892)	+	+	+	+	
33	Cá Bướm chấm	*Rhodeus ocellatus* (Kner, 1876)	+	+			
34	Cá Bướm giả	*R. vietnamensis* Yen, 1978		+			
35	Cá Dầm	*Puntius brevis* (Bleeker, 1850)	+	+	+	+	
36	Cá Đòng đong	*Capoeta semifasciolata (*Gunther,1868*)*	+	+	+	+	
37	Cá Chày đất	*Spinibarbus hollandi* (Oshima, 1919)		+	+	+	
38	Cá Bỗng	*S. denticulatus (*Oshima,1926*)*		+	+	+	Economic
39	Cá Sỉnh	*Onychostoma gerlachi (*Sauvager & Dobry,1874)		+	+	+	Economic
40	Cá Sỉnh gai	*O. laticeps* (Gunther, 1896) **Red Book (V)**		+			
41	Cá Mọm	*S. acanthopterus (*Fowler,1934*)*		+			
42	Cá gỗ	*Neolissochilus blanci* Pell. & Fa., 1940		+			
43	Cá trôi ấn	*Labeo rohita* (Hamilton)**	+	+	+	+	

N	Vienamese Name	Scientific Names	Nhuệ River	Cầu River	Red River	Thái -bình River	Note
44	Cá mrigan	*Cirrhinus mrigala***	+	+	+	+	
45	Cá Trôi	*Cirrhinus molitorella* (Cuv.& Val., 1842)**	+	+	+	+	
46	Cá Dầm đất	*Osteochilus salsburyi* (N. & P., 1927)	+	+	+	+	
47	Cá Đo	*Garra pingi* (Tchang, 1929)		+			
48	Cá Sứt mũi	*G. bourreti* (Pellegrin, 1828)		+			
49	Cá Mè hoa	*Hypophthalmichthys nobilis (*Rich,1845*)***	+	+	+	+	
50	Cá Mè trắng	*Hypophthalmichthys molitrix (*Valiennes,1844*)***	+	+	+	+	
51	Cá Rưng	*Carrasioides cantonensis cantonensis (*Heincke*)*	+	+	+	+	
52	Cá Diếc	*Carassius auratus* (Linnaeus, 1758)	+	+	+	+	
53	Cá Chép	*Cyprinus carpio* (Linnaeus, 1758)**	+	+	+	+	
54	Cá Chẻn	*C. melanes (*Yen,1978*)*		+			
55	Cá tép dầu	*Ichskauina macrolepis hainamensis* (N&P)	+	+	+	+	
	Họ chạch	**Cobitidae**					
56	Cá Chạch bùn	*Misgurnus anguillicaudatus* (Can.,1842)	+	+	+	+	Economic
57	Chạch đá	*Barbatula fasciolatus (*N&P*)*	+				
58	Chạch đá đuôi đỏ	*B. caudofurea* (Yen*)*	+				
59	Cá Chạch hoa	*Cobitis cf. sinensis* (S & D,1874)		+	+	+	
60	Cá Chạch hoa	*C. yeni* Tu, 1986		+			
	Bộ cá nheo	**Siluriformes**					
	Họ lăng	**Bagridae**					
61	Cá Lăng	*Hemibagrus elongatus (*Giinther *)* **Red Book (V)**			+		
62	Cá Bò	*Pelteobagrus fulvidraco* (Rich., 1846)	+	+			
63	Cá Mịt	*P. virgatus* (Oshima, 1926)		+			
64	Cá Mịt tròn	*Elteobagrus kyphus* Yen,1978	+	+			
	Họ cá Ngạnh	**Cranoglanididae**					
65	Cá Ngạnh	*Cranoglanis henrici (*Vaillant,1893*)*		+	+	+	
	Họ nheo	**Siluridae**					
66	Cá Nheo	*Silurus asotus* Linnaeus, 1758	+	+	+	+	

N	Vienamese Name	Scientific Names	Nhuệ River	Cầu River	Red River	Thái -bình River	Note
67	Cá Thèo	*S. cochinchinensis* (Val., 1840)	+	+	+	+	
	Họ trê	**Clariidae**					
68	Cá Trê trắng	*Clarias batrachus* (Linnaeus, 1758)		+	+	+	Economic
69	Cá Trê đen	*Clarias fuscus* (Lacepede)	+	+	+	+	Economic
70	Cá Trê vàng	*Clarias macrocephalus* Gunther, 1864		+	+	+	
71	Cá Trê lai (trê Phi)	*Clarias gariepinus* (Burchell, 1815)**	+	+	+	+	
	Bộ mang tấm	**Synbranchiformes**					
	Họ lươn	**Synbranchidae**					
72	Lươn	*Monopterus albus* (Zuiew, 1703)	+	+	+	+	Economic
	Họ chạch sông	**Mastacembelidae**					
73	Cá Chạch sông	*Mastacembelus armatus* Lacepede, 1800	+	+	+	+	
	Họ bống trắng	**Gobiidae**					
74	Cá Bống đá	*Rhynogobius giurinus* (Rutte,1897)	+	+	+	+	
75	Cá Bống đá khe	*R. leavelli* (Herre, 1935)		+			
76	Cá Bống cát	*Glossogobius giuris* (Hamilton, 1822)	+	+	+	+	
77	Cá Bống mấu mắt	*G. biocellatus* (C. & V.,1837)		+			
	Họ Bống đen	**Eleotridae**					
78	Cá Bống suối đen tối	*Eleotris fusca* Bloch & Schneider, 1801	+	+	+		
79	Cá Bống mọi	*E. melanosoma* Bleeker, 1852		+		+	
80	Cá Bống đen nhỏ	*E. oxycephala* Tem. & Schl., 1845	+	+	+	+	
81	Cá Bống suối đầu ngắn	*Philypnus chalneersi* (N. & P., 1927)		+			
	Bộ cá vược	**Perciformes**					
	Họ Rô phi	**Cichlidae**					
82	Cá Rô phi vằn	*Oreochromis niloticus* (Linnaeus, 1758) **	+	+	+	+	
83	Cá Rô phi đen	*O. mossambicus* Peters, 1880 **	+	+	+	+	
84	Cá Rô phi đỏ	*Oreochromis niloticus* & *O. aureus***		+	+	+	
	Họ cá Mú	**Pereichthyidae**					
85	Cá Rô mo thường	*Coreoperca whiteheadi* (Boul., 1869)	+				

N	Vienamese Name	Scientific Names	Nhuệ River	Cầu River	Red River	Thái -bình River	Note
	Họ rô đồng	**Anabantidae**					
86	Cá Rô đồng	*Anabas testudineus* (Bloch, 1722)	+	+	+	+	Economic
	Họ cá cờ	**Osphronemidae**					
87	Cá cờ	*Macropodus opercularis* (L., 1788)	+	+	+	+	
	Họ sặc	**Belontidae**					
88	Cá Sặc bướm	*Trichogaster trichopterus* (Pallas, 1770)	+	+	+	+	
	Họ chuối	**Channidae**					
89	Cá Xộp	*Channa striata* (Bloch, 1793)	+	+	+	+	Economic
90	Cá Chuối suối	*Ch. orientalis* (Ham. & Bloch, 1822)	+	+			
91	Cá Chuối hoa	*Ch. maculatus (*Lacepede*)*	+	+			
92	Cá Trèo đồi	*Ch. asiatica (*Linaeus*)*	+				
	Bộ cá Sóc	**Cyprinodontiformes**					
	Họ sóc	**Adrianichthyidae**					
93	Cá Sóc	*Oryzias sinensis* (Chen & Uwa., 1989)		+	+	+	
94	Cá sóc	*O. latipes*	+	+			
	Họ cá bơn	**Bothidae**					
95	Cá Bơn	*Tephrinectes sinensis* (Lacepede, 1802)	+				
			53	89	64	62	

Notes : Species: cultured species

English names

Vietnamese name	English name	*Scientific name*
Bộ cá thát lát		*Osteoglossiformes*
Họ cá thát lát	Featherbacks	*Notopteridae*
Cá that lác (+)	Bronze featherback	*Notopterus notopterus (Pallas, 1780)*
Cá còm - (++)	*Clown featherback*	*Notopterus chitala (Hamilton - Buchanan, 1822)*
Bộ Cá Chình	Eels **	*Anguilliformes*
Họ Chình	Freshwater eels	*Anguillidae*
Cá chình (+++)	Giant mottled eel	*Anguilla marmorata Quoy & Gaimard, 1824*
Bộ cá chép	Minnows and Carps	*Cypriniformes*
Họ chép	Minnows and Carps	*Cyprinidae*
Trắm cỏ (++)	Grass carp	*Ctenopharyngodon idellus (Cuvier & Valenciennes, 1844)*
Cá măng	Yellow cheek (++)	*Elopichthys sp*
Cá chày mắt đỏ	Barbel chub (+) (++)	*Squaliobarbus curriculus (Richardson, 1846)*
Cá mương	Sharp belly (+)	*Hemiculter leucisculus (Basilewsky, 1855)*
Cá thiểu = cá ngão = ngô	Predatory carp (+) (++) (+++)	*Culter flavipinnis Tirant, 1883*
Trôi ấn độ	Rohu (+)	*Labeo rohita (Hamilton, 1822)*
Cá Trôi trắng	Vietnamese mud carp (++)	*Cirrhina molitorella (Valencienes, 1844)*
Mè trắng VN (+)	Vietnamese silver carp	*Hypophthalmichthys harmandi Sauvage,1844*
Cá Rưng=cá nhưng	*(++) (+++)*	*Carassioides acuminatus (Richardson, 1846*
Cá diếc (+)	Crucian carp (++) (+++)	*Carassius auratus gibelio (Bloch, 1783)*
Cá chép (+)	Common carp (++) (+++)	*Cyprinus carpio Linnaeus, 1758*
Cá mại cá sỉnh (++)	Laticep carp	*Onychostoma spp*
Cá dộp (cá Bỗng)	Denti carp (++)	*Spinibarbichthys denticulatus Oshima, 1926*
Cá xả lửa (*cá hỏa*)= *ho lieng=cá ruuồng*	Tonkin carp (+++)	*Labeo tonkinensis Pellegrin & Chevey, 1936*

Vietnamese name	English name	*Scientific name*
Cá niên	*(+)*	*Onychostoma ovale Pellegrin & Chevey, 1936*
	(+)	*Onychostoma ovalis rhomboides Tang, 1942*
Cá lúi sọc	Bony lipped barb (++)	*Osteochilus schlegeli (Bleeker, 1851)*
Cá Cân (+)	Chinese barb (++)	*Puntius semifasciolatus*
Cá sóc (trà sóc)	*Jullien's golden, price carp (+)*	*Probarbus jullieni (Sauvage, 1880)*
Cá sứt môi	Vietnamese mud carp (+++)	*Garra poilanei*
Cá cóc (++)	Soldier river barb	*Cyclocheilichthys enoplos (Bleeker, 1850)*
Cá nun =Nu=Nung=rầm xanh (++)	Lemas carp	*Bangana lemassoni (Pellegrin & Chevey, 1936) Altigena lemassoni Pellegrin et Chevey, 1936*
Cá Cầy	??	*Cyclocheilichthys furcatus Sontirat, 1985*
	??	*Cyclocheilichthys repasson (Bleeker, 1853)*
Dền =dềnh =vền (+)	*Black amur bream*	*Sinibrama affinis (Vaillant, 1892) Megalobrama terminalis (Richardson, 1845)*
Cá mát=mác 2 loài	*(++)*	*Onychostoma ovale Pellegrin & Chevey, 1936□cá niên*
		Onychostoma ovalis rhomboides Tang, 1942 □ cá niên
Cá Khóa	*(++)*	*Tor stracheyi (Day, 1871)*
Cá trèn (+, ++)	*Butter catfish***	*Ompok bimaculatus (Bloch, 1797)*
Họ cá bám đá	River Loaches **	*Balitoridae*
Cá bám đá		*Sewellia lineolata Valenciennes, 1842*
Họ Chạch (+++)	Loaches	*Cobitidae*
Họ Lăng	Bagrid catfishes	*Bagridae*
Cá lăng chấm (+++)	Spotted catfish **	*Hemibagrus elongatus (Gunther, 1864)*
Họ Cá Ngạnh	Cranoglanids **	*Cranoglanididae*
Cá Ngạnh (++ và +++)	Cranoglanidid catfish	*Cranoglanis henrici (Vaillant, 1893)*
	Cranoglanidid	*Cranoglanis bouderius (Richardson, 1896)*

Vietnamese name	English name	Scientific name
		Cranoglanis sinensis Peters, 1880
Họ Chiên	Sisorid catfishes **	*Sisoridae*
Cá Chiên (+++)	Giant bagarius, Goonch	*Bagarius yarreli Sykes, 1838*
		Pseudecheneis sulcatus (McClelland, 1842
Họ Trê	Breathing catfishes **	*Clariidae*
Cá Trê đen (+++)	Black catfish	*Clarias fuscus (Lacepede, 1803)*
Họ cá Úc		*Arridae*
Cá núc (cá úc) (+++)	Giant catfish **	*Arius thalassinus (Ruppell, 1835)*
		Cranoglanis henrici (Vaillant, 1893) ???
	Swamp eels and Spiny eels **	*Synbranchiformes Flutidae*
Họ lươn		
	Swamp eels **	*Synbranchidae*
lươn (+++)	Swamp eel	*Monopterus albus (Zuiew, 1793)*
		Fluta alba (Zuiew, 1793)
Họ chạch sông	Spiny eels **	*Mastacembelidae*
Con chạchchạch lá tre(+++)	*Peacock eel***	*Mastacembelus taeniagaster (Fowler, 1935) Mastacembelus aculeatus (Block, 1878)*
cá lẩu=láu=Cá láo cá chạch bông (+++)	Zing - Zang eel **	*Mastacembelus taeniagaster (Fowler, 1935) Mastacembelus armatus (Lacepede, 1800)*
Cá chạch bùn (+++)	Loach	*Misgurnus anguillicaudatus (Cantor, 1842)*
Họ Bống	Gobies (+++)	*Gobiidae*
Cá Bống tượng (bống mú) (++)	*Sand goby, Marbled sleeper*	*Oxyeleotris marmorata (Bleeker, 1852)*
Cá bống cát (++)	Ganetic tank goby	*Glossogobius giuris (Hamilton, 1822)*

Vietnamese name	English name	Scientific name
Họ cá Rô Phi họ cá vược		*Cichlidae*
Rô Phi đen (++)	Mozambique cichlid	*Oreochromis mossambicus (Peters, 1852)*
Họ cá rô	Climbing perches (++) (+++)	*Anabantidae*
	Common climbing perch	*Anabas testudineus (Bloch1792)*
cá rô đồng (++)	anabas	
Họ đối	Mullets	*Mugilidae*
Đối (++)	Blue tailed mullet (++) (+++)	*Liza seheli* (Forsskal, 1775)
Họ cá Tra		*Pangasiidae*
Cá bông lau (++ và +++)		*Pangasius krempfi*
Họ cá vược		*Cichlidae*
Cá mõm heo-mõm trâu=	(+++)	*Bangana lemassoni (Pellegrin & Chevey, 1936)*
Họ chuối cá quả	Snakeheads (+++)	*Channidae Ophiocephalidae*
Cá trầu (cá chuối hoa) (++)	Snake - head mullet	*Ophiocephalus maculatus (Lacépède, 1802)*
Họ nheo		*Siluridae*
Cá leo	Walla catfish **	*Wallagonia attu (Schneider, 1801)*
Cá niết=cá thèn=cá chèn cá trèn bầu	*sheatfish ** Butter catfish*	*Pterocryptis cochinchinensis (Valenciennes, 1840) Ompok bimaculatus (Bloch, 1797)*
Họ cá Vược		*Cichlidae*
Cá vược = dược cá chẽm (++)	White seabass, Giant seaperch, Siver seaperch (++)	*Lates calcarifer (Bloch, 1790)*

Vietnamese name	**English name**	***Scientific name***
Họ khác khong rõ	Other species (do not have official Vietnamese names)	
Chạt=chạc=cháo=quạc	(++)	*Opsariichthys bidens Gunther, 1873*
Cá sặc vện (hường vện) (+++)- Họ rô biển/Nandidae	Gangetic leaffish (++)	*Nandus nandus (Hamilton, 1822)*
Cá còm - (++) Họ thát lác/Notopteridae	*Bronze featherback ()* *Clown featherback*	*Notopterus notopterus (Pallas, 1769) Notopterus chitala (Hamilton - Buchanan, 1822)*
sặc rằn - Họ cá sặc/Belontiidae	*Snake skin gourami (++)*	*Trichogaster. trichopterus (Pallas, 1770)*

SMEC ROYAL HASKONING

Appendix 3. List of recorded species of phytoplankton at some rivers in the Red River Basin in Nov., 2007

No.	Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Phylum BACILLARIOPHYTA														
	Order Discinales														
	Family Coscinodiscaceae														
1	*Melosira varians* Ag														
2	*Melosira granulata* Ralfs	+	+	+	+	+	+	+			+		+		+
3	*Melosira granulata var. angutissima*		+	+								+			
4	*Melosira islandica*				+	+	+	+			+				+
5	*Melosira distans* Kutzing		+										+		
6	*Cyclotella stelligera*		+		+	+	+	+			+				+
	Family Achnanthaceae														
7	*Cocconeis placentula Ehr*		+	+								+	+		
	Family Fragilariaceae														
8	*Synedra acus* Kutz		+		+	+	+	+	+	+	+	+	+	+	+
9	*Synedra. ulna (Mitzsch)* Ehr.		+		+	+	+	+	+	+	+		+	+	+
10	*Synedra ulna (Nitzsch) Ehr var biceps (kg)* Schonf.		+							+			+		
11	*Fragillaria. virescens* Ralfs.											+			
12	*Fragillaria construens* Grunow												+		
	Family Tabelariaceae														
13	*Diatoma elongatum Ehr*	+		+	+	+	+	+		+	+		+		+
	Family Naviculaceae														
14	*Navicula radiosa*		+												
15	*Navicula placentula Grun*	+		+	+	+	+	+	+	+	+	+	+	+	
16	*Navicula placentula fo. lanceolata*		+	+	+					+		+	+		
17	*Navicula placentula f. rostrata*	+		+						+					

18	*Navicula. gracillis* Ehr	+		+											
19	*Navicula. gastrum*	+		+											
20	*Amphora hendeyi*		+			+	+	+			+		+		+
21	*Cymbella turgida* Clever			+			+				+	+			
22	*Cymbella. naviculiformis*			+						+		+			
23	*Cymbella. parva* Clever		+												
24	*Cymbella ventricosa* Kutz		+	+											
25	*Cymbella. tumida*			+						+			+		
26	*Gomphonema sphaerophorum* Ehr	+	+	+						+			+		
27	*Gomphonema. olivaceum* Ehr	+	+	+	+	+	+	+		+	+				+
28	*Gyrosigma attenuatum*		+		+	+	+	+			+				+
	Family Nitzschiaceae														
29	*Nitzschia recta Hantsch*			+	+	+	+	+	+	+	+	+	+	+	+
30	*Nitzschia. filiformis Hust.*				+	+	+	+			+		+		+
31	*Nitzschia. philippinarum Ehr*			+						+		+			
32	*Nitzschia. nianensis*								+			+		+	
	Family Surirellaceae														
33	*Surirella robusta Ehr*				+	+	+	+	+		+			+	+
	Phylum CHLOROPHYTA														
	Order Chlorococcales														
	Family Hydrodictyaceae														
34	*Pediastrum. simplex var. simplex*								+					+	
35	*Schroederia Setigera (Schroder)* Lemm											+			
36	*Tetraedron gracille (Reinsch)* Hansg								+			+		+	
	Family Scenedesmaceae														
37	*Crucigenia tetrapedia (Kirchner)* W&G West					+	+	+			+				+

38	*Crucigenia. rectangularis*											+			
39	*Scenedesmus. obiquus*								+			+		+	
40	*Scenedesmus. ellipsoideus* Chodat								+			+		+	
	Order Zygnematales														
	Family Zygnemataceae														
41	*Spirogyra ionia*	+		+								+	+		
42	*Spirogyra. prolifica*	+		+									+		
	Family Mesotaeniaceae														
43	*Gonatozygon aculeatum Hast.*											+			
	Family Desmidisceae														
44	*Closterium. moniliferum (Bory)* Ehr											+			
45	*Closterium. porectum*				+	+	+	+			+				+
46	*Cosmarium sportella* Ehr											+			
	Order Ulotrichales														
	Family Ulotricaceae														
47	*Ulothrix zonata (Schmide)* Bohlin	+	+	+						+					
	Phylum CYANOBACTERIA														
	Order Chroococcales														
	Family Chroococcaceae														
48	*Mycrosystis aeruginosa*	+		+											
	Bộ Nostocales														
	Family Nostocaceae														
49	*Anabaena viguieri*											+			
	Family Oscillatoriaceae														
50	*Lyngbya putealis*								+					+	
51	*Lyngbya birgei* G.M.S.Smith								+			+		+	

52	*Oscilllatoria limosa Ag*		+	+	+	+	+	+		+	+	+	+		+
53	*Oscilllatoria. planetomica*														
54	*Oscilllatoria. formosa* Bory		+	+	+	+	+	+			+		+		+
55	*Oscilllatoria. princeps*	+		+						+			+		
56	*Spirulina princeps* W& G.S.West				+	+	+	+			+				+
57	*Phormidium. tenue*											+			
	Phylum EUGLENOPHYTA														
	Order Euglenales														
	Family Euglenaceae														
58	*Euglena acus* Ehr			+	+	+	+	+			+	+			+
59	*Euglena. gaumei*					+	+	+			+				+
60	*Euglena. hemichromata*				+							+			
61	*Euglena. caudata*											+			
62	*Euglena. rostifera nsp.*				+			+							
63	*Leptocylyndrus wangi*											+			
64	*Phacus. longicauda*											+			
65	*Phacus. acuminatus*											+			
66	*Strombomonas. fluviatilis var. ettlii*											+			
		13	19	25	20	20	12	21	12	16	21	31	20	12	19

Source: VESDEC and IEBR, Nov.2007

Quantitative density of phytoplankton at the sampling sites

No.	Sampling locations	Density (cell/l)				
		Total density	Bacillario-phyta	Chlorophyta	Cyanobac-teria	Eugleno-phyta
1	Nhuthuy Port	3,798	964 (25)	737 (19)	2,097 (56)	0
2	Viettri Port	2,494	1,701 (69)	283 (11)	510 (20)	0
3	Viettri Lake	4,705	1,757 (37)	794 (17)	2,041 (44)	113 (2)
4	Sontay Port	2,834	1,417 (50)	113 (4)	1,134 (40)	170 (6)
5	Chuphan Port	2,778	1,474 (53)	283 (10)	907 (33)	113 (4)
6	Phudong Port	1,928	397 (21)	1,021 (53)	510 (26)	0
7	Kenhvang Port	2,664	1,474 (55)	283 (11)	737 (28)	170 (6)
8	Congcau Port	1,928	397 (21)	1,021 (53)	510 (26)	0
9	Hanoi Port	2,438	1,531 (62)	283 (12)	624 (26)	0
10	Hongvan Port	3,004	1,587 (53)	283 (9)	1,020 (34)	114 (4)
11	Hungyen Port	2,721	1,361 (51)	283 (10)	964 (35)	113 (4)
12	Namdinh Port	2,948	1,701 (58)	510 (17)	737 (25)	0
13	Thaibinh Port	1,928	397 (21)	1,021 (53)	510 (26)	0
14	Ninhphuc Port	2,721	1,361 (51)	283 (10)	964 (35)	113 (4)

Note: value in bracket show percent rate (percentage)

SMEC ROYAL HASKONING

List of zooplankton species composition recorded in rivers in the red river delta on November 2007

No	Taxon	Nhuthuy Port	Viettri Port	Viettri Lake	Sontay Port	Chuphan Port	Phudong Port	Kenhvang Port	Congcau Port	Hanoi Port	Hongvan Port	Hungyen Port	Thaibinh Port	Namdinh Port	Ninhphuc Port
	Phylum Arthropoda														
	Class CRUSTACEA														
	Subclass COPEPODA														
	Order Calanoida														
	Family Diaptomidae														
1	*Mongolodiaptomus birulai* (Rylop)	+		+	+	+	+	+	+	+	+	+	+	+	+
2	*Phyllodiaptomus tunguidus* Shen et Tai	+	+	+	+	+	+	+	+	+	+	+	+	+	
3	*Neodiaptomus handeli* (Brehm)											+	+	+	
	Family Paracalanidae														
4	*Paracalanus crassirostris Dahl**														+
	Order Cyclopoida														
	Family Cyclopidae														
5	*Mesocyclops leuckarti* (Claus)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6	*Microcyclops varicans* (Sars)	+	+	+	+		+	+	+	+	+	+	+	+	+
7	*Thermocyclops hyalinus* (Rehberg)		+	+	+	+	+	+		+	+	+		+	+
8	*Thermocyclops taihokuensis* (Harada)					+	+				+				
9	*Eucyclops serrulatus* (Fischer)									+	+				
10	*Limnoithona sinensis* (Burckhardt)														+
	Subclass BRANCHIOPODA														
	Order Cladocera														
	Family Bosminidae														
11	*Bosmina longirostris* (O. F. Muller)							+							+
12	*Bosminopsis deitersi* Richard	+	+	+											+
	Family Sididae														
13	*Diaphanosoma sarsi* Richard			+	+	+	+	+	+	+	+		+	+	+
14	*Diaphanosoma excisum* Sars	+	+					+				+			

15	*Diaphanosoma leuchtenbergianum* Fischer		+	+	+		+		+	+	+				+
	Family Daphniidae														
16	*Moinodaphnia macleayii* (King)				+				+				+		+
17	*Moina dubia* de Guerne et Richard	+	+	+	+	+	+	+	+	+	+	+	+	+	+
18	*Daphnia lumholtzi* Sars		+	+											
	Family Chydoridae														
19	*Euryalona orientalis* (Daday)										+				
	Phylum NEMATHELMINTHES														
	Class ROTATORIA														
	Order Monogononta														
	Family Asplanchnidae														
20	*Asplanchna sieboldi* (Leydig)		+	+	+	+	+	+	+	+	+	+	+		+
	Family Brachionidae														
21	*Brachionus quadridentatus Hermann*			+											
22	*B. falcatus* Zacharias								+						
23	*B. calyciflorus* Pallas			+		+									
24	*Platyias quadricornis* (Ehrenberg)			+											
	Others														
25	Insecta larvae		+	+	+	+	+	+		+	+	+	+	+	
26	crustacean lavae	+	+	+	+		+		+		+		+	+	+
27	Amphipoda										+				
	Total	**9**	**12**	**16**	**12**	**10**	**12**	**11**	**11**	**11**	**15**	**11**	**11**	**10**	**15**

Note: * : Brackish water species

Density Distribution of Zooplankton

Zooplankton group / Locations	Copepoda Ind./m³ (%)	Cladocera Ind./m³ (%)	Rotatoria Ind./m³ (%)	Total density con/m³
Nhuthuy Port	72 (63)	42 (37)	0 (0)	114
Viettri Port	66 (38)	96 (55)	12 (7)	174
Viettri Lake	1950 (53)	1260 (34)	480 (13)	3,690
Sontay Port	360 (71)	90 (18)	60 (12)	510
Chuphan Port	180 (67)	60 (22)	30 (11)	270
Phudong Port	456 (87)	48 (9)	18 (4)	522
Kenhvang Port	570 (73)	180 (23)	30 (4)	780
Congcau Port	96 (55)	54 (31)	24 (14)	174
Hanoi Port	540 (91)	36 (6)	20 (3)	596
Hongvan Port	648 (92)	42 (6)	18 (3)	708
Hungyen Port	492 (92)	24(4)	18 (3)	534
Namdinh Port	828 (93)	48 (5)	12 (1)	888
Thaibinh Port	564 (97)	18 (3)	0 (0)	582
Ninhphuc Port	126 (46)	144 (52)	6 (2)	276

Zoo-benthos species composition recorded in rivers in the red river delta in Nov., 2007

No.	Taxon	Nhuthuy Port	Viettri Port	Viettri Lake	Sontay Port	Chuphan Port	Phudong Port	Kenhvang Port	Congcau Port	Hanoi Port	Hongvan Port	Hungyen Port	Thaibinh Port	Namdinh Port	Ninhphuc Port
	Phylum Mollusca														
	I. Class Bivalvia														
	1. Family Corbiculidae														
1	*Corbicula bocourti* Morlet								+		+				
2	*Corbicula messageri* Bav.et.Dautz	+											+		
3	*Corbicula moreletiana* (Prime)	+					+					+	+		+
	2. Family Solennidae														
4	*Pharella sp.**														+
	3. Họ Mytilidae														
5	*Limnoperna siamensis* (Morelet)		+						+						+
	4. Family Unionidae														
6	*Nodularia douglasiae crassidens* Hass						+								
	II. Lớp Thân mềm Chân bụng-Gastropoda														
	5. Family Ampullariidae														
7	*Pomacea canaliculata* (Lamarck)														+
	6. Family Bithyniidae														
8	*Bithynia fuchssiana*														+
9	*Parafossarulus striatulus* (Benson)														+
10	*Allocinma longicornis* (Benson)														+
	7. Family Planorbidae														
11	*Hippeutis umbilicalis* (Benson)							+							
	8. Family Stenothyridae														

No.	Taxon	Nhuthuy Port	Viettri Port	Viettri Lake	Sontay Port	Chuphan Port	Phudong Port	Kenhvang Port	Congcau Port	Hanoi Port	Hongvan Port	Hungyen Port	Thaibinh Port	Namdinh Port	Ninhphuc Port
12	*Stenothyra messageri* Bavey et Dautzenberg														+
	9. Family Thiaridae														
13	*Melanoides tuberculatus* (Muller)			+					+	+					+
14	*Tarebia granifera* (Lamarck)									+					
15	*Thiara scabra* (Muller)									+					
	10. Family Viviparidae														
16	*Angulyagra boettgeri* (Heude)			+											+
17	*Angulyagra polyzonata* (Frauenfeld)		+												
18	*Sinotaia aeruginosa* (Reeve)			+											
	Phylum Arthropoda														
	III. Class Crustacea														
	Order DECAPODA														
	Suborder MACRURA														
	11. Family Palaemonidae														
19	*Macrobrachium hainanense* Parisi		+	+	+	+	+	+	+	+	+				
	Suborder BRACHYURA														
	12. Family Grapsidae														
20	*Sesarma sp.**								+						
	Total	2	3	4	1	1	3	2	5	4	2	1	2	1	10

Note: * : brackish water species

Individual quantity of zoobenthos groups at rivers in the Red River Delta (Nov.2007)

Locations	Zoobenthos groups			
	Bivalvia	Gastropoda	Crustacea	Total
Nhuthuy Port	4			4
Viettri Port		3	2	5
Viettri Lake		22	9	31
Sontay Port			6	6
Chuphan Port			3	3
Phudong Port	2		1	3
Kenhvang Port		1	1	2
Congcau Port	1	3	2	6
Hanoi Port		188	4	192
Hongvan Port	1		2	3
Hungyen Port	1			1
Namdinh Port	8			8
Thaibinh Port	0	0	0	0
Ninhphuc Port	15	10		25
Total	**32**	**227**	**30**	**289**

Biomass of zoobenthos groups at rivers in the red river delta (Nov., 2007)

Trạm	Zoobenthos groups			
	Bivalvia	Gastropoda	Crustacea	Total (g)
Nhuthuy Port	2.5			2.5
Viettri Port		1.5	0.3	1.8
Viettri Lake		16.8	0.9	17.7
Sontay Port			0.5	0.5
Chuphan Port			0.2	0.2
Phudong Port	6.4		0.6	7
Kenhvang Port		0.01	1	1.01
Congcau Port	0.7	0.9	0.21	1.81
Hanoi Port		54.3	0.9	55.2
Hongvan Port	0.9		3	3.9
Hungyen Port	0.2			0.2
Namdinh Port	2.2			2.2
Thaibinh Port	0	0	0	0
Ninhphuc Port	25.6	7.42		33.02
Total (g)	**32**	**227**	**30**	**289**

Individual quantity of benthos species (Nov.,2007)

Species	**Locations**														**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Allocinma longicornis														1	1
Angulyagra boettgeri			2											1	3
Angulyagra polyzonata		1													1
Bithynia fuchsiana														2	2
Corbicula bocourti								1		1					2
Corbicula messageri	3											1			4
Corbicula moreletiana	1					1					1	7		13	23
Hippeutis umbilicalis							1								1
Limnoperna siamensis		2						2						1	5
Macrobrachium hainanense		2	9	6	3	1	1	1	4	2					29
Melanoides tuberculatus			2					1	9					1	13
Nodularia douglasiae crassidens						1									1
Parafossarulus striatulus														1	1
Pharella sp.														2	2
Pomacea canaliculata														1	1
Sesarma sp.								1							1
Sinotaia aeruginosa			18												18
Stenothyra messageri														2	2
Tarebia granifera									99						99
Thiara scabra									80						80
Total	**4**	**5**	**31**	**6**	**3**	**3**	**2**	**6**	**192**	**3**	**1**	**8**	**0**	**25**	**289**

Biomass of zoobenthos species (Nov.,2007)

Species	**Locations**														**Total (g)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Allocinma longicornis														1	0.5
Angulyagra boettgeri			2											1	3
Angulyagra polyzonata		1													1
Bithynia fuchsiana														0	0.3
Corbicula bocourti								1		1					1.6
Corbicula messageri	1											1			1.7
Corbicula moreletiana	1					1					0	2		25	29.4
Hippeutis umbilicalis							0								0.01
Limnoperna siamensis		1						0						0	1.3
Macrobrachium hainanense		0	1	1	0	1	1	0	0.9	3					7.41
Melanoides tuberculatus			3					1	2.3					0	5.6
Nodularia douglasiae crassidens						6									5.6
Parafossarulus striatulus														1	0.6
Pharella sp.														0	0.2
Pomacea canaliculata														4	4.1
Sesarma sp.								0							0.2
Sinotaia aeruginosa			13												12.5
Stenothyra messageri														0	0.02
Tarebia granifera									38						37.8
Thiara scabra									14						14.2
Total (g)	3	2	18	1	0	7	1	2	55	4	0	2	0	33	127.04

Appendix 4. Location of the sampling sites and studied environmental components

	Location	Coordinate	Studied Components					
			Water	Soil	Sediment	Noise	Vibration	Aquatic organisms
VT1	Nhuthuy landing site - Nhuthuy – Lapthach – Vinhphuc province	21^{0}19’47,4” 105^{0}26’35,2”	X	X	X	X	X	X
VT2-Port	Viettri Port – Viettri city – Phutho Province	21^{0}17’56,3” 105^{0}26’36,6”	X	X	X	X	X	X
VT2-Lake	Viettri Lake – Viettri city – Phutho province	21^{0}18’07,8” 105^{0}26’05,5”	X	X	X			X
VT3	Vinhtuong – Vinhphuc province	21^{0}15’08,6” 105^{0}26’56,8”			X			
VT4	Sontay Port –Sontay city - Hatay province	21^{0}09’36,5” 105^{0}30’53,9”	X	X	X	X	X	X
VT5	Chuphan Ferry – Vinhphuc province	21^{0}09’34,3” 105^{0}38’49,1”	X	X	X			X
VT6	Hongha Commune – Danphuong District – Hatay province	21^{0}09’52,9” 105^{0}38’02,8”			X			
VT7	Phudong landing site – Saidong District – Hanoi City	21^{0}02’41,2” 105^{0}57’34,0”	X	X	X	X	X	X
VT8	Trungmau Commune – Gialam District- Hanoi City	21^{0}04’02,0” 105^{0}59’48,5”			X			
VT9	Daila Commune – Giabinh District – Bacninh Province	21^{0}06’00,2” 106^{0}12’06,1”			X			
VT10	Kenh Vang Port – Luongtai District – Bacninh Province	21^{0}06’58,0” 106^{0}14’43,7”	X	X	X	X	X	X
VT11	Namtan Commune – Namsach District – Hungyen Province	21^{0}04’56,9” 106^{0}19’19,9”			X			
VT12	Cong Cau Port – Haiduong City – Haiduong Province	20^0’54’46,2” 106^{0}20’34,9”	X	X	X	X	X	X
VT13	Hiepson Commune – Kinhmon District – Haiduong Povince	20^0’59’28,3” 106^{0}23’21,2”			X			
VT14	Truongtho – Anlao District – Haiphong City	20^0’50’50,8” 106^{0}33’52,0”			X			
VT15	Truongson – Anlao District – Haiphong City	20^0’51’26,0” 106^{0}32’47,6”			X			
VT16	Hanoi Port – Hanoi City	20^{0}00’28,0” 105^{0}52’13,2”	X	X	X			X
VT17	Hongvan port – Thuongtin District – Hatay Province	20^{0}48’44,0” 105^{0}54’54,8”	X	X	X	X	X	X

	Location	Coordinate	Studied Components					
			Water	Soil	Sediment	Noise	Vibration	Aquatic organisms
VT18	Thongnhat – Thuongtin District – Hatay Province	20^0'48'44,0" 105^{0}54'54,8"			X			
VT19	Caoxa – Hungyen Province	20^0'40'53,8" 106^{0}02'13,1"	X	X	X			X
VT20	Quangchau – Hungyen town – Hungyen Province	20^0'37'08,7" 106^{0}02'59,6"			X			
VT21	Ankhe – Quynhphu District –Thaibinh Province	20^0'42'53,1" 106^{0}23'41,1"			X			
VT22	Que ferry – Quynhhoa Commune – Quynhphu District – Thaibinh Province	20^0'41'55,5" 106^{0}19'15,0"			X			
VT23	Vietyen – Diepnong Commune – Hungha District – Thaibinh Province	20^0'39'37,9" 106^{0}14'04,5"			X			
VT24	Thaibinh Port – Thaibinh City – Thaibinh Province	20^0'27'31,9" 106^{0}20'34,8"	X	X	X	X	X	X
VT25	Namdinh Port – Namdinh City – Namdinh Province	20^0'26'26,9" 106^{0}12'53,8"	X	X	X	X	X	X
VT26	Namphong – Namdinh Province	20^0'25'49,1" 106^{0}12'16,2"			X			
VT27	Giaothuy – Ngodong – Xuanthuy District – Namdinh Province	20^0'17'55,4" 106^{0}25'51,5"			X			
VT28	Ninhphuc Port – Ninhbinh City – Ninhbinh Province	20^0'15'03,3" 106^{0}00'06,1"	X	X	X	X	X	X
VT29	Quanlieu – Nghiahung District – Namdinh Province	20^0'11'27,3" 106^{0}11'47,3"			X	X	X	
VT30	Quankhu – Nghiahung District – Namdinh Province	20^0'11'33,4" 106^{0}11'00,6"			X			
VT31	Battrang – Anlao District – Haiphong City	20^0'51'09,7" 106^{0}30'05,0"		X				
VT32	Trunglap – Vinhbao District – Haiphong City	20^0'43'28,2" 106^{0}27'53,1"		X				
VT33	Quynhlam – Quynhphu District - Thaibinh Province	20^0'41'56,8" 106^{0}16'07,1"		X				
VT34	Lachgiang Estuary – Namdinh Province	20^{0}01684'	X	X				
VT35	In front of High School Ninh Gianh – Haiduong Province	106^{0}20362'				X	X	
VT36	On the road 17A – Ninhgiang – Haiduong Province					X	X	
VT37	Haiphong port – Haiphong City		X		X	X	X	

	Location	Coordinate	Studied Components					
			Water	Soil	Sediment	Noise	Vibration	Aquatic organisms
Location of sampling in 1.12.2007 by boat								
VW1	Duong River	$21^0$09747' $105^0$8215'			X			
VW2	Duong River	$21^0$04553' $105^0$99461'			X			
VW3	Duong River	$21^0$08213' $106^0$0746'			X			

SMEC
ROYAL HASKONING

Vietnamese Academy of Science and technology
INSTITUTE OF CHEMISTRY
Department of Analytical Science and Technology
Building A18 - Hoang Quoc Viet road, Caugiay district, Hanoi - Vietnam.
Tel: (84-4) 8 361 281 or (84-4) 7 564 333 – ext. 1045; Fax: (84-4) 8 361 283

Hanoi. December 31, 2007

Appendix 5. Analytical Methods used for the NDTD Project

(Water, soil, sediment samples collected by VESDEC team in Nov. & Dec, 2007)

PARAMETERS	METHODS	INSTRUMENTS FOR DETERMINATION
pH	TCVN 6492:1999 US EPA 1501	pH meter Metrohm
BOD	APHA 5210B TCVN 6001:1995	VELP Scientifica
COD	APHA 5220 TCVN 6186:1996	Cintra 40 UV-Visible Spectrometer /GBC Scientific Equipment Pty Ltd / Australia and USA
CN-	apha 4500	Cintra 40 UV-Visible Spectrometer /GBC Scientific Equipment Pty Ltd / Australia and USA
Phenol	APHA 5530 C	idem
NH_4	APHA 4500 TCVN 5988-95	idem
NO_3	APHA 4500 TCVN 6180-96	idem
$\sum N$	APHA 4500 N	idem
$\sum P$	APHA 4500 P TCVN 6202-96	idem
Pb, Zn, Cr, Fe Cd, Al	APHA 3113	AAS Perkin – Elmer 3300 USA
As, Hg	APHA 3114, 3112	AAS Perkin – Elmer 3300 /MHS-10 - USA
Pesticides Organochloride	apha 6630 B	HP 5890, HP 6890 GC/ECD – USA
Oil total	apha 5200	Cintra 40, UV-Visible Spectrometer Australia
Coliform	Tcvn 4584-88	ESCO LAMINAR Flow Cabinet

Conducted by a Team of Ass. Prof. ,
Dr. Le Lan Anh

Signature

Assoc. Prof. Le Lan Anh
Department of Analytical Science and Technology

Air Quality Measurement

Parameter	Measurement/ analysis equipment
Humidity	Humidity Meter SK – 80 TRA (Japan)
Noise	Noise Meter ONO SOKKI (Japan)
Dust	Dust detector KANOMAX (Japan)
SO_2	TESTO 350/XL (Germany)
NO_2	TESTO 350/XL (Germany)
CO	TESTO 350/XL (Germany)
Wind speed	Wind speed meter D – 79853 (Germany)

Appendix 6. Results of Laboratory Analysis

Water Quality of the river in the Northern Delta Nov.2007

No	Sampling sites	Temp. (^{0}C)	pH	TDS (mg/L)	Turbidity (NTU)	SS (mg/L)	DO (mg/L)	BOD_5 (mg/L)	NH_4^+ (mg/L)	Total N (mg/L)	NO_3^- (mg/L)	Total P (mg/L)	Total oil (mg/L)	Phenol (µg/L)	Coliform (MPN/100mL)
1	VT1	21	7.2	139	16	24	6.4	13	0.401	2.235	1.024	0.391	ND	0.124	7100
2	VT2 – Port	22	7.3	140	36	52	6.3	9	0.154	1.931	0.828	0.359	0.30	ND	1600
3	VT2 - Lake	21	7.4	147	6	12	6.4	8	0.132	0.586	0.622	0.407	0.16	0.146	1200
4	VT4	21	7.4	139	40	60	6.4	7	0.477	1.435	0.782	0.407	ND	ND	4500
5	VT5	22	7.3	131	38	58	6.2	14	0.578	1.044	1.016	0.342	0.34	0.115	2300
6	VT6	22	7.4	138	42	62	6.3	12	0.567	1.226	0.986	0.374	ND	ND	5800
7	VT7	21	7.2	140	36	54	5.8	5	0.797	1.215	1.124	0.359	0.26	0.123	1900
8	VT10	21	7.3	144	44	56	5.5	4	0.631	1.616	1.312	0.586	0.20	0.115	4800
9	VT12	22	7.0	145	28	34	4.8	8	0.683	1.934	1.546	0.668	ND	ND	3000
10	VT16	22	7.4	152	46	64	4.0	6	0.679	2.505	2.015	0.108	0.22	ND	1300
11	VT17	21	7.3	157	42	58	4.1	15	0.871	2.274	1.844	0.101	ND	ND	1600
12	VT19	20	7.4	163	50	62	4.2	7	0.592	2.824	2.124	0.101	ND	ND	2600
13	VT24	21	7.0	180	18	24	3.7	8	0.756	1.882	1.276	0.087	0.04	ND	1500
14	VT25	22	7.2	230	38	52	3.8	18	0.688	2.541	1.917	0.087	ND	ND	2700
15	VT28	21	7.6	264	42	56	4.4	9	0.672	1.692	1.322	0.456	0.68	ND	5200
TCVN 5942 – 1995	**B**	**-**	**5.5 -9**	**-**	**-**	**80**	**≥2**	**<25**	**1**	**15**	**-**	**-**	**0.3**	**20**	**10.000**
	A		**6 - 8,5**	**-**	**-**	**20**	**≥ 6**	**< 4**	**0,05**	**10**	**-**	**-**	**0**	**1**	**5.000**

Concentration of heavy metals in water of the rivers in the Northern Delta, Nov.2007

No	Sampling sites		Fe (mg/L)	Zn (mg/L)	Cd (µg/L)	Total Cr (µg/L)	As (µg/L)
1	VT1		0.026	0.031	0.25	4.15	13.20
2	VT2 – Port		0.028	0.042	0.30	3.98	18.97
3	VT2 - Lake		0.031	0.037	0.18	3.74	22.23
4	VT4		0.785	0.038	0.27	4.21	5.51
5	VT5		1.571	0.053	0.31	5.01	8.09
6	VT6		2.722	0.040	0.28	3.92	9.96
7	VT7		0.968	0.039	0.22	3.45	7.59
8	VT10		3.743	0.032	0.34	3.64	12.55
9	VT11		0.336	0.031	0.26	3.18	15.37
10	VT12		0.419	0.043	0.39	4.17	2.74
11	VT 13		0.985	0.035	0.30	3.29	16.09
12	VT 15		0.649	0.029	0.28	2.89	10.03
13	VT16		0.778	0.036	0.31	3.85	9.56
14	VT17		1.972	0.043	0.39	3.21	10.39
15	VT19		1.639	0.057	0.28	4.01	5.63
16	VT24		1.889	0.051	0.40	3.76	6.61
17	VT25		0.694	0.044	0.35	4.24	6.23
18	VT28		1.111	0.024	0.33	4.17	14.64
TCVN 5942-1995		**B**	**2**	**2**	**20**	**Cr (III): 1000 µg/L** **Cr (VI): 50 µg/L**	**100**
		A	**1**	**1**	**0,01**	**Cr (III): 100 µg/L** **Cr (VI): 50 µg/L**	**0,05**

Soil Contamination at the study sites, Nov.2007

N	Sampling sites	pH (H_2O)	Al (%)	Fe (%)	As (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Hg (mg/kg)	Oil (mg/kg)
1	VT1	6.78	10.25	4.8307	6.40	40.79	0.63	86.47	0.26	ND
2	VT2 – Port	7.15	8.91	4.2025	7.15	43.42	0.56	64.64	0.20	8.0
3	VT2 - Lake	6.94	8.64	4.2675	5.15	64.47	0.42	71.49	0.34	23.0
4	VT4	7.13	9.72	4.3108	13.80	76.32	1.12	69.78	0.27	ND
5	VT5	7.09	7.02	3.4660	12.42	78.95	0.70	70.21	0.30	8.0
6	VT7	7.19	7.56	4.1050	11.41	60.53	0.35	70.21	0.17	12.0
7	VT10	7.13	7.83	3.2927	11.13	57.89	0.21	65.07	0.34	10.0
8	VT12	7.18	7.83	3.4335	11.50	55.26	0.56	65.92	0.32	ND
9	VT16	7.00	7.83	4.4107	16.45	68.75	0.65	69.23	0.14	ND
10	VT17	7.06	7.52	3.4826	13.22	50.27	0.31	68.20	0.21	6.0
11	VT19	7.26	7.83	4.0630	10.98	62.54	0.42	61.10	0.18	ND
12	VT24	7.04	8.10	4.0115	16.35	73.75	0.82	74.15	0.20	27.0
13	VT25	7.02	8.02	4.2580	15.21	71.24	0.34	65.20	0.14	6.0
14	VT28	6.98	8.10	2.9025	11.18	36.25	0.32	45.26	0.15	12.0
15	VT31	6.90	5.94	2.8108	12.71	28.75	0.32	41.17	0.13	ND
16	VT32	7.15	8.91	3.6826	11.76	71.05	0.56	68.07	0.21	ND
17	VT33	7.01	9.18	3.3610	14.22	66.25	0.82	67.89	0.10	15.0
Dutch Standard (Reference value)					29	85	0.80	100	0.3	

Sediment Quality at the study area, Nov.2007

N	Sampling sites	pH	Al (mg/kg)	Fe (mg/kg)	As (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Hg (mg/kg)	Oil (mg/kg)
1	VT1	7.36	10.44	41623.24	9.68	0.47	49.62	67.14	0.17	ND
2	VT2 – Port	7.22	5.94	35201.76	12.43	0.98	51.32	56.08	0.46	ND
3	VT2 – Lake	7.21	5.46	37431.21	11.26	1.05	53.19	62.21	0.15	ND
4	VT3	7.21	9.18	45491.50	16.36	1.02	69.74	68.92	0.24	ND
5	VT4	7.22	9.45	42675.36	15.58	0.26	110.53	71.06	0.21	ND
6	VT5	7.35	10.80	39642.60	16.32	1.46	106.58	75.34	0.32	ND
7	VT6	7.50	5.67	29569.48	10.89	1,13	34.21	59.50	0.41	ND
8	VT7	7.61	6.48	30435.98	11.73	1.32	47.37	58.22	0.12	ND
9	VT8	7.56	6.21	36826.46	9.24	0.76	39.47	57.36	0.25	ND
10	VT9	7.66	6.48	21121.06	8.32	0.42	31.58	52.23	0.62	ND
11	VT10	7.51	9.18	36501.52	13.07	0.92	76.32	66.78	0.15	ND
12	VT11	7.60	7.63	39317.66	9.39	0.38	64.47	69.35	0.23	ND
13	VT12	7.49	9.45	38776.09	10.76	0.66	90.79	73.20	0.62	ND
14	VT13	7.51	8.10	35743.33	9.67	0.51	75.00	68.07	0.34	ND
15	VT14	7.57	9.18	38667.78	12.54	1.82	82.89	68.92	0.28	ND
16	VT15	7.51	8.91	38992.72	12.29	0.84	77.63	70.63	0.37	ND
17	VT16	7.30	6.48	34811.24	9.90	0.65	50.00	54.58	0.29	30.00
18	VT17	7.46	6.08	31254.12	13.24	1.28	36.42	64.10	0.53	ND
19	VT18	7.38	5.87	32869.68	14.01	0.97	37.98	58.71	0.42	ND
20	VT19	7.32	7.56	31000.15	11.27	1.05	58.75	49.26	0.24	ND
21	VT20	7.41	6.06	33215.38	15.17	1.25	60.45	50.30	0.35	ND
22	VT21	7.28	10.53	48291.73	12.01	0.82	71.38	75.13	0.28	ND
23	VT22	7.50	9.13	41256.41	10.21	0.79	70.24	71.48	0.19	ND
24	VT23	7.33	9.72	42922.33	11.92	0.94	81.25	85.46	0.33	ND
25	VT24	7.57	8.91	37227.11	8.78	0.39	75.00	70.26	0.16	ND
26	VT25	7.56	9.45	34201.48	11.39	0.79	65.00	66.03	ND	ND

N	Sampling sites	pH	Al (mg/kg)	Fe (mg/kg)	As (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Hg (mg/kg)	Oil (mg/kg)
27	VT26	ND	ND	ND	ND	ND	ND	ND	ND	48.00
28	VT27	7.51	10.26	47491.45	14.66	1.51	83.75	86.34	0.57	ND
29	VT28	7.42	9.45	32115.36	6.22	0.28	33.75	42.19	0.61	ND
30	VT29	7.53	6.75	30642.24	5.21	0.73	31.25	41.67	0.22	ND
31	VT 30	7.3	7.75	38624.42	6.12	0.57	29.52	37.76	0.19	ND

Pesticide Contamination in Sediment at the study area, Nov.2007

N	Pesticide (Organochlorines)	Analytical Method	Unit	Result				
				VT4	VT10	VT12	VT15	VT30
1	Alfa-BHC	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
2	Gamma-BHC	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
3	Beta-BHC	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
4	Delta-BHC	EPA8081A	µg/Kg	1.1	0.5	0.5	0.5	0.8
5	Heptachlor	EPA8081A	µg/Kg	0.5	< 0.4	0. 4	0.2	0.5
6	Aldrine	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
7	Heptachlorepoxide	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
8	α- Chlordan	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
9	β- Chlordan	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
10	4,4'-DDE	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
11	Endosulfan 1	EPA8081A	µg/Kg	0. 3	< 0.1	0. 1	0.2	<0.1
12	Dieldrine	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
13	Endrine	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
14	4,4'-DDD	EPA8081A	µg/Kg	< 0.1	< 0.1	0. 3	< 0.1	< 0.1
15	Endosulfan 2	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
16	4,4'-DDT	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
17	Methoxylchlor	EPA8081A	µg/Kg	0.3	0.5	0.8	0.5	0.6
18	Endirn aldehyde	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
19	Endosulfan sulfate	EPA8081A	µg/Kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Notes:

1. *Analysis of all collected water, soil and sediment samples was conducted in the analytical laboratory of the Institute of Chemistry – National Academy of Sciences and Technology, November 2007*
2. *ND: non detectable*

Water Quality of the river in the Northern Delta, Dec. 2007

N	Sampling sites	pH	TDS (mg/L)	Turbidity (NTU)	SS (mg/L)	DO (mg/L)	BOD_5 (mg/L)	NH_4^+ (mg/L)	Total N (mg/L)	NO_3^- (mg/L)	Total P (mg/L)	Total oil (mg/L)	Phenol (µg/L)	Coliform (MPN/100mL)
1	VW 11	7.1	150	48	60	5.8	10	0.218	2.169	1.712	1.635	ND	ND	1,500
2	VW 13	7.1	175	33	45	5.3	5	0.242	3.678	2.536	2.059	0.12	ND	700
3	VW 15	7.2	255	55	75	4.5	5	0.316	9.155	4.722	1.467	0.15	ND	800
4	VT 34	7.8	18,500	19	25	6.2	10	0.352	7.357	3.968	0.328	ND	ND	900

Heavy metal contamination river water, Dec. 2007

N	Sampling site	Cd (µg/l)	Cr (µg/l)	Zn (mg/l)	Fe (mg/l)	As (µg/l)
1	11	0.26	3.18	0.031	0.336	15.37
2	13	0.30	3.29	0.035	0.985	16.09
3	15	0.28	2.89	0.029	0.649	10.03
4	VT 34	0.35	3.05	0.033	0.325	12.05

Sediment contamination in the study area, Dec. 2007

N	Sampling Site	Cr (mg/kg)	Pb (mg/kg)	Fe (%)	Cd (mg/kg)	As (mg/kg)	Al (%)	Hg (mg/kg)	pH
1	VW 1	17.562	29.33	1.995	0.65	7.25	3.037	0.15	7.25
2	VW 3	27.652	32.45	2.595	0.55	8.25	4.307	0.23	7.52
3	VW 5	19.386	26.45	1.645	0.4	6.08	2.885	0.10	7.16
4	VW 6	26.764	27.62	1.715	0.75	6.85	3.240	0.25	7.46
5	VW 7	22.487	28.55	1.856	0.89	7.56	3.240	0.18	7.09
6	VW 8	31.836	25.64	1.964	0.45	7.25	3.585	0.19	7.25
7	VW 9	28.568	36.25	2.625	0.95	8.78	2.970	0.25	7.10
8	VW 11	42.726	67.97	5.704	0.3	11.88	7.560	0.20	7.14
9	VW 14	38.272	64.56	5.422	0.65	12.56	8.370	0.15	7.16
10	VW 15	46.868	52.35	4.795	1.05	10.42	7.155	0.2	7.10
11	VW 34	22.424	30.65	1.962	1.15	8.05	3.510	0.32	6.83

Grain sizes of the collected sediment sample, Dec. 2007

TT	Site	Coarse Sand (%)	Fine Sand (%)	Clay (%)	Limon (%)
1	VT 16	11.67	76.99	5.82	5.52
2	VT 19	0.12	91.06	4.86	3.96
3	VT 23	4.11	63.69	8.16	24.04
4	VT 24	0.16	61.22	6.18	32.44
5	VT 25	0.49	74.45	2.56	22.50
6	VT 27	0.09	52.45	9.94	37.52
7	VT 28	5.30	67.50	11.00	16.20
8	VT 29	5.28	85.52	4.38	4.72
9	VT 5	64.00	32.22	1.98	1.80
10	VT 11	0.79	41.01	18.52	39.68
11	VT 1	65.75	28.80	2.15	3.30
12	VT 2 - port	61.20	35.15	2.40	1.25
13	VT 4	25.10	66.05	4.50	4.35
14	VT 12	10.50	70.55	7.85	11.10

Notes: - VW 5 and VW 11: collected in December 2007
- Other samples: collected in November 2007

The Present air quality, noise, vibration and microclimate at the study site (Source: VESDEC – SINTEP, Dec, 2007)

N	Site Location	T (^oC)	R. Humidity (%)	Wind speed (m/s)	TSP mg/m^3	PM10 mg/m^3	SO_2 mg/m^3	NO_2 mg/m^3	CO mg/m^3	Noise dBA	Vibration dBA		
											L_X	L_Y	L_Z
1.	Phudong Port - Gialam – Hanoi city	18.5	80	3,0	0,16	0.05				67,8	32,8	30,1	39,3
2.	Kenh Vang Port - Luongtai – Bacninh	19.5	75	2.5	0,19	0.10	0,181	0,035	1,024	60,2	27,4	29,9	36,6
3.	Cong Cau Port - Tuky commune, Haiduong	22,2	75	1.5	0,04	0.02	0,057	0,053	1,035	56,8	25,9	22,8	31,5
4.	In front of High School Ninh Giang – Ninh Giang – Haiduong Province	21.5	74	1.2	0,03	0.01	0,158	0,061	0,256	67,5	21,0	20,3	36,4
5.	On the road 17A, beside Ninh Giang People Committee – Hai Duong	21.0	70	1.5	0,01	0.01	0,109	0,025	0,512	53,7	20,0	21,1	30,7
6.	Haiphong port – Hai Phong city	19.2	75	2.0	0,07	0.03	0,257	0,038	1,041	61,1	43,9	48,7	32,0
7.	Thai Binh Port - Thai Binh	18.5	85	1.8	0,18	0.05	0,206	0,023	0,768	68,7	30,2	31,3	46,6
8	Namdinh Port - Nam Dinh province	20.0	85	1.8	0,09	0.03	0,193	0,022	0,504	58,8	21,2	22,1	30,9
9	Dong An - Nghia Lac - Nghia Hung - Nam Dinh	20.5	80	1.5	0,27	0.11	0,286	0,092	0,760	65,6	39,1	43,5	44,4
10	Ninh Phuc Port - Ninh Binh Province	21.2	78	2.1	0,13	0.05	0,202	0,026	0,258	60,3	21,6	22,4	21,7
11	Hong Van Port - Hong Van - Thuong Tin District - Ha Tay Province	19.5	81	1.2	0,02	0.01	0,237	0,047	0,763	75,8	69,9	69,1	64,5
12	Sontay Port – Sontay city – Hatay Province	20.0	75	1.5	0,01	0.01	0,118	0,028	0,531	67,4	23,5	25,2	38,3
13	Nhuthuy landing site – Nhuthuy – Lapthach – Vinhphuc province	21.5	78	1.2	0,01	0.01	0,095	0,024	0,259	54,4	24,7	24,1	32,2
14	Viettri Port – Viettri City – Phutho Province	24.3	75	1.8	0,12	0.03	0,161	0,053	0,266	52,4	28,9	31,9	25,1
15	TCVN 5937 : 2005				0.3	-	0.35	0.20	30	60 TCVN 5949:1998			

- *Sampling duration: 60 minute*
- *The Vietnamese Standard (TCVN 5937 - 2005) for PM10 (24h average) is 0.15 mg/m^3.*
- *The Vietnamese Standard for Noise at residential, administrative area = 60dBA in day time (6 am – 6 pm) at mixed residential and commercial area = 75 dBA in day time.*
- *The Vietnamese Standard for vibration caused by construction activity at residential, administrative area = 75 dB (7 am – 7 pm)*

Appendix 7 – TCVN Standards

TCVN 5937 - 2005

Vietnamese Ambient Air Quality Standard

Nº	Parameter (mg/m^3)	1 hr. average	8 hr. average	24 hr. average	Year average
1	SO_2	0.35	-	0.125	0.05
2	CO	30	10	-	-
3	NO_2	0.2	-	-	0.04
4	O_3	0.18	0.12	0.08	-
5	Total Suspended Particulate (TSP)	0.3	-	0.2	0.14
6	PM_{10}	-	-	0.15	0.05
7	Pb	-	-	0.0015	0.0005

TCVN 6438 – 2001

Maximum Allowable Of Air Emission Level Created by Vehicles

Parameter	Petrol engine						Diesel engine		
	Car				Motorbike		Car		
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 1	Level 2	Level 3
CO (% Volume)	6.5	6.0	4.5	3.5	6.0	4.5	-	-	-
or (ppm Volume)					10.000	7.800			
- Four-stroke engine	-	1500	1200	600			-	-	-
- Two-stroke engine	-	7800	7800	7800			-	-	-
- Other engine	-	3300	3300	3300			-	-	-
Smoke (% HSU)	-	-	-	-	-	-	85	72	50

TCVN 5949 – 1998

Maximum Permitted Noise Level In Public And Residential Areas - dBA

No	Area	Period of time		
		From 6h-18h	From 18h-22h	From 22h-6h
1	Areas needed special low noise Hospitals Libraries Sanatoria Kindergartens, schools)	50	45	40
2	Residential area: (Hotels, administration offices) Houses, apartment houses, etc	60	55	50
3	Commercial and service areas	75	70	50

TCVN 5942 – 1995

Maximum Allowable Concentration Of Pollutants In Surface Water

N°	Parameter and substance	Unit	Limitation value	
			A	*B*
1	**pH value**	-	6 - 8.5	5.5 - 9
2	BOD_5 (20°C)	mg/l	< 4	< 25
3	COD	mg/l	< 10	< 35
4	DO	mg/l	≥ 6	≥ 2
5	SS	mg/l	20	80
6	Arsenic	mg/l	0.05	0.1
7	Barium	mg/l	1	4
8	Cadimium	mg/l	0.01	0.02
9	Lead	mg/l	0.05	0.1
10	Chromium. Hexavalent	mg/l	0.05	0.05
11	Chromium. Trivalent	mg/l	0.1	1
12	Copper	mg/l	0.1	1
13	Zinc	mg/l	1	2
14	Manganese	mg/l	0.1	0.8
15	Nickel	mg/l	0.1	1
16	Iron	mg/l	1	2
17	Mercury	mg/l	0.001	0.002
18	Tin	mg/l	1	2
19	Amonia (as N)	mg/l	0.05	1
20	Fluoride	mg/l	1	1.5
21	Nitrate (as N)	mg/l	10	15
22	Nitrite (as N)	mg/l	0.01	0.05
23	Cyanide	mg/l	0.01	0.05
24	Phenol compounds	mg/l	0.001	0.02
25	Oil and grease	mg/l	ND	0.3
26	Detergent	mg/l	0.5	0.5
27	Coliform	MPN/100 ml	5.000	10.000
28	Total pesticide (except DDT)	mg/l	0.15	0.15
29	DDT	mg/l	0.01	0.01
30	Gross α activity	Bq/l	0.1	0.1
31	Gross β activity	Bq/l	1.0	1.0

Note: A: Water source used for domestic purpose after treatment
B: Water source used for other purposes

Appendix 5. TCVN 5943 – 1995

Allowable concentration of pollutants in coastal water

N	Parameter and substance	Unit	Limitation values		
			Bathing and recreation area	Aquatic cultivation area	Others
1	Temperature	^oC	30	-	-
2	Odor		unobjecti-onable	-	-
3	pH value		6.5-8.5	6.5-8.5	6.5-8.5
4	Disolved solid	mg/l	□ 4	□ 5	□ 4
5	BOD_5 (20^oC)	mg/l	< 20	< 10	< 20
6	SS	mg/l	25	50	200
7	Arsen	mg/l	0.05	0.01	0.05
8	Ammonia (as N)	mg/l	0.1	0.5	0.5
9	Cadmium	mg/l	0.005	0.005	0.01
10	Lead	mg/l	0.1	0.05	0.1
11	Chromium (VI)	mg/l	0.05	0.05	0.05
12	Chromium (III)	mg/l	0.1	0.1	0.2
13	Chroride	mg/l	-	0.01	-
14	Copper	mg/l	0.02	0.01	0.02
15	Fluoride	mg/l	1.5	1.5	1.5
16	Zinc	mg/l	0.1	0.01	0.1
17	Manganese	mg/l	0.1	0.1	0.1
18	Iron	mg/l	0.1	0.1	0.3
19	Mercury	mg/l	0.005	0.005	0.01
20	Sulfide	mg/l	0.01	0.005	0.01
21	Cyanide	mg/l	0.01	0.01	0.02
22	Phenol compounds	mg/l	0.001	0.001	0.002
23	Oil and fat film	mg/l	none	none	0.3
24	Oil and fat suspenion	mg/l	2	1	5
25	Total pesticides	mg/l	0.05	0.01	0.05
26	Coliform	MPN/100ml	1000	1000	1000

TCVN 5944 – 1995

Maximum allowable concentrations of pollutants in ground water

N°	Parameter	Unit	Limitation value
1	pH	-	6.5 - 8.5
2	Colour	Pt - Co	5 - 50
3	Hardness (per $CaCO_3$)	mg/l	300 - 500
4	Total solids	mg/l	750 - 1500
5	Arsenic	mg/l	0.05
6	Cadimium	mg/l	0.01
7	Chloride	mg/l	200 - 600
8	Lead	mg/l	0.05
9	Chromium (VI)	mg/l	0.05
10	Cyanide	mg/l	0.01
11	Copper	mg/l	1.0
12	Fluoride	mg/l	1.0
13	Zinc	mg/l	5.0
14	Manganese	mg/l	0.1 - 0.5
15	Nitrate	mg/l	45
16	Phenols compound	mg/l	0.001
17	Iron	mg/l	1 - 5
18	Sulphate	mg/l	200 - 400
19	Mercury	mg/l	0.001
20	Selenium	mg/l	0.01
21	Feacal coli	MPN/100 ml	not detectable
22	Coliform	MPN/100 ml	3

TCVN 5945 – 2005

Industrial Waste Water Discharge Standards

Parameter limits and maximum allowable concentrations of pollutants in Industrial Waste Water Discharge

N°	Parameter	Unit	Limitation value		
			A	B	C
1	Temperature	^0C	40	40	45
2	pH	-	6 đến 9	5.5 đến 9	5 đến 9
3	Odor	-	unobjecti-onable	unobjecti-onable	-
4	Colour, Co – Pt at pH = 7		20	50	-
5	BOD_5 (20^0C)	mg/l	30	50	100
6	COD	mg/l	50	80	400
7	SS	mg/l	50	100	200
8	Asenic	mg/l	0.05	0.1	0.5
9	Mercury	mg/l	0.005	0.01	0.5
10	Lead	mg/l	0.1	0.5	1
11	Cadimi	mg/l	0.005	0.01	0.5
12	Chromium (VI)	mg/l	0.05	0.1	0.5
13	Chromium (III)	mg/l	0.2	1	2
14	Copper	mg/l	2	2	5
15	Zinc	mg/l	3	3	5
16	Niken	mg/l	0.2	0.5	2
17	Manganese	mg/l	0.5	1	5
18	Iron	mg/l	1	5	10
19	Tin	mg/l	0.2	1	5
20	Cyanide	mg/l	0.07	0.1	0.2
21	Phenol	mg/l	0.1	0.5	1
22	Oil and grease	mg/l	5	5	10
23	Oil and fat	mg/l	10	20	30
24	Clorine	mg/l	1	2	-
25	PCBs	mg/l	0.003	0.01	-
26	Pesticide: Organic phosphorus	mg/l	0.3	1	
27	Pesticide: Organic Clorine	mg/l	0.1	0.1	-
28	Sunfua	mg/l	0.2	0.5	1
29	Florua	mg/l	5	10	15
30	Clorua	mg/l	500	600	1000
31	Amoni (as N)	mg/l	5	10	15
32	Total Nitrogen	mg/l	15	30	60
33	Total Phosphorus	mg/l	4	6	8
34	Coliform	MNP/100ml	3000	5000	-
35	Bioassay		In 100% waste water. fish are alive 90% in 96 hour		-
36	Gross α activity	Bq/l	0.1	0.1	-

37	Gross β activity	Bq/l	1.0	1.0	-

TCVN 6772 – 2000

Maximum Allowable Concentrations Of Pollutants In Domestic Wastewater

Parameter	Unit	Limitation Value				
		Level I	Level II	Level III	Level IV	Level V
1. pH	-	5-9	5-9	5-9	5-9	5-9
2. BOD	mg/l	20	30	40	50	200
3. Suspended Solid (SS)	mg/l	50	50	60	100	100
4. Settle Solids	mg/l	0.5	0.5	0.5	0.5	-
5. Total of Suspended Solid	mg/l	500	500	500	500	-
6. Sunfide (following H_2S)	mg/l	1.0	1.0	3.0	4.0	-
7. Nitrat (NO_3^-)	mg/l	30	30	40	50	-
8. Fat and oil	mg/l	20	20	20	20	100
9. Phosphate (PO_4^{3-})	mg/l	6	6	10	10	-
10. Total coliforms	MNP/ 100ml	1000	1000	5000	5000	10000

TCVN 6986 – 2001

Maximum Allowable Concentrations Of Pollutants In Water For Aquaculture

Parameter	Limitation Value		
	F1	*F2*	*F3*
1. Colour, Co - pH = 7	50	50	50
2. Odor, perceptible	unobjecti-onable	unobjecti-onable	unobjecti-onable
3. Suspended Solid (SS), mg/l	100	80	50
4. pH	5-9	5-9	5-9
5. BOD_5 (20^0C), mg/l	50	20	10
6. COD, mg/l	100	80	50
7. Arsenic (As), mg/l	1	0.5	0.1
8. Lead (Pb), mg/l	1	0,5	0,5
9. Chromium (Cr) VI, mg/l	1	0.5	0.1
10. Copper (Cu), mg/l	1	0.5	0.1
11. Zink (Zn), mg/l	2	1	1
12. Manganese (Mn), mg/l	5	5	1
13. Mercury (Hg), mg/l	0.005	0.001	0.001
14. Total Nitrogen (as N), mg/l	20	15	10
15. Oil and grease, mg/l	10	5	5
16. Oil and fat, mg/l	30	20	10
17. Organic Phosphate, mg/l	0.5	0.2	0.2
18. Detergent, mg/l	10	5	5
19. Coliform, MNP/100ml	5000	5000	5000

Note:
F: Discharge, m^3/ngày (24 giờ)
F1: From 50 m^3/day to under 500 m^3/day
F2: From 500 m^3/ngày to under 5000 m^3/day
F3: over 5000 m^3/day

TCVN 6962 – 2001

Maximum Allowable Vibration Level Created By Construction Works In Public And Residential Areas

No.	Area	Period of Time	Allowable Value	Remark
1	Areas needed special low vibration	7 h – 19 h	75	Continuous time work is not over 10 hr/day
		19 h – 7 h	Baseline value	
2	Residential, hotel, guest house, office etc.	7 h – 19 h	75	Continuous time work is not over 10 hr/day
		19 h – 7 h	Baseline value	
3	Residential area inside commercial, service and industrial areas	6 h – 22 h	75	Continuous time work is not over 14 hr/day
		22 h – 6 h	Baseline value	

Note: Exchange of vibration acceleration value into dB and vibration acceleration per m/s^2

Vibration acceleration value, dB	55	60	65	70	75
Vibration acceleration, m/s^2	0.006	0.010	0.018	0.030	0.055

Marine Sediment Guidelines adopted for List II Metals of Environment Canada. TEL and PEL denote "threshold effects level" and " probable effects level", respectively.

	Canadian Guidelines[1]		Dutch (VROM)
Metal	**TEL (mg kg^{-1} dry weight)**	**PEL (mg kg^{-1} dry weight)**	**Limit Values[2] (mg kg^{-1} dry weight)**
Lead	30.2	112	530
Chromium	52.3	160	380
Zinc	124	271	480
Copper	18.7	108	36

Nickel	15.9	42.8	35
Arsenic	7.2	41.6	55
Vanadium	nv	nv	nv
Boron	nv	nv	nv
Iron	nv	nv	nv
Mercury*	0.41	-	-
Cadmium*	5.1	-	-

* Washington State "No Effects Levels" for sediment quality.