Japan International Cooperation Agency (JICA)
Ministry of Environment and Water Management, Romania

Final Report

The Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore in Romania

Volume 2

Feasibility Study of Coastal Protection and Rehabilitation Project at Mamaia Sud and Eforie Nord

August 2007

ECOH CORPORATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF ENVIRONMENT AND WATER MANAGEMENT, ROMANIA

FINAL REPORT

THE STUDY ON PROTECTION AND REHABILITATION OF THE SOUTHERN ROMANIAN BLACK SEA SHORE IN ROMANIA

VOLUME 2

FEASIBILITY STUDY OF COASTAL PROTECTION AND REHABILITATION PROJECT AT MAMAIA SUD AND EFORIE NORD

AUGUST 2007

ECOH CORPORATION

Exchange rates applied in this Study are:

EURO 1.00 = 3.5 RON
EURO 1.00 = 140 Yen
(as of June 2006)

FOREWORD

In response to a request made by the Government of Romania, the Government of Japan decided to conduct the Study on Protection and Rehabilitation on the Southern Romanian Black Sea Shore and entrusted the project to the Japan International Cooperation Agency (JICA).

JICA sent to Romania a study team headed by Dr. Yoshimi GODA of ECOH CORPORATION between May 2005 and March 2007.

The team held discussions with the officials concerned of the Government of Romania and conducted field studies in the targeted area in the Study. The team prepared present report upon the final modification.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Romania for their close cooperation extended to the team.

August, 2007

Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Ariyuki MATSUMOTO
Vice President
Japan International Cooperation Agency

Dear Mr. Matsumoto,

It is my great pleasure to submit herewith the Final Report of "the Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore in Romania".

The study team composed of ECOH CORPORATION conducted surveys in Romania over the period between May 2005 and March 2007 according to the contract with the Japan International Cooperation Agency (JICA).

The study team compiled this report, which proposes an overall coastal protection plan aimed for 2020, and feasibility study on the coastal protection and rehabilitation plan of Mamaia Sud and Eforie Nord, including an operation and management plan, a monitoring plan and an institutional framework, through consultation with officials of the Government of Romania and other authorities concerned.

On behalf of the study team, I would like to express my sincere appreciation to the Government of Romania and other authorities for their diligent cooperation and assistance and for the heartfelt hospitality, which they extended to the study team during our stay in Romania.

I am also very grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs of Japan, the Ministry of Land, Infrastructure and Transport of Japan and the Embassy of Japan in Romania for giving us valuable suggestions and assistance during the course of the study

Yours faithfully,

August, 2007

Yoshimi GODA
Team Leader,
The Study on Protection and
Rehabilitation of the Southern Romanian
Black Sea Shore in Romania

PREFACE

In response to the request of the Government of Romania, the Government of Japan has decided to conduct the Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore (hereinafter referred to as "the Study"), in accordance with the relevant laws and regulations in force in Japan.

Accordingly, Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for implementation of the technical cooperation program of the Government of Japan, has undertaken the Study in cooperation with the authorities concerned of Romania based on the Scope of the Study agreed upon by the both governments on July 30, 2004, which is attached to the present report in Annex J in Volume 3. JICA awarded ECOH CORPORATION the contract for the execution of the Study in March 2005, and the latter has formed a team of seven experts (hereinafter referred to as "the Team") and dispatched the Team to Romania for six occasions, intermittently since May 2005. The composition of the Team and the information on the Study mission are given in Annex J.

This final report describes the accomplishment of the basic study in the Phase I, the formulation of coastal protection plan in the Phase II, and the feasibility study on the coastal protection and rehabilitation project at Mamaia Sud and Eforie Nord in the Phase II of the Study, which have been executed by the Team during the period of March 2005 to September 2006. The report is comprised of three volumes. Volume 1 presents the main results of the basic study and the coastal protection plan for the whole study area. Volume 2 describes the outcome of the feasibility study on the Mamaia and Eforie Project, while Volume 3 is compilation of Annexes that contain detailed information and data.

Volumes 1 and 2 are provided with their own Executive Summaries for quick references to the contents of the main bodies of the report.

ACKNOWLEDGMENT

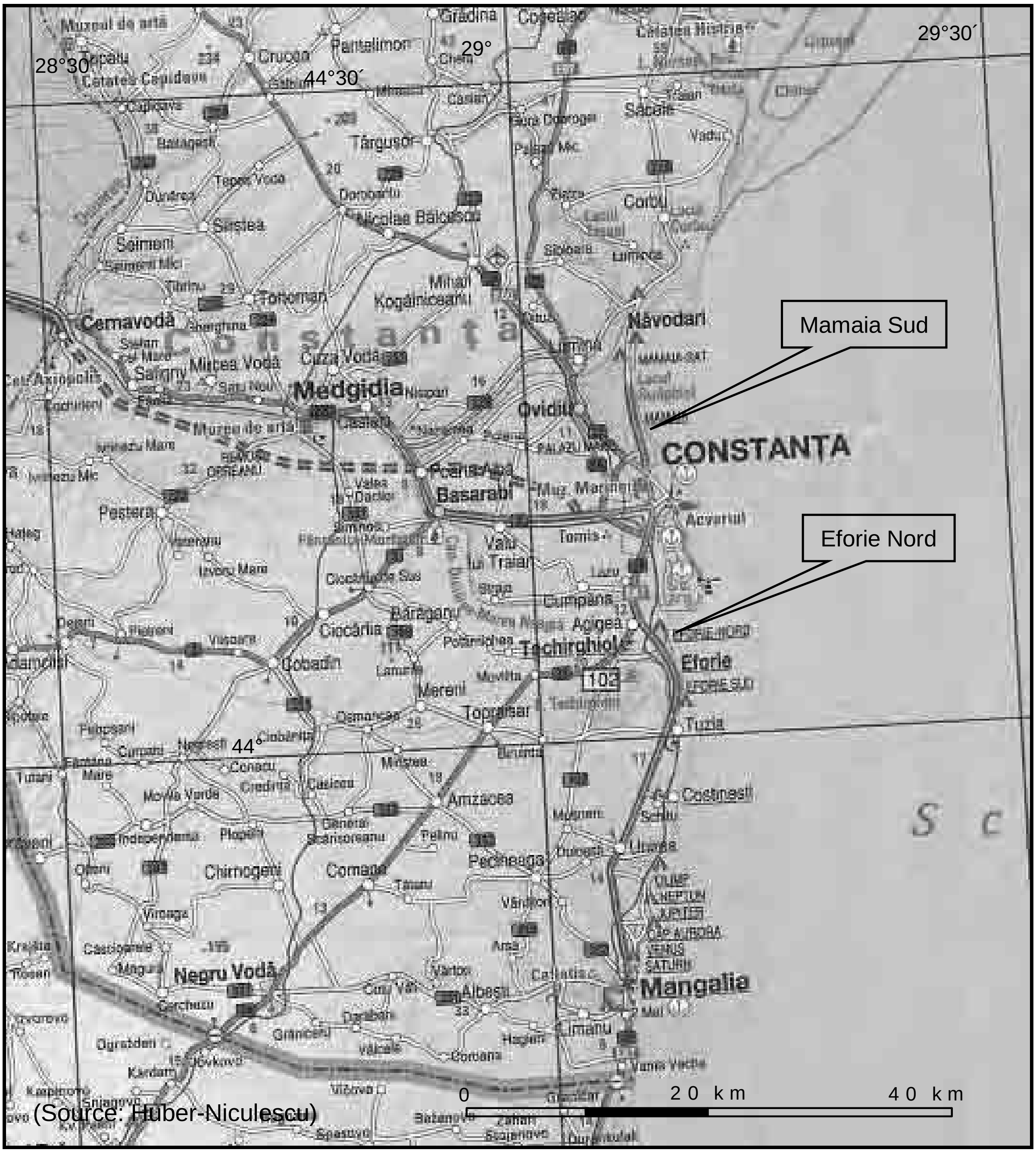
The Study has been made possible through the cooperation and collaboration of many people in Romania. The Team first expresses its sincere thanks to all the Romanian counterparts, the names of which are listed in Annex J.3. They have earnestly assisted the activities of the Team and brought the Study to its completion.

Secondly, the Team acknowledges the excellent works under subcontracts executed by the staff of the National Institute of Marine Geology and Geo-ecology (GeoEcoMar), the National Institute for Marine Research and Development "Grigore Antipa," IPTANA S.A., and INSERT S.R.L., even though the Team refrains itself from listing the names of individual persons involved.

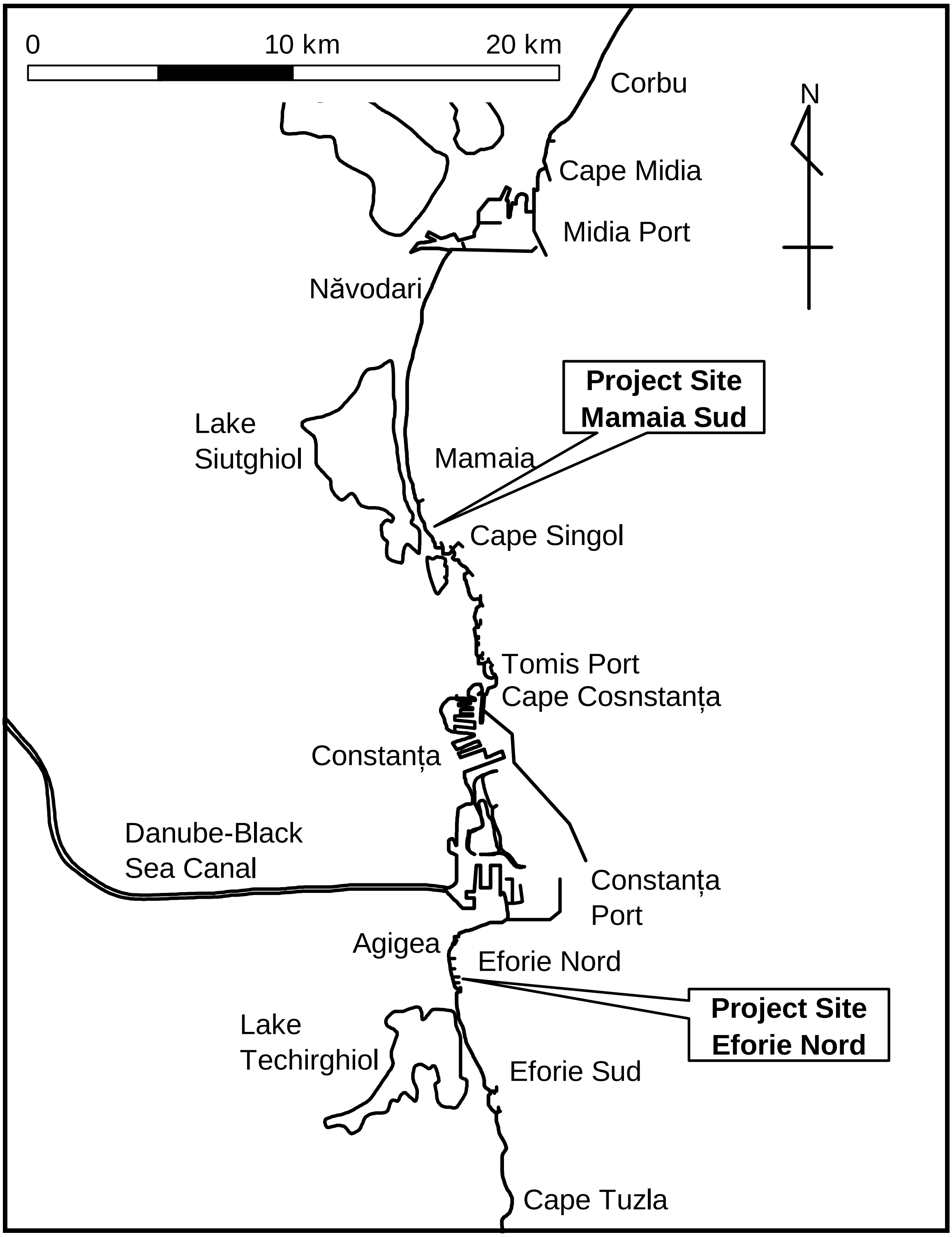
Thirdly, the Team was given invaluable information and data through interviews with the National Agency for Mineral Resources, the River Administration of the Lower Danube Galati, the Administration of Navigable Canal S.H., the National Company Maritime Ports Administration S.A., the Danube Delta Biosphere Reserve Authority, the Delegation of the European Commission in Romania, the Office of the International Bank for Reconstruction and Development, and others.

Last but not least, the Team would like to express its appreciation to Professor Virgil Breaban and his staff at "Ovidius" University of Constanța, who offered the first guidance on coastal problems in Romania in August 2004, assisted the field survey on the willingness-to-pay (WTP), and arranged the use of the university's auditorium for the JICA Symposium in June 2006 in Constanța.

Yoshimi GODA, Prof.
Team Leader of the Study Team



Location Map of Project Sites and Adjacent Area



Location Map of Project Sites

Mamaia South before Project Implementation

Mamaia South after Project Implementation

Eforie Nord after Project Implementation

Eforie Nord before Project Implementation

Photo-1
Aerial View of Project Site for Mamaia South

Photo-2
Aerial View of Mamaia Beach

Photo-3
Perspective View of Mamaia South

Photo-4
Perspective View of Mamaia South

Photo-5
Beach Utilization in Summer, Mamaia South

Photo-6
Offshore Breakwaters in Mamaia South

Photo-7
Frozen Sea Surface in Mamaia, 2006

Photo-8
Beach Profile of South End, Mamaia South

Photo-9
Shore Protection Facility in Mamaia South

Photo-10
Beach Profile of Mamaia South

Photo-11
Toe Scouring of Beach Service Facility in Mamaia South

Photo-12
Beach Profile of Mamaia South

Photo-13
Hinter Area of Mamaia South

Photo-14
Beach Utilization in Mamaia South

Photo-15
Beach Utilization in Mamaia South

Photo-16
Wind Blown Sand Fence in Mamaia South

Photo-17
Beach Cleaning Work by DADL

Photo-18 Aerial View of Project Site for Eforie Nord

Photo-19
Aerial View of Eforie Nord

Photo-20
Shore Protection Facilities in Eforie Nord

Photo-21
Fishing Village at North End of Eforie Nord

Photo-22
Shore Protection Facility in Agigea

Photo-23
Shore Protection Facilities in Eforie Nord

Photo-24
Shore Protection Facility in Agigea

Photo-25
Aerial View of Shore Protection Facilities in Eforie Nord

Photo-26
Beach Profile of Eforie Nord

Photo-27
Beach Utilization in Eforie Middle

Photo-28
Beach Utilization in Eforie Middle

Photo-29
Beach Utilization in Eforie Middle

Photo-30
Aerial View of Europa Marina

Photo-31
Coastal Cliff of Eforie Middle

Photo-32
Hinter Area of Eforie Nord

Photo-33
Promenade behind Beach in Eforie Nord

Photo-34
Winter Rough Sea Condition in Eforie Nord

CONTENTS

CONTENTS OF VOLUME 2

FEASIBILITY STUDY OF COASTAL PROTECTION AND REHABILITATION PROJECT AT MAMAIA SUD AND EFORIE NORD

EXECUTIVE SUMMARY OF VOLUME 2

CHAPTER 1 INTRODUCTION 1-1
1.1 Selection of Project Sites 1-1
1.2 Composition of the Present Volume 1-1

CHAPTER 2 OUTLINE OF THE PROJECT AND SURROUNDING CONDITIONS 2-1
2.1 General Description 2-1
2.2 Project Objectives and Justification 2-2
2.3 Social and Economic Conditions of Project Site 2-4
2.3.1 Population 2-4
2.3.2 Employment 2-5
2.3.3 Tourism 2-5
2.3.4 Coastal fishery 2-6
2.4 Physical and Geomorphological Conditions of Project Site 2-6
2.4.1 Meteorological conditions 2-6
2.4.2 Water level and astronomical tide 2-7
2.4.3 Waves 2-7
2.4.4 Characteristics of beach sand 2-8
2.4.5 Beach morphology 2-8
2.5 Source of Beach Fill Sand for Mamaia Sud and Eforie Nord 2-10
2.5.1 Possible sources of beach fill sand and sediment characteristics 2-10
2.5.2 Survival rate of sea and river sand at filled beach 2-10
2.5.3 Selection of beach fill sources based on preliminary cost estimate 2-11

CHAPTER 3 DESCRIPTION OF PROJECT COMPONENT “A” AT MAMAIA SUD 3-1
3.1 Outline of Project Component “A” at Mamaia Sud 3-1
3.2 Alternatives Studied and Main Reasons for Final Choice 3-2
3.2.1 Alternative choices of the components of shore protection facilities 3-2
3.2.2 Options for shore protection facility installation plan 3-4
3.2.3 Selection of final plan for shore protection facilities 3-6
3.3 Project Component “A” using River Sand 3-14
3.3.1 Structural Components and Their Layout 3-14
3.3.2 Implementation Schedule and Construction Plan 3-25
3.3.3 Cost Estimate 3-25
3.4 Project Component “A” using Sea Sand 3-28
3.4.1 Structural Components and Their Layout 3-28
3.4.2 Implementation Schedule and Construction Plan 3-31
3.4.3 Cost Estimate 3-32

CHAPTER 4 DESCRIPTION OF PROJECT COMPONENT “B” AT EFORIE NORD....4-1
4.1 Outline of Project Component B at Eforie Nord....4-1
4.2 Main Alternatives Studied and Main Reasons for Final Choice....4-2
4.2.1 Alternative choices of the components of shore protection facilities....4-2
4.2.2 Options for shore protection facility installation plan....4-3
4.2.3 Selection of final plan for shore protection facilities....4-4
4.3 Structural Components and Their Layout....4-10
4.4 Implementation Schedule and Construction Plan....4-20
4.5 Cost Estimate of Project Component “B”....4-21
4.6 Estimate of Total Project Cost at Mamaia Sud and Eforie Nord....4-23

CHAPTER 5 POTENTIAL ENVIRONMENTAL IMPACT AND MITIGATION MEASURES....5-1
5.1 Water....5-1
5.1.1 Basic Data on Water Quality....5-1
5.1.2 Water Impact Prognosis....5-2
5.1.3 Impact Mitigation Measures....5-3
5.2 Air....5-3
5.2.1 Basic Data on Air Quality....5-3
5.2.2 Sources of Pollution during Project Execution....5-4
5.2.3 Air Impact Prognosis....5-5
5.2.4 Impact Mitigation Measures....5-10
5.3 Noise and Vibration....5-11
5.3.1 Basic Data on Noise and Vibration....5-11
5.3.2 Mobile Source of Noise and Vibration during Construction Works....5-11
5.3.3 Noise and Vibration Impact Prognosis....5-11
5.3.4 Impact Mitigation Measures....5-12
5.4 Fauna, Flora and Biodiversity....5-12
5.4.1 Basic Data on Biodiversity....5-12
5.4.2 Biodiversity Impact Prognosis....5-22
5.4.3 Impact Mitigation Measures....5-23
5.5 Landscape....5-23
5.5.1 Present Beach Scenery....5-23
5.5.2 Landscape Impact Prognosis....5-24
5.5.3 Impact Mitigation Measures....5-25
5.6 Waste....5-26
5.6.1 Solid Waste Collection/Disposal System in Constanta....5-26
5.6.2 Possible Source of Waste During Construction Works....5-27
5.6.3 Waste Impact Prognosis....5-27
5.6.4 Impact Mitigation Measures....5-27
5.7 Bottom Sediment....5-28
5.7.1 Basic Data of Bottom Sediment and Sand for Beach Fill....5-28
5.7.2 Sediment Impact Prognosis....5-30
5.7.3 Impact Mitigation Measures....5-30
5.8 Fishery....5-31
5.8.1 Fishing Activity in the Nearshore Water....5-31
5.8.2 Fishery Impact Prognosis....5-32
5.8.3 Impact Mitigation Measures....5-33

5.9 Social and Economical Environment Inclusive of Tourism 5-33
5.9.1 Overview of the Present Conditions...5-33
5.9.2 Impact Prognosis on Social and Economic Environment 5-33
5.9.3 Impact Mitigation Measures...5-34
5.10 Impact Prognosis of Other Environment Factors 5-34
5.10.1 Soil and Subsoil..5-34
5.10.2 Human Settlement 5-34
5.10.3 Cultural Heritage 5-34
5.10.4 Local Conflict of Interests and Misdistribution of Benefits 5-35
5.11 Evaluation of Impact of River and Sea Sand Nourishment...............................5-35

CHAPTER 6 RISK MANAGEMENT AND MONITORING PLAN
6.1 Risks of Accidents and Mitigation Measures 6-1
6.1.1 Risks of accidents 6-1
6.1.2 Mitigation measures 6-2
6.2 Environmental Monitoring during Construction Works..6-4
6.2.1 General...6-4
6.2.2 Sampling survey of benthos and benthic plant 6-4
6.2.3 Aquatic life 6-5
6.2.4 Water quality measurement 6-5
6.2.5 Sediment quality measurement...6-5
6.2.6 Noise and vibration measurement 6-5
6.2.7 Others...6-5
6.3 Environmental Monitoring after Project Implementation 6-7
6.3.1 General...6-7
6.3.2 Sampling survey of benthos and benthic plant 6-7
6.3.3 Monitoring of social environment 6-8
6.4 Geophysical Monitoring during and after Project Implementation.......................6-8
6.4.1 General...6-8
6.4.2 Beach and inshore survey 6-9
6.4.3 Wave measurement..6-10
6.4.4 Water level measurement...6-10

CHAPTER 7 PROJECT EVALUATION 7-1
7.1 Environmental Sectoral Operational Program (ESOP) 7-1
7.1.1 Outline view 7-1
7.1.2 Priority areas including coastal protection 7-1
7.1.3 Coastal protection and rehabilitation of the Southern Black Sea shore 7-2
7.1.4 Financing plan 7-3
7.2 Financial Affordability Analysis and Financing Plan..7-5
7.2.1 Initiating remarks...7-5
7.2.2 Affordability analysis 7-5
7.2.3 Financing plan with EU funding in sight...7-16
7.3 Economic Analysis of the Project...7-18
7.3.1 Introduction 7-18
7.3.2 Analytical framework and methodology 7-19
7.3.3 Economic costs..7-22
7.3.4 Economic benefits 7-24
7.3.5 Model Configuration and Assumptive Parameters...7-26
7.3.6 EIRR analysis of Component “A” at Mamaia Sud...7-36

7.3.7 EIRR analysis of Component "B" at Eforie Nord 7-37
7.3.8 EIRR analysis of the Aggregate ("A + B") 7-37
7.3.9 Sensitivity analysis 7-40
7.3.10 Incremental employment generated by the project......................................7-40
7.4 Conclusive Summary of Economic Analysis 7-40

CHAPTER 8 INSTITUTIONAL ANALYSIS..8-1
8.1 Legal and Institutional Framework for Coastal Protection 8-1
8.1.1 Legal framework for environment protection within EU framework 8-1
8.1.2 Legal framework for coastal protection within EU framework 8-3
8.1.3 Institutional Framework for Coastal Protection-Game Players and TOR 8-4
8.2 Overall Management Scheme..8-11
8.2.1 Institutional Framework for Project Implementation 8-11
8.2.2 Game players of in the arena of institutional framework agreed 8-18
8.3 Operational Frameworks for Project Implementation 8-19
8.3.1 Indicative TOR for game players..8-19
8.3.2 Implementing procedures 8-22

CHAPTER 9 CONCLUSIONS, RECOMMENDATIONS AND FURTHER ISSUES 9-1
9.1 Conclusions 9-1
9.2 Recommendations 9-4
9.3 Further Issues...9-5

APPENDICES
Appendix A: Statistics of Seaside Tourists
A.1 Data source of tourists in accommodations A-1
A.2 Analysis of tourists statistics A-2
A.3 Estimate of daily number of beach visitors A-3

Appendix B: Regional Economy of Constanța County
B.1 Gross domestic regional product of Southeast Region B-1
B.2 Employment in Constanța County B-2
B.3 Tourism B-3

Appendix C: Sediment Grain Size Characteristics at Project Site and Beach Fill Sand Sources
C.1 Outlines C-1
C.2 Sampling Stations Coordinates and Water Depth C-2
C.3 Location Maps of Sampling Stations C-4
C.4 Grain Size Distribution Data C-8

Appendix D: Survival Rate of Fill Sand on Beach
D.1 Concept of Survival Rate of Fill Sand D-1
D-2 Grain Size Characteristics of Fill Sand and Beach Sand.......................................D-1
D-3 Threshold Grain Size of Washing Out...D-2
D-4 Estimation of Survival Rate of Fill Sand...D-3

Appendix E: Execution Schedule with Bills of Quantities
E.1 Project Component “A” at Mamaia Sud with River Sand E-2
E.2 Project Component “A” at Mamaia Sud with Sea Sand E-8
E.3 Project Component “B” at Eforie Nord with River Sand E-14

Appendix F: Beach Monitoring Program
F.1 Introduction.. F-1
F.2 Objective.. F-1
F.3 Scope of beach monitoring F-2
F.4 Methodology of beach profile survey... F-2
F.5 Methodology of shoreline map survey F-3
F.6 Methodology of bathymetric survey... F-4

Appendix G: Wave Measurement Record
G.1 Introduction G-1
G.2 Procedure of Data Analysis..G-1
G.3 Wave Climate off Mamaia G-4
G.4 Temporal Variations of Wave Conditions off Mamaia..G-6

Appendix H: Discussion on Economic Internal Rate of Return of Environment Sector Project
H-1 Background and Objective H-1
H-2 Methodology H-1
H-3 Results H-2
H-4 Discussion H-3

Appendix I: Indicative TOR for PIU and FIDIC Contracting Method
I-1 Responsibility of PIU... I-1
I-2 Indicative TORs for PIU specialists... I-3
I-3 FIDIC contracting method (outline view)... I-7

LIST OF TABLES IN VOLUEME 2

Table 2.5.1: Beach fill augmentation factor 2-11
Table 2.5.2: Beach fill volume and approximate cost 2-13
Table 2.5.3: Comparison of project costs using the river and sea sand..2-14
Table 2.5.4: Tentative specification for sediment characteristics of beach fill sand 2-15

Table 3.2.1: Options for shore protection facility installation plan at Mamaia Sud..3-4
Table 3.2.2: Earliest time of beach width down-crossing the threshold of 75 or 50 m
after beach fill..3-12
Table 3.2.3: Comparison of the options examined and evaluation of their merits for Mamaia Sud...3-13

Table 3.3.1: Works-wise cost breakdown of project cost at Mamaia Sud using river sand 3-26
Table 3.3.2: Currency-wise cost breakdown of project cost at Mamaia Sud using river sand............3-26

Table 3.4.1: Works-wise cost breakdown of project cost at Mamaia Sud using sea sand...................3-33
Table 3.4.2: Currency-wise cost breakdown of project cost at Mamaia Sud using sea sand 3-33

Table 4.2.1: Options for shore protection facility installation plan at Eforie Nord..4-4
Table 4.2.2: Comparison of the options examined and evaluation of their merits for Eforie Nord....4-10

Table 4.5.1: Works-wise cost breakdown of project cost at Eforie Nord using river sand 4-21
Table 4.5.2: Currency-wise cost breakdown of project cost at Eforie Nord using river sand.............4-22

Table 4.6.1: Total project cost with use of river sand for Mamaia Sud..4-23
Table 4.6.2: Total project cost with use of sea sand for Mamaia Sud 4-24

Table 5.2.1: Physico-chemical characteristics and nutrient concentrations in surface
water from the Eforie Nord and Mamaia Sud areas..5-2
Table 5.2.2: Evaluation of water impact at Mamaia Sud and Eforie Nord 5-3
Table 5.3.1: Monthly air temperature at Constanța..5-4
Table 5.3.2: Maximum daily traffic during the construction period 5-5
Table 5.3.3: Equipment list for Mamaia Sud 5-7
Table 5.3.4: Equipment list for Eforie Nord..5-8
Table 5.3.5: Evaluation of air impact..5-10
Table 5.3.1: Acoustical power level of construction equipment 5-12
Table 5.3.2: Evaluation of noise and vibration impact..5-12
Table 5.4.1: General characterization of the Romanian shallow water benthos population
in the Sulina, Cap Midia, Mamaia and Eforie North beaches..5-15
Table 5.4.2: Average values of densities, biomasses and dominance of
different benthic taxonomic groups in the four studied sectors 5-17
Table 5.4.3: Characterization of parameters for sampling stations in the Romanian shallow water...5-17
Table 5.4.4: General characterization of the Danube river benthos population
in the Oltina, Cochirleni and Cernavoda..5-21
Table 5.4.5: Bottom populations parameters* from the Danube River in 2006,
in the zone of interest 5-21
Table 5.4.6: Evaluation of biodiversity impact 5-23
Table 5.5.1: Evaluation of landscape impact of crest elevation at Mamaia Sud................................5-24
Table 5.5.2: Evaluation of landscape impact of crest elevation at Eforie Nord.................................5-25
Table 5.5.3: Evaluation of landscape impact of river sand color at Mamaia Sud and
at Eforie Nord 5-25
Table 5.6.1: Evaluation of waste impact 5-27
Table 5.7.1: Heavy metals contents of sediment samples 5-29
Table 5.7.2: Concentration of organic pollutants in sediment samples..5-30
Table 5.7.3: Evaluation of sediment impact..5-30
Table 5.8.1: Species captures (tones) at the Romanian marine sector within 2000-2005...................5-32
Table 5.8.2: Evaluation of impact on fishing activity 5-33

Table 5.9.1: Evaluation of impact on social and economic environment....5-34
Table 5.11.1: Evaluation of expected impacts of using river sand for beach fill 5-35
Table 5.11.2: Evaluation of expected impacts of using sea sand for beach fill....5-36

Table 6.1.1: Mitigation plan....6-3
Table 6.2.1: Environmental monitoring plan during construction works....6-6
Table 6.2.2: Cost estimate of monitoring during construction works per project site per year.....6-6
Table 6.3.1: Environmental monitoring plan after Project Implementation....6-7
Table 6.3.2: Cost estimate of monitoring after project implementation per project site per year. 6-8
Table 6.3.3: Environmental monitoring cost from 2007 to 2013. 6-8
Table 6.4.1: Items of beach monitoring program with cost estimate 6-9

Table 7.1.1: Annual allocation of funds to ESOP (2007-13) by EU fund by Axis (EUR million)....7-3
Table 7.2.1: State budget for coastal protection 2007-2009 (US$ mil)....7-7
Table 7.2.2: MoEWM-ANAR budget proposal on coastal protection 2006-2008....7-7
Table 7.2.3: Financial Statement – Balance Sheet, DADL 2002-2004 7-9
Table 7.2.4: Financial statement of DADL – profit-loss statement, 2002-2004 7-10
Table 7.2.5: Indicative project cost by eligibility for EU funding Component “A” 7-17
Table 7.2.6: Indicative project cost by eligibility for EU funding Component “B”....7-17
Table 7.2.7: Indicative project cost by eligibility for EU funding Components “A” and “B”....7-18
Table 7.2.8: Indicative eligible costs for EU financing by components....7-18
Table 7.3.1: Economic and Financial Costs by project component 7-22
Table 7.3.2: Economic cost of aggregate “A+B” 7-23
Table 7.3.3: Economic cost of component “A”....7-23
Table 7.3.4: Economic cost of component “B” 7-23
Table 7.3.5: Economic benefits by project components and items 7-24
Table 7.3.6: Indicative investment schedule by sub-component of the project....7-32
Table 7.3.7: Summary Net Cash-flow Table for Mamaia Sud 7-37
Table 7.3.8: Summary Net Cash-flow Table for Eforie Nord 7-38
Table 7.3.9: Summary Net Cash-flow Table for Mamaia Sud and Eforie Nord 7-38
Table 7.3.10: Sensitivity analysis and the resulting EIRRs....7-39
Table 7.3.11: Sensitivity analysis and the resulting EIRRs....7-40

Table 8.2.1: Management schemes of the externally funded projects previously and currently in place 8-12
Table 8.2.2: SWOT analysis....8-16
Table 8.3.1: Procurement threshold-goods and equipment....8-25
Table 8.3.2: Procurement threshold-consultant services, TA and training....8-25

Table A.1.1: Statistics of seaside tourists (source: Romanian Statistical Yearbook 2004)....A-1
Table A.3.1: Estimate of daily number of beach visitors based on approximate visitor density....A-4

Table B.1.1: Gross regional domestic product (GDRP) of the Southeast Region, consumer price indices, and foreign exchange rate B-1

Table C.2.1: Coordinates of sampling stations at Eforie, Mamaia and Cape Midia C-2
Table C.2.2: Coordinates of sampling stations at Sulina....C-3
Table C.2.3: Coordinates of sampling stations at Cernǎvoda and Cochirleni....C-3
Table C.2.4: Coordinates of sampling stations at Oltina....C-4
Table C.4.1: Percentage of the sediment fractions in the samples at Mamaia area....C-9
Table C.4.2: Percentage of the sediment fractions in the samples at Eforie area....C-9
Table C.4.3: Percentage of the sediment fractions in the samples around Cape Midia C-10
Table C.4.4: Percentage of the sediment fractions in the samples at Sulina area and within the dredger’s hopper C-10
Table C.4.5: Percentage of the sediment fractions in the samples at Cernǎvoda and Cochirleni C-11

Table C.4.6: Percentage of the sediment fractions in the samples at Oltina area C-12

Table D.2.1: Grain size characteristics of beach sand and fill sand D-2
Table D.4.1: Estimation of survival rate of fill sand at Mamaia Sud and Eforie Nord D-4

Table G.3.1: Joint distribution of wave height versus wave period based on the data observed on Black Sea (Dec. 2005 – Mar. 2007) G-5
Table G.3.2: Joint distribution of wave height versus wave direction based on the data observed on Black Sea (Dec. 2005 – Mar. 2007) G-5

Table H.3.1: World Bank projects related to coastal protection aspects H-3

LIST OF FIGURES IN VOLUME 2

Fig. 2.5.1: Cumulative distributions of grain size of beach fill sand 2-10
Fig. 2.5.2: Revised facility layout with river sand at Mamaia Sud 2-12
Fig. 2.5.3: Revised facilities layout with sea sand at Mamaia Sud 2-12
Fig. 2.5.4: Revised facilities layout with river sand at Eforie Nord....2-13
Fig. 2.5.5: Revised facilities layout with sea sand at Eforie Nord 2-13

Fig. 3.1.1: Bird's-eye of the beach before project implementation at Mamaia Sud....3-1
Fig. 3.1.2: Bird's-eye of the beach after project implementation at Mamaia Sud....3-1
Fig. 3.1.3: Layout of the shore protection facilities around Mamaia Sud....3-2
Fig. 3.2.1: Sketch of the option B for shore protection facilities at Mamaia Sud 3-5
Fig. 3.2.2: Sketch of the option E for shore protection facilities at Mamaia Sud 3-5
Fig. 3.2.3: Sketch of the option G for shore protection facilities at Mamaia Sud....3-6
Fig. 3.2.4: Sketch of the option H for shore protection facilities at Mamaia Sud....3-6
Fig. 3.2.5: Temporal variation of shoreline position in the plan A (zero-option)....3-7
Fig. 3.2.6: Temporal variation of shoreline position in the plan B (long jetty with river sand)....3-8
Fig. 3.2.7: Temporal variation of shoreline position in the plan D (short jetty with river sand)....3-8
Fig. 3.2.8: Temporal variation of shoreline position in the plan F (long jetty and low crest with river sand) 3-9
Fig. 3.2.9: Temporal variation of shoreline position in the plan I (two jetties and low crest with river sand) 3-9
Fig. 3.2.10: Predicted shoreline position in 20 years for the option E 3-11
Fig. 3.2.11: Predicted shoreline position in 20 years for the option F 3-11
Fig. 3.2.12: Predicted shoreline position in 20 years for the option E 3-11
Fig. 3.3.1(1): General layout of shore protection facilities at Mamaia Sud with river sand 3-15
Fig. 3.3.1(2): General layout of shore protection facilities at Mamaia Sud with river sand 3-16
Fig. 3.3.2: Area of beach fill with river sand at Mamaia Sud 3-17
Fig. 3.3.3: Examples of beach fill profile....3-20
Fig. 3.3.4: Plan of breakwater rehabilitation....3-20
Fig. 3.3.5: Typical cross-section breakwater rehabilitation....3-20
Fig. 3.3.6: Plan shape of sand-retaining jetty....3-21
Fig. 3.3.7: Longitudinal section of sand-retaining jetty 3-22
Fig. 3.3.8 (1): Cross sections 1-1 and 2-2 of sand-retaining jetty 3-23
Fig. 3.3.8 (2): Cross sections 3-3, 4-4, and 5-5 of sand-retaining jetty....3-23
Fig. 3.3.9: Cross sections of submerged groin 3-24
Fig. 3.3.10: Standard cross section of supplementary submerged groin 3-24
Fig. 3.4.1: General layout of shore protection facilities at Mamaia Sud with sea sand 3-29
Fig. 3.4.2: Area of beach fill with sea sand at Mamaia Sud....3-30
Fig. 3.4.3: Examples of beach fill profile with underwater dike at Mamaia Sud using sea sand....3-30
Fig. 3.4.4: Examples of cross section of underwater dike....3-31

Fig. 4.1.1: Bird's-eye of the beach before project implementation at Eforie Nord....4-1
Fig. 4.1.2: Bird's-eye of the beach after project implementation at Eforie Nord....4-1
Fig. 4.1.3: Bathymetric map around the project at Eforie Nord....4-2
Fig. 4.2.1: Sketch of the option B for shore protection facilities at Eforie Nord 4-5
Fig. 4.2.2: Sketch of the option D for shore protection facilities at Eforie Nord....4-5
Fig. 4.2.3: Temporal variation of shoreline position in the plan A (zero-option)....4-6
Fig. 4.2.4: Temporal variation of shoreline position in the plan D (short jetty extension with river sand)....4-7
Fig. 4.2.5: Predicted shoreline position in 20 years for the option B....4-8
Fig. 4.2.6: Predicted shoreline position in 20 years for the option D....4-8
Fig. 4.3.1: General layout of shore protection facilities at Eforie Nord....4-11
Fig. 4.3.2: Layout of beach fill, jetty extension and artificial reefs 4-12
Fig. 4.3.3: Examples beach fill profiles 4-15
Fig. 4.3.4: Layout of artificial reef....4-16
Fig. 4.3.5: Standard cross section of artificial reef....4-16
Fig. 4.3.6: Plan shape of rehabilitation and extension of jetty J-1 4-17

Fig. 4.3.7: Cross section of the head portion of extended jetty J-1 4-18
Fig. 4.3.8: Plan shape of Jetty-2 rehabilitation...4-19

Fig. 5.2.1: Map of traffic survey locations..5-6
Fig. 5.2.2: Traffic volume at Location No. 1 - Blvd. Aurel Vlaicu at the northern limits
of the City of Constanta, close to Mamaia resort. 5-9
Fig. 5.2.3: Traffic volume at Location No. 2 - The National Road DN39
(Constanta - Mangalia - B/C Bulgaria), km 13+800,
at the northern incidence to the Town of Eforie Nord..5-9
Fig. 5.23.4: Traffic volume at Location 3 - Blvd. Aurel Vlaicu at the western limits of
the City of Constanta, between Blvd. Bratianu and
the intersection with Blvd. Baba Novac...5-10
Fig. 5.4.1: Dendrograme of similarity between the stations performed in the Romanian
shallow water (Sulina, Cap Midia, Mamaia and Eforie beaches)
for the assessment of benthos population. 5-18
Fig. 5.4.2: MDS - ordination of all benthos stations performed at the Romanian shallow waters
(Sulina, Cap Midia, Mamaia and Eforie beaches)
in order to assess the ecological state of bottom populations 5-19
Fig. 5.4.3: Dendrograme of similarity between the stations performed in 2006
in the Danube River sector of interest (Oltina, Cochirleni and Cernavoda areas),
for the assessment of benthos population...5-20
Fig. 5.4.4: – MDS – ordination of all benthos stations performed in 2006
at the Danube River sector of interest (Oltina, Cochirleni and Cernavoda areas),
for the assessment of benthos population...5-22

Fig. 7.1.1: Annual allocation of funds to ESOP by EU fund by category..7-3
Fig. 7.1.2: Outline view of sectoral operational program – ENV 7-4
Fig. 7.2.1: Macroeconomic and debt positions of Romania 1990-2003 7-6
Fig. 7.2.2: State budget for MoEWM, 1996-2005 7-7
Fig. 7.2.3: Main components in balance sheet of DADL in 2002-2004 7-10
Fig. 7.2.4: Main category of revenue for DADL 7-11
Fig. 7.2.5: Profit-loss statement of DADL, 2002-2006...7-11
Fig. 7.2.6: ANAR revenues and expenses, 2001-2005...7-12
Fig. 7.2.7: Development budget of ANAR, 1992-2005 7-12
Fig. 7.2.8: Investment budget by category 2001-2004...7-13
Fig. 7.2.9: Revenue by Administrative Unit in Constanta County, 2004 7-15
Fig. 7.3.1: Economic benefits in the framework of “with” and “without” the project........................7-20
Fig. 7.3.2: Prospective Beach Conditions in Mamaia Sud and Eforie Nord.......................................7-28
Fig. 7.3.3: Population distribution of Constanța County...7-29
Fig. 7.3.4: Check-in tourists to Constanta by origin and location..7-29
Fig. 7.3.5: Sequential flow of analysis in estimation of WTP by CVM...7-33
Fig. 7.3.6: Sequential flow of analysis in estimation of incremental foreign exchange 7-34
Fig. 7.3.7: Sequential flow of analysis in estimation of foreign exchange saved 7-35
Fig. 7.3.8: Sequential flow of analysis in estimation of social costs saved...7-36

Fig. 8.1.1: Organizational framework of MoEWM for policy planning, coordination,
and implementation..8-5
Fig. 8.2.1: Indicative structure of PIU with expertise in need 8-13
Fig. 8.2.2: Alternative I: MoEWN - ANAR HQ - DADL line of order 8-14
Fig. 8.2.3: Alternative II: MoEWM – DADL line of order...8-15
Fig. 8.2.4: Alternative III: MoEWN direct implementation type..8-17
Fig. 8.2.5: Schematic framework for project implementation: alternative plan agreed......................8-18

Fig. A.1.1: Tourists to Constanta County by origin and administrative unit A-2
Fig. A.2.1: Yearly variation of numbers of tourist..A-2
Fig. A.2.2: Regression analysis of tourists...A-3

Fig. A.2.3: Regression analysis of foreign tourists A-3

Fig. B.1.1: Share of gross domestic regional product of the Southeast Region by activity in 2001....B-1
Fig. B.2.1: Number of average employee in respective sectors of activities in 2002 ....B-2
Fig. B.2.2: Relative earnings of employees in various sectors of economic activities B-3

Fig. C.3.1: Locations of sampling stations in Mamaia Sud C-4
Fig. C.3.2: Locations of sampling stations in Eforie Nord C-5
Fig. C.3.3: Locations of sampling stations in Cape Midia....................C-5
Fig. C.3.4: Locations of sampling stations in Sulina area....................C-6
Fig. C.3.5: Bathymetric chart with sampling locations around Cernăvoda between Km 299 – 300 ...C-6
Fig. C.3.6: Bathymetric chart with sampling locations around Cochirleni between Km 303 – 307....C-7
Fig. C.3.7: Locations of sampling stations around Oltina in the Epuraşul branchi
between Km 334 – 342 ....C-8

Fig. D.2.1: Representative grain size distributions of fill sand and beach sand....................D-2
Fig. D.3.1: Frequency distributions of the grain sizes of fill sand (Midia) and beach sand (Eforie)...D-3
Fig. D.4.1: Calculation diagram of beach fill augmentation factor RA by James....................D-4

Fig. E.1.1: Execution schedule at Mamaia Sud with river sand....................E-3
Fig. E.1.2: Equipment mobilization schedule at Mamaia Sud with river sand E-4
Fig. E.1.3: Labor mobilization schedule at Mamaia Sud with river sand E-6
Fig. E.2.1: Execution schedule at Mamaia Sud with sea sand E-9
Fig. E.2.2: Equipment mobilization schedule at Mamaia Sud with sea sand....................E-10
Fig. E.2.3: Labor mobilization schedule at Mamaia Sud with sea sand....................E-12
Fig. E.3.1: Execution schedule at Eforie Nord with river sand....................E-15
Fig. E.3.2: Equipment mobilization schedule at Eforie Nord with river sand E-16
Fig. E.3.3: Labor mobilization schedule at Eforie Nord with river sand E-18

Fig. F.4.1: Map of Southern Romanian Black Sea shore (1)....................F-6
Fig. F.4.2: Map of Southern Romanian Black Sea shore (2)....................F-7

Fig. G.1.1: General location of the position of the wave and current observation G-2
Fig. G.1.2: Detailed location of the measurement site G-2
Fig. G.2.1: Examples of temporal variations of mean water level, significant wave height
and period, and wave direction G-3
Fig. G.4.1: Monthly variations of wave height, period, and direction in the year 2005....................G-6
Fig. G.4.2: Monthly variations of wave height, period, and direction in the year 2006....................G-7
Fig. G.4.3: Monthly variations of wave height, period, and direction in the year 2007....................G-8

ABBREVIATIONS

A	AFDJG:	River Administration of the Lower Danube, Galati
	AIS:	Agreement of Subsidiary Loan
	ANAR:	National Administration of Romanian Waters "Apele Romane"
	AR:	Artificial Reefs
C	C/B:	Cost-Benefit
	CAS:	Country Assistance Strategy
	CBA:	Cost Benefit Analysis
	CBC:	Cross Border Cooperation
	CEB:	Council of Europe Development Bank
	CET:	Heating Power-Station
	CF:	Cohesion Fund
	CFCU:	Central Financial and Control Unit
	CIF:	Cost, Insurance and Freight
	CIGCCE:	Committee for Guarantees and Credits for External Trade
	CNP :	National Commission of Forecast
	COA :	Romanian Court of Accounts
	CPS:	Country Partnership Strategy
	CQ:	Consultant's Qualification
	CRF:	Capital Recovery Factor
	CVM:	Contingency Valuation Method
	CVM:	Contingent Valuation Method
D	DADL:	"Apele Romane", Water Directorate Dobrogea - Litoral
	DC:	Direct Contracting
	DFI:	Direct Foreign Investment
	DFID:	Department for International Development
	DL:	Datum Level
	DR:	Development Regions
	DSCR:	Debt-service Coverage Ratio
E	EBRD:	European Bank for Reconstruction and Development
	EC:	European Council
	ECMWF:	European Centre for Medium Range Forecasting
	EEC:	European Economic Community
	EFN:	Eforie Nord
	EGO:	Emergency Governmental Ordinance
	EIA:	Environment Impact Assessment
	EIB:	European Investment Bank
	EIRR:	Economic Internal Rate of Return
	EMP:	Environmental Management Plan
	ENPV:	Economic Net Present Value
	EPA:	Environmental Protection Agency
	EPAC:	Environment Protection Agency, Constanța
	EPI:	Environmental Protection Inspectorates
	ERDF:	European Regional Development Fund
	ESF:	European Social Fund
	ESOP:	Environmental Sectoral Operational Program
	EU:	European Union
F	FB:	Final Beneficiary
	FIRR:	Financial Internal Rate of Return
	FOB:	Free on Board
	FX:	Foreign Exchange
G	GD:	Government Decision
	GDP:	Gross Domestic Product

	GDRP:	Gross Domestic Regional Product
	GEF:	Global Environment Facility
	GeoEcoMar:	National Institute of Geology and Geo-ecology
	GOR:	Government of Romania
H	HC:	Hydrocarbons
	HRMEP:	Hazard Risk Mitigation and Emergency Preparedness Project
	HWL:	High Water Level
I	IBRD:	International Bank for Reconstruction and Development
	ICB:	International Competitive Bidding
	ICCE:	International Conference on Coastal Engineering
	ICZM :	Integrated Coastal Zone Management
	IDA:	International Development Association
	IFC:	International Financing Corporation
	IFI:	International Financing Institutions
	IMF:	International Monetary Fund
	IPCC :	Intergovernmental Panel on Climate Change
	IPPC:	Integrated Pollution Prevention and Control
	IRR:	Internal Rate of Return
	ISPA:	Instrument for Structural Policies for Pre-Accession
J	JBIC:	Japan Bank for International Cooperation
	JICA :	Japan International Cooperation Agency
L	L/A:	Loan Agreement
	LAPEP:	Local Action Plan for Environmental Protection
	LCP:	Large Combustion Plants
	LCS:	Term of Low Crested Structure
	LCS:	Least Cost Selection
	LEP:	Local Environmental Policy
	LEPA:	Local Environment Protection Agency
	LRMC:	Long-run Marginal Cost
	LWL:	Mean Monthly Lowest Water Level
M	M/E:	Monitoring and Evaluation
	MAFRD:	Ministry of Agriculture, Forests and Rural Development
	MAI:	Ministry of Administration and Interior
	MDS:	Multivariate Statistics Methods - Multidimensional Scaling
	MIG:	minimum income guarantee
	MIR:	Minimum Ratio of Residual Correlation Coefficient
	MIU:	Management and Implementation Unit
	MOC:	Marginal Opportunity Cost
	MoEWM:	Ministry of Environment and Water Management
	MoHF:	Ministry of Health and Family
	MoPA:	Ministry of Public Administration
	MoPF:	Ministry of Public Finance
	MoTCT:	Ministry of Transport, Construction and Tourism
	MTEF:	Medium-tern Expenditure Framework
	MWL:	Mean Water Level
N	NAMR:	National Agency for Mineral Resources
	NAPEP:	National Action Plan for Environmental Protection
	NATO:	North Atlantic Treaty Organization
	NB:	Net Benefit
	NBR:	National Bank of Romania
	NCB:	National Competitive Bidding
	NCCZ:	National Committee of the Coastal Zone
	NDP:	Romanian National Development Plan
	NEAP:	Romanian National Environment Action Plan
	NEG:	National Environmental Guard

	NEP:	Romanian National Environmental Policy
	NEPA	National Environmental Protection Agency
	NGO:	Non-governmental Organization
	NIMRD:	National Institute for Marine Research and Development "Grigore Antipa."
	NPV:	Net Present Value
	NSEP:	National Strategy for Environmental Protection
	NSRF:	Develop Basic Infrastructure to European Standards
O	OM:	Operation and Maintenance
P	PAH:	Polycyclical Aromatic Hydrocarbons
	PAL:	Programmatic Adjustment Loan
	PCC:	Project Coordination Committee
	PCO:	Primary Credit Orderers
	PFM:	Public Financial Management
	PIU :	Project Implementation Unit
	PMU:	Project Management Unit
	POP:	PAH and Organochlorine Pesticides
	POT:	Peaks-over-Threshold
	PSC:	Project Steering Committee
	PYG:	Pay-as-you-go
Q	QC:	Consultant Qualification
	QCBS:	Quality and Cost-based Selection
R	Raja:	Water Company
	REPA:	Regional Environment Protection Agency
	RkD:	Rank of Species
	RMA:	Romanian Meteorological Administration
S	SA:	Special Account
	SAPARD:	Special Action Program for Agricultural and Rural Development
	SC:	Steering Committee
	SCF:	Standard Conversion Factors
	SDR:	Social Discount Rate
	SEA:	Strategic Environmental Assessment
	SME:	Small and Medium Scale Enterprises
	SOP:	Sectoral Operational Program
	SRMOC:	Short-run Marginal (Opportunity) Cost
T	TA:	Technical Assistance
	TAC :	Total Admissible Captures
	TC:	Total Cost
	TOR:	Terms of Reference
	TPH:	Total Petroleum Hydrocarbons
	TR:	Total Revenue
	TRC:	Technical Review Committee
U	UGO:	Urgent Government Ordinance
	UNCED:	United Nations Conference on Environment and Development
	USAID:	United States Agency for International Development
V	VAT:	Value Added Tax
	VOC:	Volatile Organic Compound
W	WB:	World Bank
	WD:	Significance Index
	WFD:	EU Water Framework Directive
	WFD:	Water Framework Directive
	WTP:	Willingness to Pay

EXECUTIVE SUMMARY OF VOLUME 2

Executive Summary of Volume 2

Table of Contents

A. Selection of Feasibility Study Sites II-1

B. Project Objectives and Justification II-1

C. General Description of the Project II-2

D. Main Alternatives Studied and Main Reasons for the Final Choice II-5
- D.1 Alternatives studied for Mamaia Sud II-5
- D.2 Alternatives studied for Eforie Nord II-5

E. Project Cost and Implementation Schedule II-6
- E.1 Component “A” at Mamaia Sud II-6
- E.2 Component “B” at Eforie Nord II-7
- E.3 Total project costs for Components “A” and “B” II-8

F. Potential Environmental Impacts and Mitigation Measures II-9

G. Project Evaluation II-13
- G.1 Affordability Analysis of the Project II-13
- G.2 Economic Analysis of the Project II-13

H. Operational Framework for and PIU of the Project II-14

I. Recommendation and Further Issues II-16

A. Selection of Feasibility Study Sites

The Coastal Protection Plan for the Southern Romanian Black Sea Shore has designated nine sub-sectors among twenty sub-sectors as the areas that require implementation of coastal protection and rehabilitation projects. Based on examination and comparison of the urgency of coastal protection, beach utilization, economical feasibility of project implementation, and needs for promotion of regional development,, the sub-sectors of Mamaia Sud and Eforie Nord were selected as the sites of priority implementation of the coastal protection and rehabilitation projects. The selection was made at the Steering Committee held on November 4, 2005 and was acknowledged by the stakeholders in the meetings held in Constanța on November 24 and in Bucharest on November 25, 2005. The selection was further confirmed at the stakeholder meeting held in Constanța on June 6, 2006.

A feasibility study for the coastal protection and rehabilitation project at Mamaia Sud and Eforie Nord was carried out by the JICA Study team. An executive summary of this feasibility study is presented hereinafter.

B. Project Objectives and Justification

The objectives of the Project are to relieve the coastal areas of Mamaia Sud and Eforie Nord from the threat of coastal erosion and to enhance the beach utilization through enlargement of beach areas.

Justification of the Project is made hereinafter. The project site at Mamaia Sud has been plagued by the acute progress of beach erosion that amounts to the rate of 2.0 m per year. The narrowest beach width at the southern end of Mamaia beach is only 20 m from the edge of a shop on beach. In less than 10 years, the shop will be destroyed by waves if no protective measures are taken. The seaward edges of the buildings of Hotel Parc and Hotel Dacia are located at the distance of about 40 m from the present shoreline. Structural damage to the buildings will start within 20 years without project implementation. The project aims at widening beaches by bringing sand from outside sources to mitigate further beach erosion. The enlarge beach area will greatly contribute to the local tourism.

The beach at Eforie Nord is very narrow and sandy beach disappears in the north of Restaurant Acapulco. It has been verified that the project site area has retreated by some 40 m during the past 78 years. Since the project site area is basically a cliff coast of about 10 m high, the shoreline retreat is associated with the gradual collapse of cliffs. Further possibility of cliff collapse threatens the safety of hotels, restaurants and other buildings built near the cliff edge.

Expansion of the beach at the foot of the cliff provides a valuable space for cliff stabilization works, which will be composed of reformation of the cliff slope into milder gradient, provision of efficient drainage systems, and revetments at the foot of cliff for protection against the scouring action of waves. New sandy beach to be created by the Project will attract many tourists to the area and contribute to the local economy.

C. General Description of the Project

(1) General

The general information of the Project is as follows:

Project Name:	Coastal Protection and Rehabilitation Project at Mamaia Sud and Eforie Nord
Component "A":	Coastal Protection and Rehabilitation Works at Mamaia Sud
Component "B":	Coastal Protection and Rehabilitation Works at Eforie Nord
Beneficiary:	National Administration of Romanian Waters The Department of Waters Dobrogea – Litoral Constanța, Romania
Consultant:	ECOH CORPORATION 2-6-4 Kita-Ueno, Taito-ku, Tokyo 110-0014, Japan tel: +81-3-5828-8412, fax: +81-3-5828-8418

The sites of the two components are separated by about 17 km, and their construction works are carried out independently.

(2) Major works

The major items of construction works at the Component "A" at Mamaia Sud are as follows:

Beach fill:	alongshore distance of 1.2 km, beach width increase of 50 m, and sand volume of 224,000 m^3.
Rehabilitation of two (2) breakwaters:	length of 250 m each.
Construction of one (1) sand retaining jetty:	length of 200 m.
Construction of three (3) submerged groins:	length of 100 m each.

The major items of construction works at the Component "B" at Eforie Nord are as follows:

Beach fill:	alongshore distance of 1.2 km, beach width increase of 80m, and sand volume of 467,000 m^3.
Rehabilitation and extension of one existing jetty:	extension length of 60 m.
Rehabilitation of one existing jetty:	length of 180 m.
Construction of three (3) submerged breakwaters:	lengths of 200m, 200m and 275 m.

In addition to the above, four existing short groins in Eforie Nord are removed for safety of beach users and their debris is recycled as the core materials of submerged breakwaters. The volumes of beach fill sand slightly differ from those estimated at the time of formulating the Coastal Protection Plan for the Southern Romanian Black Sea Shore, because the preliminary design works in the feasibility study are based on the new information obtained by the bathymetric and topographic surveys specially commissioned for the feasibility study.

Figures II.1 and II.2 show the layout of the shore protection facilities and a bird's-eye view of the beach after project implementation at Mamaia Sud, respectively. The two existing breakwaters to be rehabilitated are shown in red color in Fig. II.1. Other four breakwaters are not rehabilitated in the present project. The jetty at the left end of beach fill area is built for retaining filled sand within the fill area. Three groins (submerged) at the left to center bottom are provided there to slow down the longshore currents induced by waves and to reduce the alongshore sediment transport.

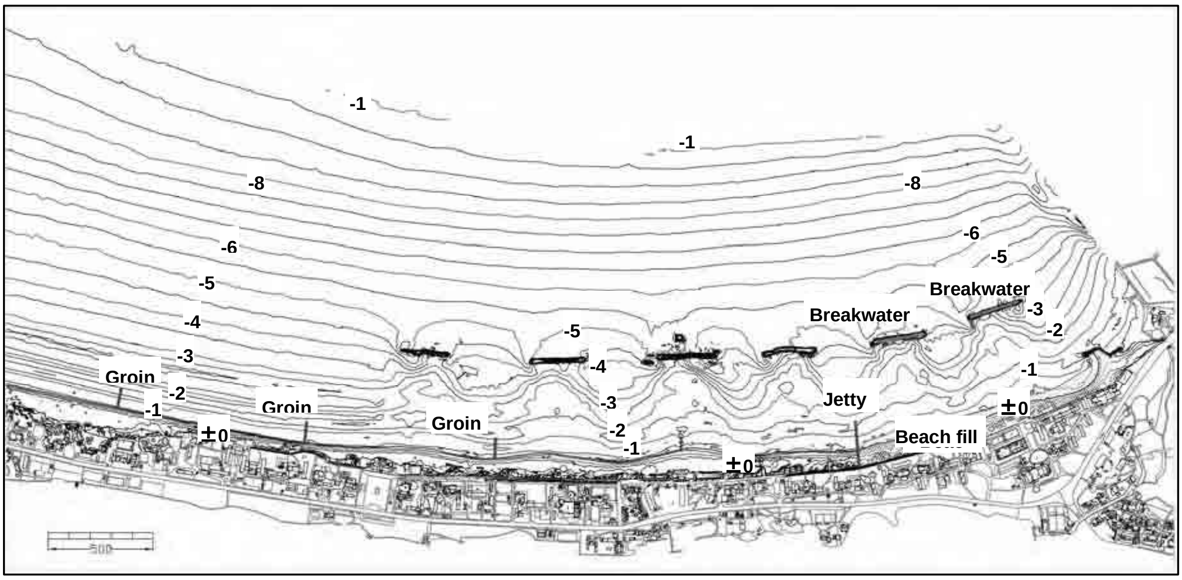


Fig. II.1: Layout of the shore protection facilities around Mamaia Sud

Fig. II.2: Bird's-eye view of the beach after project implementation at Mamaia Sud

Figures II.3 and II.4 show the layout of the shore protection facilities and a bird's-eye view of the beach after project implementation at Eforie Nord, respectively. The breakwaters marked as B-1, B-1', and B-2 are all submerged type with wide crests. The jetty J-1 is extended by 60 m with rehabilitation of the existing section. The jetty J-2 is rehabilitated for the whole section.

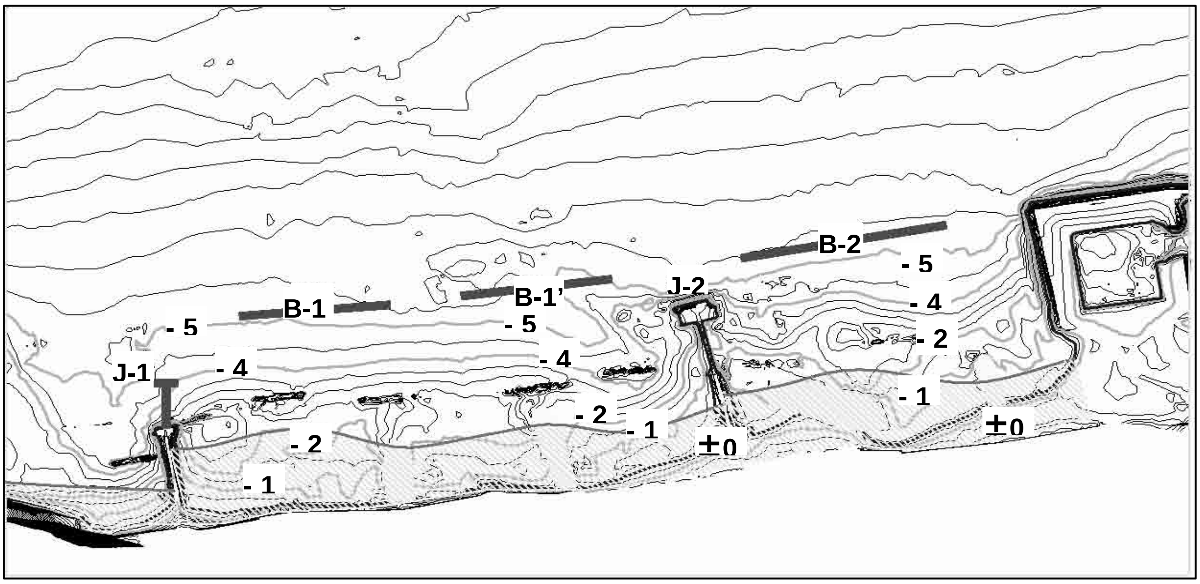


Fig. II.3: Layout of the shore protection facilities at Eforie Nord
with the shoreline in one year after the beach fill

Fig. II.4: Bird's-eye view of the beach after project implementation at Eforie Nord

(3) Beach fill sand

The principal candidate source of beach fill sand is the riverbed of the Danube in the location between km 305 to km 340, provided that the permit of sand mining will be issued by the National Administration for Mineral Resources and the mining operation will be authorized by the River Administration of the Lower Danube, Galati and the National Administration of Romanian Waters. The environmental agreement for sand mining must also be obtained through the Environmental Impact Assessment for the priority project.

The beach fill sand should be medium to coarse sand with the median diameter of 0.20 to 0.30 mm for the Component "A" at Mamaia Sud and 0.35 to 0.45 mm for the Component "B" at Eforie Nord. The sand should contain no silt fraction.

D. Main Alternatives Studied and Main Reasons for the Final Choice

D.1 Alternatives Studied for Mamaia Sud

In designing the shore protection facilities and their layout of the Component "A" at Mamaia Sud, the following four items of component options were taken into consideration:

1) Option of the river sand or the sea sand for beach fill,
2) Option of the crest elevation of two detached breakwaters to be rehabilitated:
   Choice of the crest elevation of +2.4 m or +1.0 m,
3) Option of the extension length of two detached breakwaters to be rehabilitated:
   Choice of present length of 250 m or extended lengths of 350 m, and
4) Options of the length of sand-retaining jetty at the northern boundary of beach fill area:
   Choice of the length of 210 or 120 m (310 or 220 m in case of sea sand),

Nine alternative plans including "zero-option" alternative were selected by rational combinations of the above four options. The alternative plans were examined for their capacity to mitigate beach erosion, aesthetic factor of ocean view, and construction cost.

Use of the river sand is less expensive than the sea sand and slightly more stable; the total project cost using the river and sea sand has been estimated as 11.5 and 19.0 million Euro, respectively. It was agreed at the Steering Committee meeting held on August 22, 2006 that the beach fill will be executed by using the river sand unless the environmental impact assessment demands the use of sea sand. The second item of the crest elevation of rehabilitated breakwaters was concluded to employ a lower elevation of +1.0 m to reduce the aesthetic impact as much as possible. The third and fourth items were mainly examined from the viewpoint of erosion mitigation capacity. Extension of existing breakwater by 100 m increases the effectiveness of beach protection, but the degree of increase is not large enough to compensate an increase in construction cost and the adverse effect on the aesthetic view will be brought in. Shortening of the sand-retaining jetty decreases the sand retaining capacity and induces rapid retreat of the beach fill shoreline. Thus, the third option of breakwater extension and the fourth option of short jetty were rejected.

D.2 Alternatives Studied for Eforie Nord

In designing the shore protection facilities and their layout of the Component "B" at Eforie Nord, the following four items of component options were taken into consideration:

1) Option of the river sand or the sea sand for beach fill,
2) Construction of the extended portion of the two jetties (EN-J-1 and EN-J-2):
   Choice of 60 and 150 m for EN-J-1 and 0 and 25 m for EN-J-2,
3) Construction of submerged breakwaters:
   Choice of two breakwaters (EN-B-1 and EN-B-2) or three breakwaters (EN-B-1, EN-B-1' and EN-B-2), and
4) Crest elevation of submerged breakwaters:
   choice of submerged or emerged breakwaters

A preliminary cost comparison was made between the use of river and sea sand for beach fill at Eforie Nord (see **2.5.3**). Because the sediment on beach and inshore there is made of medium to coarse sand, beach fill using the sea sand which is very fine in grain size will require a large volume of sea sand and underwater dikes to prevent the sand from flowing out from the fill area. The total project cost using the river sand and the sea sand was estimated as 28.7 and 54.1 million Euro, respectively. Because of the large cost difference, use of the sea sand at Eforie Nord was discarded and the decision was supported by the Steering Committee at the meeting on August 22, 2006.

The third option of emerged reefs was rejected from the aesthetic viewpoint and its adverse impact on water quality due to less efficient water circulation. Four alternative plans including "zero-option" alternative were selected by rational combinations of the second and third options. They were mainly examined from the viewpoint of erosion mitigation capacity. Because the project site is bounded by the south breakwater of Constanța Port at the northern side and the breakwater of "Yacht Club Europa" Marine at the southern side, the alongshore sediment transport rate is small, and the difference between the alternative plans except "zero-option" was not large. Nevertheless, the plan shown in Fig. II.3 demonstrated the best performance with the least cost.

E. Project Cost and Implementation Schedule

E.1 Component "A" at Mamaia Sud

Because of the uncertainty of the exact date when the fund for the Project is secured in an early time of the year 2007 and the Project Implementation Unit (PIU) is established, the implementation schedule is counted from the year after the provision of the fund. The Project Component "A" at Mamaia Sud is scheduled to start in July of the first year and to be completed by December of the second year. The following is the periods of major construction works:

- rehabilitation of the first detached breakwater:	August to November of the first year
- rehabilitation of the second detached breakwater:	May to August of the second year
- sand-retaining jetty:	October of the first year to February of the second year
- submerged groins:	October of the first year to May of the second year
- beach fill:	March to May of the first year and September to November of the second year

Major construction works are carried out in the off-season of summer tourism. However, rehabilitation works of existing breakwaters which are executed by floating vessels at the distance of 500 m from the shore are continued throughout the year, because they will not interfere the beach users in the summer season.

The total project cost of the Component "A" is estimated as 11.53 million Euro on the basis of the market price in the summer of 2006,, and the works-wise cost breakdown is listed in Table II.1.

Table II.1: Works-wise cost breakdown of project cost at Mamaia Sud using river sand

(units: million Euro)

No.	Item	Quantity	Amount
1	Construction works		
	Beach fill	224,000 m^3	4.72
	Rehabilitation of detached breakwaters	2 @ 250 m	2.81
	Sand-retaining jetty	200 m	0.66
	Submerged groins	3 @ 100 m	0.64
	Supplementary submerged groins	3 @ 70 m	0.13
	Temporary access road	1 unit	0.30
	Net construction cost		9.26
2	Management and monitoring cost		0.84
3	Engineering Service		0.65
4	Taxes and public charges		0.23
5	Base cost		10.98
6	Contingency		0.55
7	TOTAL		11.53

Note: 1) The engineering service fee is estimated as 7% of the net construction cost.
2) The taxes and public charges are estimated as 2.5% of the net construction cost.
3) The contingency is estimated as 5% of the base cost.
4) All the cost is based on the market price in the summer of 2006.

E.2 Component "B" at Eforie Nord

With the condition same as that for the Component "A,", the Project Component "B" at Eforie Nord is scheduled to start in January of the third year and to be completed by June of the fourth year. The following is the periods of major construction works:

- removal of existing short groins: February to May of the third year
- submerged breakwaters: February to December of the third year
- Rehabilitation and extension of two jetties: February to May of the third year with minor works from October of the third year to May of the fourth year
- Beach fill: March to May of the third year and September of third year to May of the fourth year

Major construction works are carried out in the off-season of summer tourism. However, construction of submerged breakwaters which are executed by floating vessels at the distance of 300 m from the shore are continued throughout the year, because it will not interfere the beach users in the summer season. When the construction works are completed as scheduled, the new beach at Eforie Nord will be fully available for the beach users in the summer of the fourth year.

The total project cost of the Component "B" is estimated as 28.72 million Euro on the basis of the market price in the summer of 2006,, and the works-wise cost breakdown is listed in Table II.2.

Table II.2: Works-wise cost breakdown of project cost at Eforie Nord using river sand

(units: million Euro)

No.	Item	Quantity	Amount
1	Construction works		
	Beach fill	467,000 m^3	8.82
	Submerged breakwaters (3 units)	675 m in total	12.14
	Rehabilitation of Jetty J-1	146 m	0.46
	Extension of Jetty J-1	60 m	0.99
	Rehabilitation of Jetty J-2	200 m	1.02
	Removal of existing groins	1 unit	0.45
	Temporary access road	500 m	0.34
	Net construction cost		24.22
2	Management and monitoring cost		0.82
3	Engineering Service		1.70
4	Taxes and duties		0.61
5	Base cost		27.35
6	Contingency		1.37
7	TOTAL		28.72

Note: 1) The engineering service fee is estimated as 7% of the net construction cost.
2) The taxes and public charges are estimated as 2.5% of the net construction cost.
3) The contingency is estimated as 5% of the base cost.
4) All the cost is based on the market price in the summer of 2006.

E.3 Total Project Cost of Components "A" and "B"

The Coastal Protection and Rehabilitation Project at Mamaia Sud and Eforie Nord is estimated to cost 40.25 million Euro excluding price contingency, based on the market price in the summer of 2006. Its breakdown into the foreign and local costs is listed in Table II.3.

Table II.3: Total project cost of Components "A" and "B"

(units: million Euro)

No.	Item	Foreign Cost	Local Cost	Total Cost
1	Material	1.01	7.14	8.15
2	Equipment	0.00	17.30	17.30
3	Labor Cost	3.25	4.78	8.03
	Skilled	3.25	3.30	6.55
	Unskilled	0.00	1.48	1.48
4	Management (PIU) and monitoring cost	0.00	1.66	1.66
5	Engineering Service	1.41	0.94	2.35
6	Taxes and Duties	0.00	0.84	0.84
7	Base Cost	6.17	32.16	38.33
8	Physical Contingency (Base Cost ×5%)	0.31	1.61	1.92
9	TOTAL	6.48	33.77	40.25

If the environmental agreement based on the environmental impact assessment is issued on the condition of using the sea sand around Midia Port instead of the river sand from the Danube for the Project Component "A", the total project cost will be increased by 7.44 million Euro to the amount of 47.69 million Euro. In a bid to estimate a whole financing need for the project, price contingency is added to the above project cost as reflected in **7.2.3**.

F. Potential Environmental Impacts and Mitigation Measures

(1) Water

Potential impact of the project implementation is the turbidity associated with mining and placement of beach fill sand. In case of the river sand from the Danube, turbidity by sand mining is negligible because of the turbid river water with suspended sediment. Its placement on the beach and inshore water will not yield turbidity because of little content of silty fractions. Thus, the environmental impact will be of low level.

In case of the sea sand, it may contain a certain amount of silt and mud fractions depending on the dredging locations. Turbidity will be generated at both the dredging and the beach fill sites. However, silty sediment will be settled down after elapse of a certain time and will not affect the water quality in a long time span. Thus, the environmental impact will be of moderate level. Nevertheless, whenever water pollution by turbidity is anticipated, some silt protection measures such as silt protection screens should be spread out around the work site.

Another source of water pollution is a possible oil spill from working vessels and other construction equipment. Every care is to be taken to prevent oil spill.

Basically, there will be no water pollution impact by construction works. Nevertheless, the water pollution problem owing to eutrophication is still present. In case of no further improvement of wastewater treatment installations including full administration of pipeline systems, there may appear a possibility of water quality degradation by construction of shore protection facilities owing to potential decrease of water circulation in the nearshore zone. Close collaboration with another EU project on wastewater treatment plants at Mamaia and

Eforie Sud and timely adjustment of execution schedules of coastal protection and wastewater treatment projects will be called for.

(2) Air

A possible source of air pollution is the exhaust gas emitted during the operation of sand mining, transport of beach fill sand and other construction materials, and vessels and equipment employed in construction. Because the sand mining is carried out at the places far from inhabited areas, impact on air quality is hardly expected.

The transport of the river sand for beach fill is executed by hopper barges through the Danube – Black Sea Canal and dump trucks on roads. The maximum daily traffic of 25-ton trucks is estimated to be less than 200 trips. Because the routes of sand transport are already utilized by 1,300 to 4,200 large vehicles per 12 hours according to the traffic survey in June 2006, addition of the truck traffic by the project will increase the traffic load only modestly and the increase of air pollution will be slight. Thus the impact on air quality will be of low to moderate level.

Nevertheless, proper maintenance of dump trucks and other equipment should be administered to minimize the pollution load.

(3) Noise and vibration

A possible source of noise and vibration is the traffic of dump trucks carrying beach fill sand and other construction materials. Increase of traffic volume by the project is small as mentioned above, and the impact of noise and vibration on the area along the road will be of low to moderate level. Nevertheless, no construction activities will be carried out during the night-time, and proper maintenance of the engines should be administered to avoid malfunctions which result in increased noise.

(4) Fauna, flora and biodiversity

There are some species of flora in water along the riverbanks of the Danube river, but few flora can grow in the turbid water of several meters deep on the sand shoals. Thus little impact on flora will be expected. As to fauna, there are fresh-water shells of common species. Detailed assessment on impact to fauna and flora with sand mining would be implemented in the following environmental impact assessment.

For the beach fill works in Mamaia Sud and Eforie Nord, low impact is expected on benthos and benthic plants and marine biodiversity, because the damage to benthos by covering of seabed with beach filling sand will be recovered soon by natural process.

On the long term, the installation of submerged breakwaters and jetties provides the water area with new additional hard bottoms and they will have positive effects of enhancing biodiversity.

Thus, the impact on fauna, flora and biodiversity will be of low to moderate level. However, monitoring of fauna, flora and biodiversity around the sand mining area as well as the project sites should be undertaken in order to ensure no adverse effect by the project implementation.

Dredging vessels and equipment for sand mining must observe the internal and international rules for the navigable routes pollution protection.

(5) Landscape

The beach of Mamaia Sud has a series of six detached breakwaters which were built in 1989 to 1990. Beach is very narrow at its southern area. The Project rehabilitates the two existing breakwater by widening them with installation of rear rubble mounds and protecting them with armour blocks of stabilopods. However, the crest is set at the same elevation as before and the scenery from the shore will be the same as the present one. The sand-retaining jetty may bring forth an impression of discontinuity of a long continuous shoreline, but the beach fill is so designed to minimize the difference between the shoreline positions across the jetty. Expanded beach width will provide beach visitors with ample space for sunbathing and weaken the impression of discontinuous shoreline.

Changes in the beach scenery of Eforie Nord by implementation of the project are disappearance of short groins, rehabilitated two long jetties, and widened beach area. Presence of submerged breakwaters is only noticeable with a series of sea marks emerged on top of reefs. No objections to the new beach scenery will be raised by beach visitors.

Thus, the impact on landscape by the project implementation will be of low to moderate level.

(6) Waste

Construction works for the project yields little amount of waste, because main construction materials are sand, stones, concrete blocks, and fresh concrete, which are all utilized in facility construction. Demolished short groins at Eforie Nord yield stones and fragments of concrete blocks, but they are recycled as the core materials of submerged breakwaters located in the offshore.

There will be no lodging facilities for workers and thus no sleep-in workers in the project. Household waste will be kept minimal and treated properly.

Thus, the impact on waste by the project implementation will be of low level.

(7) Bottom sediment

Sediment samples of the river sand of the Danube indicated that the contents of the heavy metals Cd, Cr, Cu, Pb, and Zn are well below the limits concentration by the Romanian regulations. The concentrations of total petroleum hydrocarbon (TPH) are below the detectable level 25 mg/kg d.w.[1] and the organoclorinate pesticides are below the detectable level 0.001 mg/kg d.w. There are detected a certain level of the polycyclical aromatic hydrocarbons (PAH), but no specific regulations are in force with regard to PAH.

The concentration levels of heavy metals, TPH, PAH in the river sand are of the same levels with the sea bottom sediment of Mamaia Sud and Eforie Nord. Thus, no severe on bottom sediment is foreseen with the project implementation using the river sand at the present moment while detailed study and assessment will be implemented in EIA procedure..

[1] d.w.: dry weight

(8) Fishery

Potential impacts by the project using the river sand on fishery are temporal minor turbidity by sand placement in the nearshore water, inconvenience to fishermen by temporal use of fishing harbor area by working vessels, departure of fish from the water area of the project site by noise of construction works, and others. However, the construction works are limited to the water area shallower than 5 m, where the fish resources are few. Installation of submerged breakwaters and other facilities, on the other hand, has positive ecological effects by providing hard underwater surface which has ecological and bioproductive potential higher than sandy seabed.

Thus, the impact on fishery by the project implementation using the river sand will be of low level.. When the sea sand around Midia Port is used for beach fill, some moderate impact on fishery is expected because of the turbidity generated during dredging and placement of beach fill sand.

(9) Social and economic environment

The project sites of Mamaia Sud and Eforie Nord are situated amidst the summer resort beach zones, with a large number of tourists and visitors in hot season and just a little number of permanent inhabitants in the sites. Owners and staff of hotels, restaurants, bars and other enterprises move out from the beach areas in the off-season. The Project does not require any land acquisition, because all the works are made on beach and nearshore water areas. There is no possibility of involuntary resettlement of inhabitants. Thus, little impact on the social environment is expected by the project implementation.

As for the economic environment, no adverse effect is expected. Rather, positive effects such as the enhancement of the tourism industry by increased number of visitors to the region and the improvement of labor market by way of amplified number of workers in the hotel and restaurant sector are expected in the wake of the project completion. Construction works during the project implementation will generate incremental employment of laborers up to some 800.

(10) Other environmental factors

The project does not induce any impact on soil and subsoil, because it engages in the shore area only.

There are no submerged sites of historical and/or cultural importance, which have been known in the work areas. If such sites will be identified during construction, they will be preserved and investigated in compliance with the related law.

The local conflict of interest may arise from the misdistribution of benefits produced after the project implementation. Main direct beneficiaries will be the owners of resort hotels, restaurants and other enterprises, but increased profits will be distributed indirectly to the entire community through taxation and other civil means.

G. Project Evaluation

G.1 Affordability Analysis of the Project

Affordability of public investments includes (i) affordability at the sector level, and (ii) affordability at the project level. With regard to the macro-front of the coastal protection and rehabilitation scheme in the Romanian economy (former element), there are readily available of external public funds for collaborative effort for the country's socio-economic development, with the EU post-accession fund as a forerunner in particular. Besides, the World Bank newly approved the Municipal Services Project to MoEWM for the development of environment protection-related infrastructure in pilot eleven counties, in line with the newly coming *Country Partnership Strategy 2007-2009*, following the Environment Management Project of US$150 million in 2005 as the possible financing sources. Further, financing from the Council of European Development Bank (CDB) would be within the realm of possibility, while considering the Bank's preferential support extended thus far to Romania. Likewise, the state government has a medium-term rolling budget program for coastal protection over the forthcoming three years of 2007-2009, with US$157.8 million in aggregate as an indicative fund package for the sector as listed in Table 7.2.1.

On the micro-side of affordability, the Coastal Protection and Rehabilitation Project at Mamaia Sud and Eforie Nord constitutes a part of the pipeline projects for EU post-accession financing within the operational framework for ESOP. Further, the uprising revenue and associated financial position of the project beneficiary – DADL, as reflected in **7.2.2 (3)**, is favorable for implementing operation and maintenance works on their own financial basis.

G.2 Economic Analysis of the Project

Economic analysis of the Project has duly been undertaken with the economic internal rate of return (EIRR) as the efficiency measurement index. The economic costs of the components "A" (Mamaia Sud), "B" (Eforie Nord), and "A+B" (the aggregate) are estimated at 11.0 million Euro, 27.3 million Euro, and 38.3 million Euro, in that order, with the breakdown by cost component as summarized in Tables ES.1 to ES.3.

As for the economic benefits, the following items have been quantified:

(i) People's welfare as perceived by the presence of beaches on a sound basis (use- and non-use value) – Willingness-to-Pay (*WTP*),
(ii) Foreign exchange (FX) earned in association with the incremental beach areas and expatriate tourists to the region,
(iii) Foreign exchange saved due to the prevention of downsizing expatriate tourism to the region associated with beach preservation, and
(iv) Social costs saved, attributable to the prevention of the collapse of promenade and cliff revetment on the beach.

The amount of WTP is estimated at 21.8 Euro per year per household (2.8 persons on average) on the basis of interview survey with 449 interviewees. The WTP population specifically attributable to the present project at Mamaia Sud and Eforie Nord is presumably set at around 435,000 in compliance with the estimated numbers of check-in tourists and day-visitors to the concerned beaches. This item yields the benefit of 3.1 million Euro per year at maximum.

The second item of the increase of foreign exchanged is estimated as 0.3 million Euro per year at maximum in aggregate of the two components. The third item of the foreign exchanged saved is evaluated as 1.5 million Euro per year at maximum. The fourth item that is applicable for Eforie Nord is estimated as 0.1million Euro for the period from 2007 to 2017 and 0.5 million Euro afterwards.

With these economic costs and benefits, EIRR is calculated as 20.6% for the Component "A" at Mamaia Sud, 7.8% for the Component "B" at Eforie Nord as, and 9.4% for the Project aggregate of "A" and "B." Sensitivity analysis has also been presented.

The proposed project in aggregate reveals economic feasibility at each 20.6 percent, 7.8 percent and 9.7 percent in total. With this, the proposed project deserves implementation in terms of the efficient allocation of scare resources in the Romanian economy. In other words, the Project would likely to be the investment opportunity at a margin, given that the economic return attributable exceeds the economic foregone loss accrued. The Economic Net Present Value (ENPV) in aggregate of the two subcomponents stands at 13.7 million Euro (US$ 17.4 million) at the social discount rate (SDR) of 8 percent.

H. Operational Framework for and PIU of the Project

The Project of coastal protection and rehabilitation at Mamaia Sud and Eforie Nord is going to need to be financed by external sources to the extent possible, such as the EU Cohesion Fund. The project will involve a number of governmental ministries, agencies and other institutions such as listed below.

- i) The Ministry of Public Finance (Certifying Authority),
- ii) The Ministry of Environment and Water Management (Managing Authority),
- iii) Regional and Local Environment Protection Agency (REPA/LEPA) as Intermediary Body
- iv) Water Department Dobrogea Litoral (DADL) as Final Beneficiary,
- v) Project Implementation Unit (PIU) under DADL,
- vi) Consultant group attached to MoEWM and closely work with PIU, and possibly MoPF in the light of procurement procedures,
- vii) Steering Committee (an off-line advisory board), and
- viii) Supreme Audit Institution as Auditing Authority

In close consultation and discussions with the Romanian counterpart officials as well as those at the European Commission Delegation to Romania, the idea on the possible framework and scheme for project management and implementation has substantially been brought about as shown in Fig. II.5. The Ministry of Public Finance is a "final certifying authority" in charge of financial management and settlements (payments), and the Ministry of Environment and Water Management acts as the managing authority. The Regional and Local Environment Protection Agency (REPA in Galati/LEPA in Constanta) are placed as "intermediary bodies" administratively responsible for project management and the part of fund management with procurement procedure in particular. The final beneficiary is DADL, within which the Project Implementation Unit (PIU) is set up. Indicative TORs for the above ministries, agencies and institutions are respectively given in **8.3.1**.

PIU is proposed to be composed of around eleven professional staff supported by secretaries and workers. The staff is to be full-time assignment having been recruited outside sources with the Project fund. Indicative TOR for PIU is given in Appendix J.

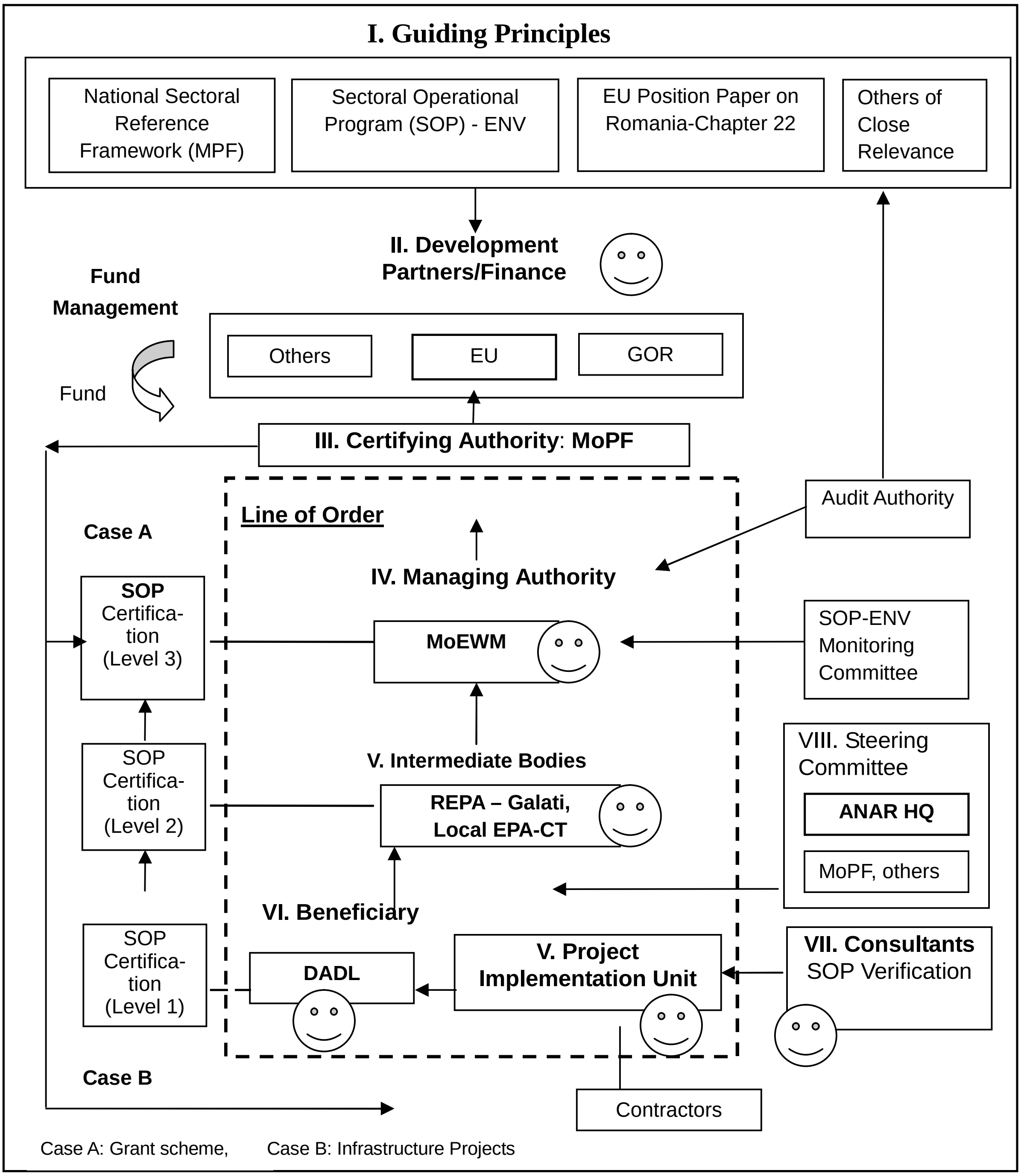


Fig. II.5: Schematic framework for project implementation

I. Recommendations and Further Issues

A set of twelve recommendations are made for the project before, during, and after the implementation as listed in **9.2**. The Study team wishes that they will be duly followed by the Romanian side.

A scenario has been drawn for the start of the coastal protection and rehabilitation project at Mamaia Sud and Eforie Nord. Preliminary designs of shore protection facilities are presented with the execution schedule and cost estimate. Affordability of the fund for the project is acknowledged, and economic analysis yields the economic internal rate of return (EIRR) at a high value of 9.7 percent. Operational framework of the project is set in close consultation with the Romanian government officials concerned, and the function and framework of the project implementation unit (PIU) are prescribed.

During the public debate of the SEA procedure on the coastal protection and rehabilitation plan of the Southern Romanian Black Sea shore, which was held on March 29, 2007 (the number of participants was 49 including 19 numbers related to the Study) at the National Institute for Marine Research and Development in Constanța, several questions and opinions were raised regarding the Master Plan. Among them, the following is the main opinions:

- Consultations with and approval from the local community (especially the fishermen) and owners are needed.
- Transport of sand by dump trucks on road may cause significant environmental impact. The methods of transport by water should be studied and examined.

In preparation of EIA application documents and execution of EIA procedures in future, it is recommended to pay due considerations to outcomes of public debates and other relevant matters.

CHAPTER 1:

INTRODUCTION

Chapter 1 Introduction

1.1 Selection of Project Sites

The southern Romanian Black Sea shore, which is the area under study, extends from Midia to Vama Veche over the distance of about 80 km. The area includes three major port zones of Midia, Constanța and Mangalia. The extension of the coastal zone excluding the port zones is approximately 59 km, which was divided in seven sectors and twenty sub-sectors for the purpose of carrying out the Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore (hereinafter referred to as "the Study"). These seven sectors are regarded as the independent coastal sediment cells so that any measures taken in one cell will not cause environmental impacts on adjacent cells, as described in Chapter 5 of Volume 1. Thus, there will be no transboundary environmental impacts by a coastal protection and rehabilitation project undertaken within the southern Romanian Black Sea shore.

The twenty sub-sectors have been suffering from the problem of coastal erosion for many years. The causes of coastal erosion are several, such as the decrease of sediment supply to beaches, offshore loss of sediment induced by wave actions, collapse of cliffs by geotechnical instability of upper slopes and/or wave scouring at the feet of cliffs, natural process of gradual cliff retreat, and others. The extent of coastal erosion differs from a sub-sector to another. The degree of coastal utilization also differs.

Among the twenty sub-sectors, nine sub-sectors are recommended for implementation of coastal protection and rehabilitation projects and the plans for construction of shore protection facilities have been proposed as described in Chapter 5 of Volume 1. These projects cannot be undertaken simultaneously, however, but they must be implemented one by one owing to the limitation of the fund available. Thus, the necessity and urgency of project implementation at respective sub-sectors were evaluated for mutual comparison as described in Sections 6.1 and 6.2 of Volume 1. Based on this evaluation, the sub-sectors of Mamaia Sud and Eforie Nord were selected as the site of priority projects at the Steering Committee held on November 4, 2005. The selection was acknowledged at the third stakeholder meeting in Constanța held on November 24, 2005 and at the second stakeholder meeting in Bucharest held on November 25, 2005. It was further confirmed at the fifth stakeholder meeting in Constanța held on June 6, 2006.

1.2 Composition of the Present Volume

The present volume deals with the results of the feasibility study on the coastal protection and rehabilitation project at Mamaia Sud and Eforie Nord (hereinafter referred to as "the Project). The Project has two components of "A" at Mamaia Sud and "B" at Eforie Nord. The outline of the Project is described in Chapter 2, which has four sub-sections. The names of the beneficiary and the consultant, major elements of the Project and other general information are given in **2.1**, while the objectives and justification of the Project are discussed in **2.2**. The social and economic conditions at the project site are briefly described in **2.3** as the background information. The physical and geomorphologic conditions at Mamaia Sud and Eforie Nord are summarized in **2.4** with the information and data taken from Volume 1. Discussion is made in **2.5** for the source of beach fill sand to be utilized at Mamaia Sud and Eforie Nord, the supply of sand being the key factor of the present project.

Technical aspects of the Project are described in Chapters 3 and 4, the former for the Component “A” at Mamaia Sud and the latter for the Component “B” at Eforie Sud. Both chapters begin with the outlines of project components, i.e. descriptions of the facilities to be installed for coastal protection and rehabilitation. Then several alternatives to be examined in the feasibility study are introduced and their mutual comparisons are made. The main reasons that led to the final selection of the project components are presented. Next, the design aspects of structural components are discussed with their layouts. The quantities of materials to be used in construction works are listed in **3.3**, **3.4**, and **4.3** for the Component “A” with the river sand and the sea sand, and the Component “B,” respectively. Execution schedules are briefly described with detailed schedules of execution, equipment and labor mobilizations listed in Appendix F. Finally the estimate of the Project cost inclusive of the maintenance is presented at the end of each chapter.

The environmental aspects are dealt with in Chapters 5 and 6. First, the potential environmental impacts of the Project and their mitigation measures are discussed in Chapter 5 for each environmental element; water, air, noise and vibration, bottom sediment, fishery, and social and economical environmental conditions inclusive of tourism are discussed. For each element, present conditions are described, impact prognosis is made, and mitigation measures are recommended. Other environmental elements such as soil and subsoil, human settlement, cultural heritage, local conflict of interests, and misdistribution of benefits, on which the Project is not considered to cause negative impacts, are given the prognosis only.

The subjects of the risks of accidents and monitoring plan are dealt with in Chapter 6. The first sub-section makes a survey of possible risks of accidents and the mitigation measures. The next sub-section describes the environmental monitoring during construction works, being followed by the sub-section on the environmental monitoring after project implementation. The necessity of monitoring physical conditions such as beach shapes and waves during and after the implementation of the Project is discussed in the last sub-section together with the recommendation for the monitoring method. Cost estimate for the environmental and physical monitoring is also presented and incorporated in the total project cost estimate.

The project evaluation is made in Chapter 7, beginning with the affordability analysis concerning the Government of Romania as a whole, the National Administration of Water Management and its regional office “the Department of Waters Dobrogea – Litoral” as the beneficiary of the Project, and Constanța County Council. Project costs are examined in terms of foreign and local costs, and the debt sustainability analysis is made for examination of the fiscal impact of the Project. Economic analysis is then made with the benefits accounted from three sources: i.e. the amount of Willing-to-Pay (WTP) as an intangible benefit, the expected increase of the Gross Domestic Product by the increase of foreign tourists after the implementation of the Project, and the avoidable costs otherwise accrued to beach erosion. The economic internal rate of return (EIRR) is calculated for the Component A at Mamaia Sud and Component B at Eforie Nord separately.

Chapter 8 deals with the institutional analysis for project implementation. The managerial framework is discussed for the operational line of responsibility among the institutions involved and the management structure of project undertaking. Proposals are made for the setup of management bodies for construction and maintenance of the Project as well as for the systems of fund management and procurement.

The last of the present volume, Chapter 9, summarizes conclusions of the feasibility study and recommendations for the project implementation.

CHAPTER 2:

OUTLINE OF THE PROJECT AND SURROUNDING CONDITIONS

Chapter 2 Outline of the Project and Surrounding Conditions

2.1 General Description

(1) General information

Project Name: Coastal Protection and Rehabilitation Project at Mamaia Sud and Eforie Nord

Component "A": Coastal Protection and Rehabilitation Works at Mamaia Sud

Component "B": Coastal Protection and Rehabilitation Works at Eforie Nord

Beneficiary: National Administration of Romanian Waters
The Department of Waters Dobrogea – Litoral
Constanța, Romania

Consultant: ECOH CORPORATION
2-6-4 Kita-Ueno, Taito-ku, Tokyo 110-0014, Japan
tel: +81-3-5828-8412, fax: +81-3-5828-8418

(2) Project components

The project is the first of a series of projects for protection and rehabilitation of the southern Romanian Black Sea shore, which has been suffering from the problem of coastal erosion for many years. Because of the acute situation of coastal erosion and the high degree of coastal utilization, the areas of Mamaia Sud and Eforie Nord have been selected as the sites of the first project implementation among various sites along the coast.

Because the two sites are separated by about 17 km, the Project is divided into two components: i.e., Component "A" at Mamaia Sud and Component "B" at Eforie Nord. Both the Components A and B expand the diminished beach areas by bringing sand from outside sources and placing sand on beaches and in the nearshore water area. It is called the beach fill or beach nourishment. The filled beaches require some coastal structures to prevent or mitigate the outward flux or loss of filled sand from the nourished areas, which may be induced by waves and currents.

(3) Component "A" at Mamaia Sud

In case of the Component "A" at Mamaia Sud, there exist a series of old detached breakwaters at the distance of about 500 m from the shoreline, which were built in 1988 to 1990. They have been deteriorated such that the armor concrete blocks of Stabilopods were scattered away and the crests were subsided more than 1 m. The wave dissipating function of the breakwaters has decreased by deterioration, but the function can be restored by rehabilitation and the breakwaters will mitigate the offshore movement of filled sand. For mitigation of alongshore sand movement, a jetty needs to be built at the northern boundary of beach fill area; the southern boundary is protected by an existing jetty. The dimensions of beach fill and shore protection facilities to be installed in the Component "A" at Mamaia Sud are listed below.

Beach fill:	alongshore distance of 1.2 km, beach width increase of 50 m, and sand volume of 224,000 m^3.
Rehabilitation of two (2) breakwaters:	length of 250 m each.
Construction of one (1) sand retaining jetty:	length of 200 m.
Construction of three (3) submerged groins:	length of 100 m each.

(4) Component "B" at Eforie Nord

In case of the Component "B" at Eforie Nord, the alongshore movement of sand is limited by the presence of the breakwater of a marina "Yacht Club Europa" at the southern boundary and two existing jetties. However, these jetties are not long enough to control the sand movement, and therefore they need some extensions toward the sea. The filled sand may be carried away offshore by strong incoming waves. To attenuate waves, three submerged, wide-crested breakwaters will be built along the isobath of about 4 m at the offshore side of the project site. The dimensions of beach fill and shore protection facilities to be installed in the Component "B" at Eforie Nord are listed below.

Beach fill:	alongshore distance of 1.2 km, beach width increase of 80 m, and sand volume of 467,000 m^3.
Rehabilitation and extension of one existing jetty:	extension length of 60 m.
Rehabilitation of one existing jetty:	length of 180 m.
Construction of three (3) submerged breakwaters:	length of 200, 200, and 275 m.

(5) Necessity of maintenance works

With construction of these structures, loss of sand from the filled beach areas will be kept at minimum. Although occasional re-supply of beach fill sand may become necessary; the numerical simulation employed in the present study indicates that the filled beach will retain its considerable portion in the coming twenty years without re-supply of fill sand. Nevertheless it will be safe to maintain a reserve fund for future possible need of emergent beach re-fill operation. Rehabilitated parts of breakwaters, extended jetties, and new submerged breakwaters are built with rocks, concrete blocks, and cast-in-place concrete. They are all durable materials, and the structures will not require major repair or maintenance in many years. Submerged groins are planned to be built with sand-filled geotextile bags, which may require replacement in future owing to possible deterioration.

Once the beach fill is made and coastal structures are built, there will be no running cost because no machinery is installed by the Project. Nevertheless, environmental and physical monitoring must be executed at regular intervals, and the coastal protection scheme must be administered efficiently.

2.2 Project Objectives and Justification

(1) Objectives of the project

The objectives of the Project are to relieve the coastal areas of Mamaia Sud and Eforie Nord from the threat of coastal erosion and to enhance the beach utilization through enlargement of beach areas.

(2) Justification of the project from viewpoint of coastal protection

The project site at Mamaia Sud has been plagued by the acute rate of beach erosion that amounts to the rate of 2.0 m per year as presented in **4.2** of Volume 1. The narrowest beach width at the southern end of Mamaia beach is only 20 m from the edge of a shop named “Dream Pizza” located between Hotel Parc and Hotel Dacia. In less than 10 years, the shop will be destroyed by waves if no protective measures are taken. The seaward edges of the buildings of the both hotels are located at the distance of about 40 m from the present shoreline. Structural damage to the buildings will start within 20 years.

The beach erosion at Eforie Nord is less severe than that at Mamaia Sud. However, the beach at Eforie Nord is very narrow and sandy beach disappears in the north of Restaurant Acapulco. Comparison of the shoreline locations on the topographical maps prepared in 1924 and the satellite images of Ikonos taken in 2002 indicate that the project site area has retreated by some 40 m during 78 years, as discussed in **4.1.3** of Volume 1. Since the project site area is basically a cliff coast of about 10 m high, the shoreline retreat is the result of the gradual collapse of cliffs. Further possibility of cliff collapse threatens the hotels, restaurants and other buildings built near the cliff edge. Actually a heavy rain in August 2004 caused a slip failure of the upper slope of the cliff in Eforie Nord. Along the promenade on the cliff edge between Restaurant Acapulco and Hotel Belona, a careful observer will notice a slight subsidence of pavement blocks at the seaward edge of the promenade, which suggests geotechnical weakness of the upper slope of the cliff.

Expansion of the beach at the foot of the cliff provides a valuable space for cliff stabilization works, which will be composed of reformation of the cliff slope into milder gradient, provision of efficient drainage systems, and revetments at the foot of cliff for protection against the scouring action of waves. The cliff stabilization works themselves are not included in the present project, however. Presently the delimitation of the coastal zone under the Emergence Ordinance no. 202/2002 for the integrated coastal zone management has not been made yet and the question of the competence for cliff protection has not been settled.

(3) Justification of the project from viewpoint of tourism promotion

Both the project sites of Mamaia Sud and Eforie Nord are attracting a large number of summer visitors. As shown in Appendix A of this Volume, the whole area of Mamaia had been visited by 301,000 tourists in 2004, while the Eforie Nord had 83,000 tourists; the total number of tourists who stayed in the coastal zone in 2004 was 755,000. They are the visitors who stayed in hotels and other accommodations for around six nights. The average number of tourists per day is estimated at around 50,000.

The economic activity of the sector of hotels and restaurants is estimated to be about seven percent of the Gross Domestic Regional Product of Constanța County, or around US$112 million in 2002 (see **2.3.3** of this volume). Therefore, tourism is a very important sector of economic activities of this county.

There is no statistics on the spatial distribution of beach visitors within the areas of Mamaia and Eforie Nord. Nevertheless, the Project sites of Mamaia Sud and Eforie Nord are the most crowed areas in the Study area. According to visual inspection by the Study team, the beach visitor density is estimated to be of the order of 0.5 and 0.3 persons per square meters in Mamaia Sud and Eforie Nord, respectively (see Annex **A.2** in Volume 3). Based on such observations, the Study team has made a conservative estimate that the daily number of people enjoying summer beaches throughout the Southern Romanian Black Sea shore is about 72,000 (see Table A.3.1 of Appendix **A.3** of this volume).

The beach expansion by nourishment covers the area of 5 and 11 hectares at Mamaia Sud and Eforie Nord, respectively. The visitor density will decrease in the expanded beaches, but an assumption of 0.1 persons per square meters yields an estimate of additional 16 thousands people. Even the estimate is tentative, a significant increase of beach users and tourists will surely happen when the beach areas are expanded by the implementation of the Project.

As listed in Table A.1.1 of Appendix **A.1** of this volume, the number of hotels and other accommodation has increased in the past few years. According to the Chamber of Commerce, Industry, Shipping and Agriculture of Constanța County, the hotel owners on the seaside have invested, beginning with the end of 2003, over US$150 million in refurbishing the existing hotels and in opening six new ones. Eforie Nord has also seen a construction boom of small hotels and lodging houses, as there is a sufficient space for new buildings. Although the Mamaia area does not have much vacant spaces for new buildings, hoteliers will anyhow find land lots for new facilities so long as the prospect of the increase of visitors is good. Thus the Project with beach enlargement is the right stimulus for tourism promotion.

2.3 Social and Economic Conditions of Project Site

2.3.1 Population

The population of Romania is 21.7 million as of July 2004. The County of Constanța in which the Project sites are situated has the population of 714 thousands, among which Municipality of Constanța has the largest share of 307 thousands (see Table I.3.2 of Annex **I.3** in Volume 3). Mangalia has the population of 41 thousands and Eforie has about 9,500. Mamaia is a part of Constanța City.

The average life expectancy of Romanian people was 71.2 years in 2000 – 2002, with 68.6 and 75.5 years for male and female in urban areas, respectively. The average life expectancy of Constanța County is 69.9 years with 67.2 and 75.3 years for male and female in urban areas, respectively.

The population in the coastal zone of the Project site has a drastic contrast between the vacation season of summer and the off-season. During summer, some 50,000 tourists stay in hotels and other accommodations every day and they stay for six nights on the average (see Appendix A of this volume). Local citizens also come to beaches by walking, riding on buses and trains, and by other means. It is difficult to estimate the daily number of these people, but it may amount to some 47,000 persons on a sunny summer day.

During the off-season from the mid-September to the mid-June, however, almost all hotels and other accommodations close the houses and the streets of Mamaia and Eforie are deserted. There is no private residence within a distance of say 100 m from the shoreline at the Project sites. Therefore, it can be concluded that no permanent inhabitants are found around the Project areas.

2.3.2 Employment

Among 714 thousands people in Constanța County, people working as employees count about 170 thousands as the annual average, excluding people in the agriculture sector. The sector of industry has the largest number of 44 thousands, being followed by the sectors of trade (27 thousands), transport (26 thousands), construction (18 thousands), and so on. In the sector of hotels and restaurants, the average number of employees is 7,619, but there would have been much more people during the summer season when the accommodation facilities are open to summer visitors.

The average net nominal monthly earnings of the all employees in Constanța County were 4.07 million lei (US$123) in 2002, which was 1.07 times the national average; they were 5.28 million lei (US$159) and 6.25 million lei (US$188) in 2003 and 2004, respectively. The amount of earnings differs among various sectors of economic activities. Employees in the transport sector earn 1.37 times the overall average, while employees in the hotel and restaurant sector earn 0.67 times the overall average. The earnings of employees in the fish sector are lowest with 0.59 times the overall average.

2.3.3 Tourism

Tourism in Constanța County is mainly engaged by visitors enjoying ocean bathing and sunbathing on summer beaches. The number of tourists stayed in hotels and other accommodation at the seashore zone amounted to 1.5 million in 1989, but it decreased in the 1990s owing to economic difficulties after the Romanian Revolution in December 1989. The number of tourists declined gradually down to 659 thousands in 2001, but since then showed a healthy growth. The number rose to 755 thousands in 2004 and it is expected to exceed 1 million soon (see Appendix A of this volume).

The above tourists are mainly Romanian, but they also include people coming from foreign countries. The number of foreign tourists was 268 thousands in 1989, decreased to the lowest of 33 thousands in 2000, and rose to 84 thousands in 2004.

The accommodation facilities in the seashore zone open only for the summer season. Hotels open for about 100 days and small facilities open their houses for about 60 days. Tourists stay in accommodations for about five and half days, but foreigners stay for seven days. The turnover of tourists is estimated about 16 times for Romanians and 13 times for foreigners during the season, and the average number of tourists per day may be 50 thousands.

The Gross Domestic Regional Product (GDRP) of the hotel and restaurant sector of the Southeast Region in 2002 was 4686 billion lei (equivalent of about US$147 million), which was 3.1% of the total GDRP of 154,814 billion lei (before addition of VAT). Because the hotels in Constanța County occupy about 80% of those of the Southeast Region, it may be estimated that the GDRP of the hotel and restaurant sector of Constanța County is 3,705 billion lei (about US$112 million) and has a share of 6.8% of the GDRP of Constanța County. Thus, the seaside tourism is a very important sector of economical activity of Constanța County.

2.3.4 Coastal fishery

Fishery is the sector to which due attention should be paid from the viewpoint of environmental and social considerations. In the GDRP of the Southeast Region, the sector of fishery and fish culture has the share of only 0.015% (19.5 billion lei or about US$670 thousands). The GDRP of the fishery sector mainly comes from Tulcea County, where the estuarine and fluvial fishing is active. The number of employment in the fishery sector is 2.3 thousands in the end of 2002, while the average number is 1,156 in the Southeast Region (the reason of this difference has not been clarified yet). Among the above total numbers, Tulcea County has 1.7 thousands civil employees and 528 average employees, while the corresponding numbers Constanța County are 0.2 thousands and 260, respectively.

As described in **7.2.7** of Volume 1, coastal fishing is made with passive gears set in about thirty locations between Sulina and Vama Veche in the waters of 5 to 10 m depth. In the Study area between Mamaia and Vama Veche, the number of the locations of passive gears is about twenty. The volume of fish catches in the Romanian Black Sea Waters was more than 10,000 tons in the 1980s, but it dropped drastically in the 1990s to the level of about 2,000 tons. In 2004, the total volume of fish catches was 1,831 tons, out of which 481 tons was resulted from the fishing with stationary tools and the rest was gotten by vessels of coastal fishing trawls. Thus, the economic activity of coastal fishing along the Study area is at the lowest level.

2.4 Physical and Geomorphological Conditions of Project Site

2.4.1 Meteorological Conditions

(1) Air temperature

The annual mean temperature at Constanța is around 12 degrees in Celsius. July is the hottest month with the mean of around 23 degrees, while January is the coldest month of around 0 degrees (see Table 3.2.1 in **3.2.1** of Volume 1). However, the air temperature is characterized with large variations from year to year. During 90 years from 1901 to 1990, the highest temperature of January was 18.8 degrees while the lowest temperature of May was 1.8 degrees. There is a slight tendency of temperature rise in recent years.

(2) Precipitation

The annual amount of precipitation at Constanța averaged over the period from 1901 to 1990 was 383 mm, but the precipitation in recent years tends to exceed the above mean value (see Table 3.2.2 in **3.2.2** of Volume 1). The 90-year averages of the monthly precipitation vary from 24 mm in March to 42 mm in June, but the yearly variation is great. For example, the month of August 2003 recorded only 0.2 mm of rain, but the next month of September 2004 had the rain amounting 80 mm. Rain becomes snow in winter.

(3) Winds

The predominant wind direction at Constanța is the north-northwest to the northeast, but the wind from the south to the southwest also prevails with lesser wind speeds. Winds from the east or the west do not blow often. The annual mean wind speed is 3.8 m/s with the calm (wind speed less than 0.5 m/s) being 13.7%. Winds are strongest in January with the mean speed of 4.5 m/s and the calm of 8.3%, while they are weakest in August with the mean speed of 3.0 m/s and the calm of 19.5%. The 10% exceedance wind speed is 8.7 m/s and the 1% exceedance wind speed is 13.7 m/s.

2.4.2 Water Level and Astronomical Tide

The astronomical tide is very weak in the southern Romanian Black Sea. The spring tidal range, which is twice the sum of the amplitudes of the principal lunar and solar semidiurnal components, is 4.0 cm at Constanța and 5.1 cm at Mangalia. The neap spring range, which is twice the difference of the amplitudes of the principal lunar and lunar semidiurnal components, is 1.5 cm at Constanța and 2.1 cm at Mangalia.

The water level along the southern Romanian Black Sea shore is dominated by irregular fluctuation with the period ranging from several days to several weeks and the amplitudes of a few decimeters. The causes of these water level fluctuations are unknown. The highest water level (daily mean) ever recorded in Constanța Harbor is 0.902 m above the tide gage datum, and the lowest water level ever recorded is 0.304 m below the tide gage datum. No record of storm surge, or abnormal rise of water level by storm, has been reported.

The sea level is gradually rising with the mean rate of 2.2 mm per year during the period from 1933 to 2004 (see Fig. 3.3.1 in **3.3** of Volume 1). Thus the overall mean sea level is 0.163 m above the tide gage datum, but the recent five year period from 2000 to 2004 yields the mean sea level of 0.233 m.

2.4.3 Waves

Waves along the southern Romanian Black Sea shore are essentially wind-generated waves and few swell appears. Thus the wave climate is governed by the wind conditions. The predominant wave direction in the offshore is the north to the east, but it becomes the northeast to the east as the result of wave refraction effect. However, there are some waves coming from the southerly direction.

The annual mean of the significant wave height[1] is 0.95 m with the period of 5.1 s. Waves are roughest in December and January with the average significant waves of 1.2 m in height and 5.3 s in period. The months of June and July have the lowest wave activities with the average significant waves of 0.67 m in height and 4.5 s in period. The 1% exceedance significant wave height is 3.6 m for the whole year and 4.4 m for the winter season (November to March).

The extreme waves with the return periods of 10 and 100 years are estimated to have the significant height of 6.5 and 7.8 m, respectively, with the corresponding periods of 10.2 and 11.0 s. As these waves approach to the shore, however, their heights are limited by the local water depth as the result of wave breaking process. At the depth of 5.0 m, for example, the 100-year waves

[1] The significant wave height is defined as the average height of highest one-third waves among a wave group or a wave record of 20 minutes or so, and the significant wave period is the average period of the waves defining the significant wave height. When a same state of wave activities continues for a few hours, the highest wave among the whole waves will have the height being about 1.8 times the significant wave height. Therefore, the 100-year significant wave of 7.8 m will have a possibility of being accompanied with a single highest wave of 14 m in height.

will have the significant height of 3.5 m only (see Annex **D.5.2** of Volume 3).

2.4.4 Characteristics of Beach Sand

Beach sand of Mamaia Sud is of terrigenous origin, having been transported by wave-induced longshore currents from the mouths of the Danube. Fragments of calcareous shells of bivalves are mixed with terrigenous sand. According to the mineral content analysis, terrigenous sand at Mamaia Sud is about 55%, while calcareous sand is about 45%. The median diameter d_{50} of sand on beach is 0.23 mm and sand is well-sorted one (see **4.3** of Volume 1). Sand in the nearshore zone between the shoreline and the detached breakwaters is finer than the beach sand, because it has the origin from the bottom of Lake Siutghiol. A very mild bottom slope of 1/163 behind the southernmost breakwater (see Fig. E.7.4 in Annex **E.7.2** of Volume 3) is typical of the nearshore beach profile made of the sediment of fine grain size.

Beach sand of Eforie Nord is composed of shell fragments with a small content of limestone fragments. No trace of terrigenous sand from the Danube can be found. The mean diameter of beach sand is d_{50} = 0.40 mm and sand is well-sorted one. The mean diameter of seabed sand at the depth of 5 and 10 m is 0.17 mm.

2.4.5 Beach Morphology

(1) Erosion rate

The beach of Mamaia Sud had the width of nearly 100 m up to the early 1970s. The extension of the north breakwater of Midia Port undertaken after 1977 stopped the supply of the Danube sand to the beaches of Năvodari and Mamaia and caused the chronic beach erosion; the shoreline retreated more than 80 m at the Mamaia Sud area. In order to restore the beach, the Government constructed six detached breakwaters along the isobath of 5 m and nourished the eroded beach with the sediment dredged from the bottom of Lake Siutghiol in 1988 to 1990. The exact quantity of beach fill is unknown because of the absence of any record available. Judging from the comparison of the old bathymetric chart and the present one, a half million cubic meters of fine sand seems to have been placed in situ.

The shoreline recovered its original position by beach fill, but it quickly began to retreat again. Analysis of the periodical shoreline location survey has proved that the shoreline in Mamaia Sud is retreating with the mean rate of 1.9 to 2.3 m per year since 1991 (Fig. 4.2.3 of **4.2** in Volume 1 and Figs. E.2.34 to E.2.36 of Annex **E.2** in Volume 3). The shoreline retreat may represent not a total loss of filled sand but a change of bottom slope toward the equivalent state corresponding to the fine grain size.

In case of the beach at the project site of Eforie Nord, no quantitative assessment is possible because of the lack of data, except for the comparison of the topographic map of 1924 and the satellite images by Ikonos in 2002 as described in **2.2 (2)** of the present volume. The mean rate of shoreline retreat is around 0.6 m per year.

The mean sea level rise will contribute to the future beach erosion. At Mamaia Sud, the mean sea level rise of 2.2 mm per year is translated into the shoreline retreat rate of 0.18 m per year. At Eforie Nord, it becomes 0.15 m per year (see **4.6** of Volume 1).

(2) Alongshore sediment transport rate

A numerical simulation study has been made for evaluation of the sediment transport rate and prediction of future beach morphology. Based on the wave hindcast data, two energy-averaged waves were chosen for the simulation: the northerly waves with $H_{1/3}$ = 1.65 m and $T_{1/3}$ = 6.2 s from the direction of N64ºE and the southerly waves with $H_{1/3}$ = 1.11 m and $T_{1/3}$ = 6.2 s from the direction of N115ºE. Transformations of these representative waves by shoaling, refraction and diffraction from the offshore to the outside of the breaker zone were computed with the directional spectral method. The breaker characteristics were calculated by the significant wave approach. The energy levels of the both representative waves were adjusted every month to reflect the seasonal wave climate and the simulation was repeated every one to three hours for the required length of years up to 20 years. Details of the numerical simulation can be found in Annex **E.6** of Volume 3.

The simulation method was validated through comparison of the past records of shoreline change and the hindcast ones as demonstrated in **4.5.2** of Volume 1. The simulation revealed the alongshore sediment transport along the southern Romanian Black Sea shore. At the project site of Mamaia Sud, the transport rate is high at the openings between the detached breakwaters, amounting to 136,000 m^3 per year in the northward and 118,000 m^3 per year in the southward with the resultant net northward transport rate of 18,000 m^3 per year.

At the project site of Eforie Nord, prediction was made with the assumption of sufficient beach width, because the present situation of no beach and/or existence of seawall at the feet of cliff do not yield a correct information. The sediment transport rate is largest around the northern boundary of the project site; 55,000 m^3 per year in the southward and 51,000 m^3 per year in the northward with the net southward transport rate of 4,000 m^3 per year.

(3) Future beach morphology without any countermeasures

Simulation was further carried out for the future beach morphology in case that no countermeasures against beach erosion are undertaken, as presented in **4.5.3** of Volume 1. The shoreline change model described in **E.6** of Annex E of Volume 3 is employed. The model has been calibrated with the records of the shoreline changes at Mamaia and Eforie as described in **4.5.2** of Volume 1.

At Mamaia Sud, the shoreline retreat in 20 years is estimated as 30 m on the average with the maximum of 40 m. At the project site of Eforie Nord, the shoreline retreat in 20 years is estimated to amount up to 20 m where beach is present or up to the foot of cliff where beach is absent. Reference is made to **4.5.3** of Volume 1 for detail.

(4) Future beach morphology with beach fill and installation of new facilities

Prediction of the future shoreline changes after installation of the proposed shore protection facilities has been made as described in **5.7.4** of Volume 1. The prediction of the shoreline change has been revised with several alternative layouts of shore protection facilities at Mamaia Sud and Eforie Nord to be described in Chapters 3 and 4 of this volume. The predicted results are presented in **3.2** and **4.2** for Mamaia Sud and Eforie Nord, respectively.

2.5 Source of Beach Fill Sand for Mamaia Sud and Eforie Nord

2.5.1 Possible Sources of Beach Fill Sand and Sediment Characteristics

As described in **5.7** of Volume 1, there are four possible sites from where beach fill sand may be mined. They are the seabed around Midia Port, sand bars outside the Sulina Channel, and two areas of the Danube, i.e. Cochirleni at km 305 to km 308 and Oltina at km 338 to km 340. The grain size of the sea sand varies considerably at the sampled locations with a large difference in silt and clay fractions. One site just south of the south breakwater of Midia Port seems to produce the sediment with no silt and clay fractions, and it is selected as a possible site of sea sand mining. Similarly, two sites at Sulina with no silt and clay fractions are selected as the sites of sand mining.

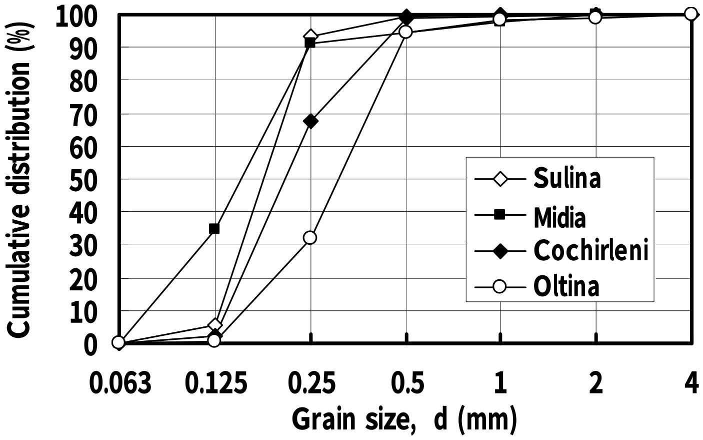


Fig. 2.5.1: Cumulative distributions of grain size of beach fill sand

The river sand at Cochirleni shows less diversity in the grain size characteristics although a few samples taken near the river bank contained some fractions of silt and clay. The mean grain size distribution has been calculated for fifteen samples by excluding two samples containing silt and clay contents and another containing gravel. Among twelve samples taken at Oltina, five samples produced relatively coarse sand, and their grain sizes are used to calculate the mean grain size distribution. Figure 2.5.1 shows the cumulative distributions of sediment grain size at four possible sites of sand mining.

The median diameter of the sand at four possible sources is d_{50} = 0.18, 0.15, 0.22, and 0.33 mm, respectively at Sulina, Midia, Cochirleni, and Oltina. The median diameter of the sea sand as a whole at Sulina and Midia is 0.12 and 0.10 mm. The grain size data of sediment samples are listed in Appendix C of this volume.

2.5.2 Survival Rate of Sea and River Sand at Filled Beach

When sand is imported from an outside source to a beach for artificial nourishment, there is a question of the survival rate such that how much percentage of imported sand could remain on beach without washing away by waves and currents. At a natural beach, sand there has been exposed to waves and currents for a long time and its grain size distribution is regarded to be at a state of equilibrium. When sand of grain size finer than the existing beach sand is placed on beach, most of the imported sand will be lost and do not contribute to formation of beach fill. Therefore, it is important to obtain the outsourcing sand coarser than existing beach sand. If the fill sand has the grain size equal to or smaller than the beach grain size, the survival rate become less than 1. The volume of fill sand needs to be greater than the design volume of beach fill. The ratio of the required sand volume to the design fill volume is hereby called the beach fill augmentation factor.

The median diameter of the beach at Mamaia Sud and Eforie Nord is d_{50} = 0.17 and 0.32 mm, respectively. It is the mean of the sediment samples at the depth of about 1 and 3 m, where beach fill sand will be placed. According to the analysis presented in Appendix D of this volume, the beach fill augmentation factor is calculated as listed in Table 2.5.1.

As demonstrated in Table 2.5.1, the sand from a selected site around the south breakwater of Midia Port can be utilized for beach fill at Mamaia Sud with a 35% increase in the fill volume, but it is impossible to be employed at Eforie Nord because the augmentation factor is so large that more than ten times the design volume of sand is required. The sand from selected sites outside the Sulina Channel can be utilized at both Mamaia Sud but not at Eforie Nord.

Table 2.5.1: Beach fill augmentation factor

Beach fill area	Mamaia Sud				Eforie Nord			
Fill sand source	Sulina	Midia	Cochirleni	Oltina	Sulina	Midia	Cochirleni	Oltina
Augmentation factor	1.05	1.35	1.00	1.00	Over 10	Over 10	2.00	1.07

The river sand from Cochirleni is most suitable for use at Mamaia Sud, but it is too fine to be employed at Eforie Nord. The river sand of coarse grain size such as found around Oltina should be used instead.

In construction work practices, transport of sand is always associated with a certain loss during loading and unloading and other operations. Natural compaction of sand layer will also take place by wave actions after placement of sand on the nearshore area of beach. In consideration of the beach fill augmentation factor and a margin for sand loss, the required sand volume is set with an increase of 20% for the river sand and 40% for the sea sand. Although the augmentation factor is estimated as more than 10 for the case of placing sea sand on Eforie Nord, it is the case without any protective measure. The beach fill area of Eforie Nord is protected by two jetties and three offshore breakwaters, the loss of filled sand by waves and currents will be much smaller than that predicted without protection.

2.5.3 Selection of Beach Fill Sources Based on Preliminary Cost Estimate

(1) Layout of shore protection facilities at Mamaia Sud and Eforie Sud

At the stage of preparation of the overall coastal protection plan described in Volume 1, the shore protection facilities and beach fill have been designed for Mamaia Sud as shown in Fig. 6.3.1 of **6.3** for the case of river sand and in Fig. 6.3.2 for the case of sea sand. During execution of the preliminary design works, more detailed bathymetric information has been obtained. Accordingly, the facilities layout has been revised as shown in Figs. 2.5.2 and 2.5.3, respectively for the cases of river sand and sea sand.

The beach fill area is marked with yellow color for the portion above the mean water level only. In the case of sea sand in Fig. 2.5.3, the submerged dike at the toe of filled area is shown with the dashed line in orange color. The volume of beach fill with sea sand is about 70% greater than that of river sand.

The revised facilities layout at Eforie Nord is shown in Figs. 2.5.4 and 2.5.5, respectively for the cases of river sand and sea sand. The jetty extension and submerged breakwaters have been modified from the previous designs shown in Figs. 6.4.1 and 6.4.2 in **6.4** of Volume 1 after consideration of the newly acquired bathymetric information and comparison among possible alternatives (see **4.2** of this volume).

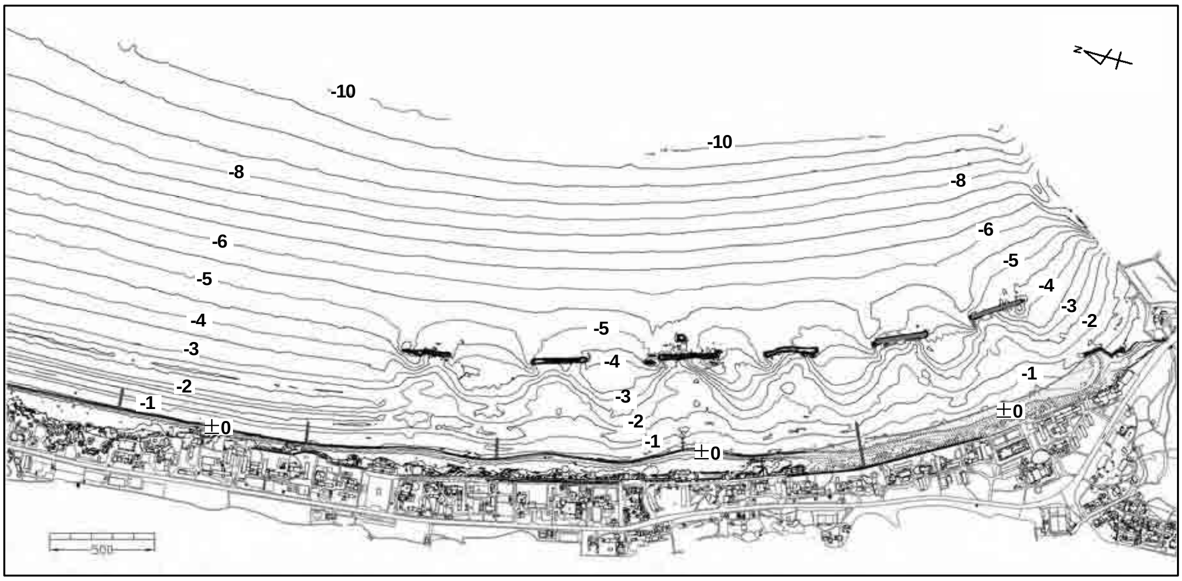


Fig. 2.5.2: Revised facility layout with river sand at Mamaia Sud

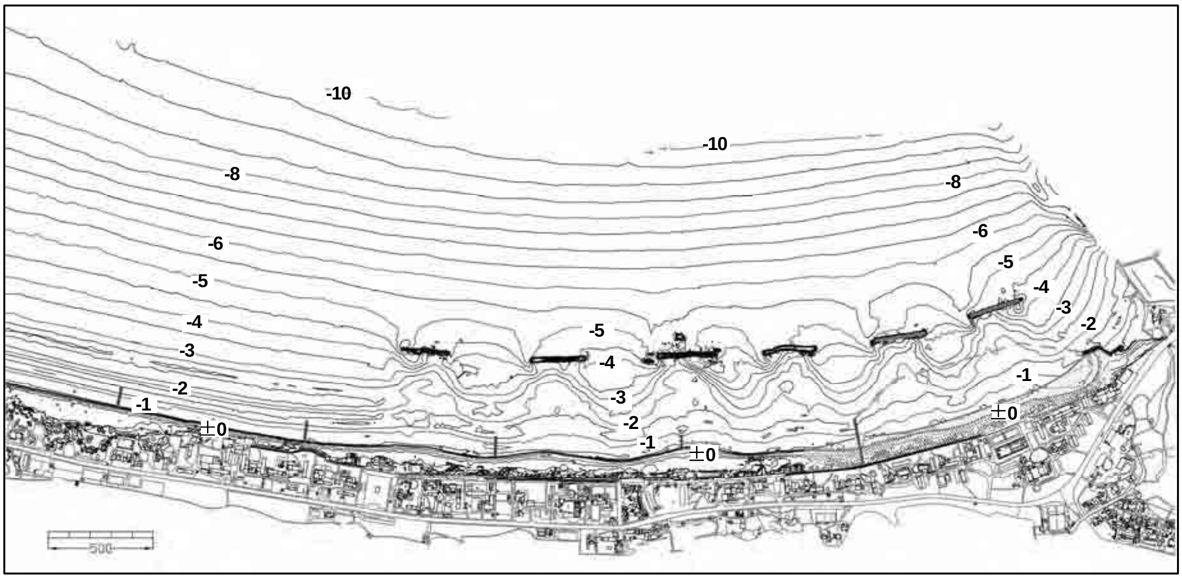


Fig. 2.5.3: Revised facilities layout with sea sand at Mamaia Sud

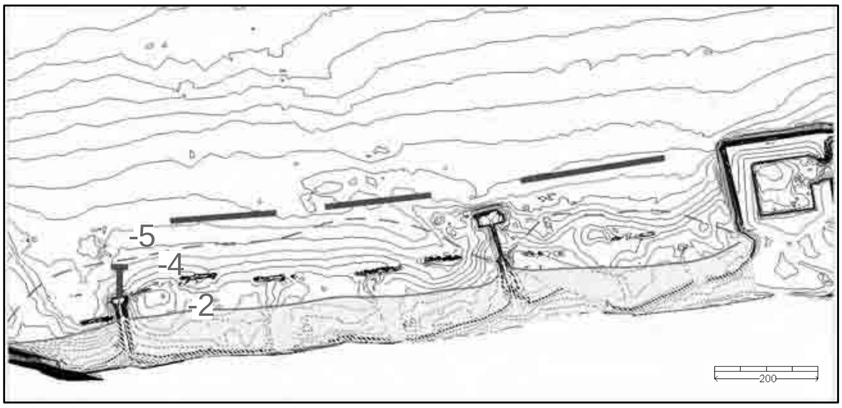


Fig. 2.5.4: Revised facilities layout with river sand at Eforie Nord

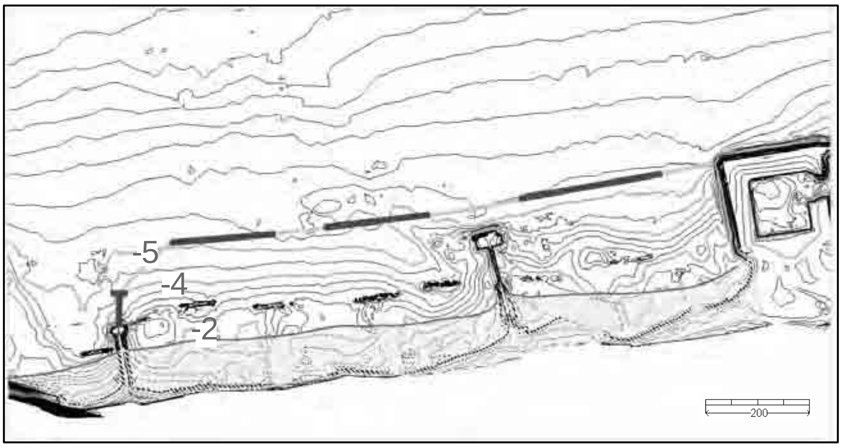


Fig. 2.5.5: Revised facilities layout with sea sand at Eforie Nord

In Fig. 2.5.4 for the case of river sand, the toe position of beach fill is shown with the dashed lines in orange color. For the case of sea sand, the gaps between the submerged breakwaters, the northern jetty and the north breakwater of the marina have to be closed with submerged dikes, because the filled beach has a very gently slope and reaches to the depth of –2 m only.

(3) Volume of beach fill and cost estimate

The estimated volumes of beach fill with the river and sea sand are listed in Table 2.5.2, where the unit price and total cost are also listed.

Table 2.5.2: Beach fill volume and approximate cost

Fill area	Mamaia Sud			Eforie Nord		
Fill sand source	Cochirleni	Midia	Sulina	Oltina	Midia	Sulina
A. Unit price (Euro/m^3)	21.09	23.59	36.75	18.90	31.66	38.13
B. Fill volume (m3)	224,000	379,000	379,000	467,000	906,000	906,000
C. Cost (=A x B) (Million Euro)	4.72	8.94	13.93	8.82	28.68	34.54

Note: Unit price of fill sand is estimated by multiplying the net unit price by the augmentation factor and it includes the overhead cost.

The differences in the unit price of fill sand reflect the method of sand mining and the method and distance of transport. The estimate of the unit price of the sea sand from Sulina is less accurate than other estimates due to uncertainties associated with mobilization of dredgers from their mother ports in foreign countries. Although use of the Midia sand for beach fill at Eforie Nord is unfeasible from the viewpoint of its large beach fill augmentation factor listed in Table 2.5.1, a cost estimate is made here with the factor of 1.4 same as for Mamaia Sud for the purpose of mutual comparison.

(4) Comparison of approximate project cost

The total project cost for the cases using the river and sea sand has been approximately estimated as listed in Table 2.5.3. The cases at Mamaia Sud using the river sand at Cochirleni and the sea sand at Mamaia as well as the case at Eforie Nord using the river sand at Oltina have been elaborated with details of the bills of quantities and the execution schedules as will be introduced in Chapter 3 and 4 of this volume. The cost estimates of the other three cases are approximate ones by using the data of the preliminary design of the former three cases.

The project cost varies considerably depending on the project site and selection of beach fill sand. The cost of the project at Mamaia Sud with the river sand of Cochirleni is estimated as 11.5 million Euro and it increases to 19.0 million Euro (66% up) when the sea sand around Mamaia is used. The cost of the project at Eforie with the river sand of Oltina is estimated as 28.7 million Euro, while the use of the sea sand increases the cost twofold.

Table 2.5.3: Comparison of project costs using the river and sea sand

(units: million Euro)

No.	Beach fill site	Mamaia Sud			Eforie Nord		
	Beach fill sand	River sand at Cochirleni	Sea sand at Midia	Sea sand at Sulina	River sand at Oltina	Sea sand at Midia	Sea sand at Sulina
1)	Beach fill works	4.72	8.94	13.93	8.82	28.68	34.54
2)	Fixed facilities works	4.54	6.80	6.80	15.40	17.62	17.62
3)	Net construction cost	9.26	15.74	20.73	24.22	46.3	52.16
4)	Management and monitoring cost	0.84	0.84	0.84	0.82	0.82	0.82
5)	Engineering Service	0.65	1.10	1.45	1.70	3.24	3.65
6)	Taxes and public charges	0.23	0.39	0.52	0.61	1.16	1.30
7)	Total cost	10.98	18.07	23.54	27.35	51.52	57.94
8)	Contingency	0.55	0.90	1.18	1.37	2.58	2.90
9)	Total project cost	11.53	18.97	24.72	28.72	54.09	60.83

Note: No. 4) The management and monitoring cost is estimated as 7% of the net construction cost
No. 5) The engineering service fee is estimated as 7% of the net construction cost.
No. 6) The taxes and public charges are estimated as 2.5% of the net construction cost.
No. 8) The contingency is estimated as 5% of the total cost in 7).

(5) Selection of beach fill sand sources

The results of the project cost comparison in Table 2.5.3 indicate that the use of sea sand makes the project too expensive beyond a reasonable range of acceptance. The project at Mamaia Sud with the sea sand around Midia might be taken into consideration, because the difference in the amount of project cost is 7.5 million Euro only and it would be better not to discard the possibility of using the sea sand.

Thus, selection is hereby made to use the river sand at Cochirleni and Oltina and the sea sand around Midia Port for beach fill works. The sea sand outside the Sulina Channel requires a high transportation cost and thus it is not selected for the beach fill works.

When the project will be implemented, there should be specifications on the median diameter of the mined sand, because the survival rate of the filled sand largely depends on the relationship between the filled sand and the beach sand. Table 2.5.4 is a tentative specification of sediment characteristics for beach fill sand. Prospective suppliers of the beach fill sand should find appropriate sand quarries satisfying the specification and obtain the exploitation permit from the National Agency for Mineral Resources.

Table 2.5.4: Tentative specification for sediment characteristics of beach fill sand

Project site	Type of sand	Median diameter d_{50} (mm)	Silt fraction
Mamaia Sud	Sea sand	0.12 to 0.16	below 5%
Mamaia Sud	River sand	0.20 to 0.30	0%
Eforie Nord	River sand	0.35 to 0.45	0%

(6) Color and texture of beach fill sand compared with beach sand

There may be an apprehension such that beach visitors dislike the color and touch of externally brought sand for beach fill, compared with the existing beach sand. For clarification of such apprehension, it is necessary to examine the characteristics of the present beach sand. As described in 2.4.4, the present beach sand at Mamaia is composed of terrigenous sand (55%) from the Danube and calcareous sand (45%) by shell fragments. Before the 1960s, the sand at Mamaia beach was very fine (median diameter of around 0.1 mm) and looked grayish. Because the production of bivalve shells increased greatly by immigration of North Atlantic species in the 1970s, the beach sand began to contain an appreciable amount of shell fragments and the median grain size increased to around 0.2 mm with change of color to the present brownish one. The beach sand at Eforie Sud is composed of shell fragments with a small content of limestone fragments. The median diameter is around 0.4 mm and the color is brown.

The sand on the seabed around Midia Port is terrigenous one from the Danube without any content of shell fragments. The median diameter of sand grain is around 0.1 mm as described in 2.5.1; the original beach sand at Mamaia must have been similar with it. The color is grayish because of its small grain size. Beach fill with the sea sand will produce odd feeling of the sand color and texture to beach visitors.

The river sand from Cochirleni or Oltina has the median diameter 0.22 or 0.33 mm. Because of large grain size compared with the sea sand, the river sand has lighter color or brownish one. Absence of shell fragments in the river sand may produce slight strangeness to beach visitors when it is used for beach fill in the beginning. However, the grain size of the river sand is similar as the present beach sand. Also, natural production of bivalve shells will eventually yields shell sand on the filled beach and diminish any difference in color and texture between the filled and original sand.

CHAPTER 3:

DESCRIPTION OF PROJECT COMPONENT “A” AT MAMAIA SUD

Chapter 3 Description of Project Component "A" at Mamaia Sud

3.1 Outline of Project Component "A" at Mamaia Sud

The Project Component "A" at Mamaia Sud is to execute a beach fill of about 5 ha with 224,000 m^3 of the sand taken from the riverbed of the Danube around Cochirleni (km 305), rehabilitating the two existing detached breakwater, constructing a sand-retaining jetty at the northern boundary of the beach fill area and setting three submerged groins in the areas of Mamaia Center and Mamaia North. Bird's-eye views of the present beach and the filled beach after the project implementation are shown in Figs. 3.1.1 and 3.1.2.

Fig. 3.1.1: Bird's-eye view of the beach before project implementation at Mamaia Sud

Fig. 3.1.2: Bird's-eye view of the beach after project implementation at Mamaia Sud

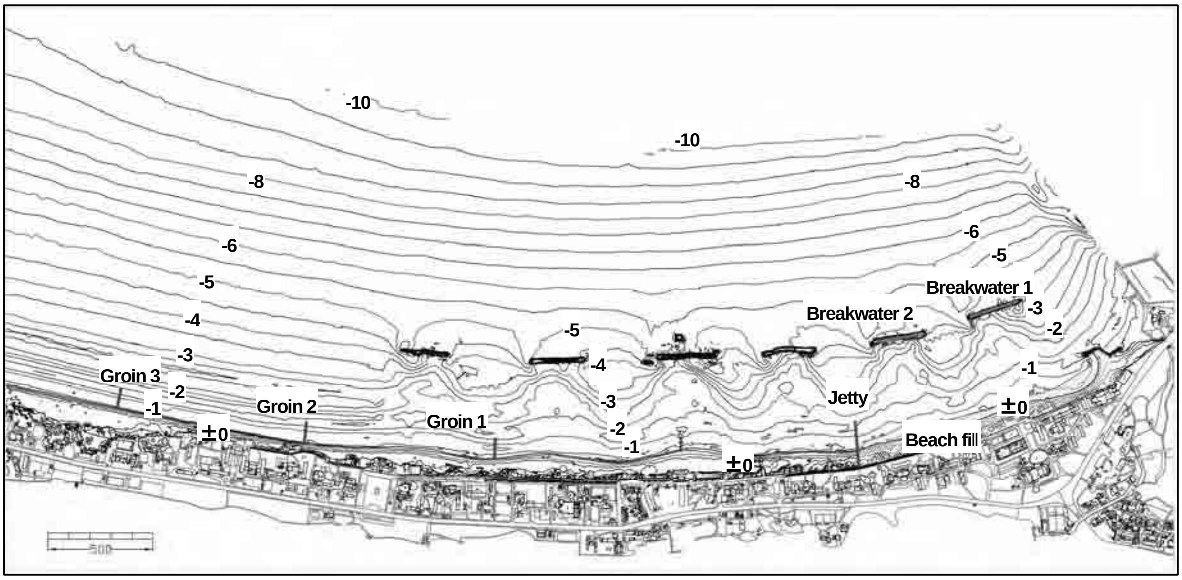


Fig. 3.1.3: Layout of the shore protection facilities around Mamaia Sud

Figure 3.1.3 shows the map of Mamaia Nord to Mamaia Sud with isobaths, indicating the locations of shore protection facilities planned in the proposed project. The three submerged groins are indicated with short red bars in the left-hand side of the diagram, while the sand-retaining jetty is shown with a long red bar in the right-hand side and the beach fill area is marked with yellow color. The two detached breakwaters to be rehabilitated in the right-hand side are marked with red color.

3.2 Alternatives Studied and Main Reasons for Final Choice

3.2.1 Alternative Choices of the Components of Shore Protection Facilities

The shore protection facilities being planned at Mamaia Sud have been determined after considering the following items of component choices:

1) Beach fill with increase of beach area by about 5 ha:
   Choice of river sand or sea sand,
2) Rehabilitation of existing two detached breakwaters:
   Choice of the crest elevation of +2.4 m or +1.0 m,
3) Extension of rehabilitation of existing detached breakwaters:
   Choice of present length of 250 m or extended lengths of 350 m
4) Sand-retaining jetty at the northern boundary of beach fill area:
   Choice of the length of 210 or 120 m (310 or 220 m in case of sea sand),
5) Necessity of additional jetty at the center of beach fill area,
6) An underwater dike of 1,200 m long for the case of beach fill with sea sand:
   No option if the use of sea sand is decided, and
7) Three submerged groins of 100 m long each in the area of Mamaia Center and North:
   No option.

The question of the first choice is the source of beach fill sand whether to use the sand from the riverbed of the Danube or the sand from the seabed in the area around Midia Port. The question concerns with the required volume of beach fill sand, the cost of dredging and transport, the texture of sand felt by the feet of people, and the cost of additional protection facility of underwater dike when the sea sand is used for beach fill. The sand on the seabed around Midia Port is very fine with some silty components. Because of its fine grain size, the equilibrium slope of filled beach becomes very mild such as 1/300, and the required volume becomes 1.7 times that of the river sand.

Beach fill is planned to provide the foreshore width of 100 m measured from the edge of the parapet of the promenade. However, the target shoreline of beach fill is gradually extended offshore at the southernmost zone so that the shoreline will reach at the head of the existing jetty. The fill width varies from 20 to 100 m depending on the condition of the existing foreshore with the mean width of 40 m. The beach area will be increased by 5 ha by fill operation.

The question of the second choice is the crest elevation of the rehabilitated portion of the existing detached breakwaters. Presently, the breakwaters have the crest elevation ranging from +0.5 m to +2.0 m, which represent the legs of stabilopods protruded upward. If the average elevation of the portion above the mean sea level, it would be lower than +1.0 m. A high crest elevation is preferable to reduce the wave overtopping and the height of transmitted waves behind, but it may disturb the ocean view of people visiting the beach of Mamaia Sud and have disadvantage from the aesthetic viewpoint.

The question of the third choice is the lengths of the rehabilitated portions of the detached breakwaters. Presently, the two existing ones have the lengths of 250 m with the opening width of 250 m in between. By extending the breakwaters to the lengths of 350 m and narrowing the opening to 150 m, the wave energy reaching to the beach will be reduced to 36% of the incoming energy from the level of 74% in the present breakwater conditions, while the rehabilitated breakwaters with the length of 250 m will allow 54% of the incoming wave energy to reach to the beach. The rehabilitation cost is increased and the aesthetic view will be deteriorated to some extent. The selection of the rehabilitation length must await for the analysis of alongshore sediment transport and the required volume of maintenance supply of beach sand in future.

The question of the fourth choice is the extent to which the northward sediment transport may be allowed beyond the sand-retaining jetty. Because the beach fill area has a strong tendency of alongshore sediment transport toward the north, the filled sand will be easily moved out of the fill area if no jetty is built at the northern boundary. However, a construction of a long jetty may destroy a beauty of the natural, long shoreline and not be preferable from the aesthetic viewpoint. Shortening of the jetty will diminish the adverse effect, but a certain amount of filled sand will move northward across the jetty and the shoreline of the filled beach will retreat faster than the case of a long jetty. Selection of a long or short jetty should be made with the result of numerical simulation for the future shoreline change after beach fill.

If the alongshore sediment transport across the long jetty is significant and the filled shoreline will retreat beyond an acceptable limit after some years, an additional jetty may need to be built at the center of the beach fill area. This is the fifth choice.

The underwater dike to protect the nourished beach is needed for the case of using the sea sand only. It is not built in the case of using the river sand.

The three submerged groins to be installed with the in-between distance of about 900 m in the areas of Mamaia Center and Mamaia North are intended to slow down the alongshore sediment transport there, by providing artificial resistance to the longshore currents induced by incoming waves. They will be built regardless of the choices of other components and thus they are not given any option.

From the viewpoint of environmental impacts, the above five items of the component choices are mainly concerned with the landscape factor or aesthetic view. Possible impacts on other environmental factors are minimal, and the results of the component choices will not affect them.

3.2.2 Options for Shore Protection Facility Installation Plan

The five items of the choices of the facility components can be combined in various ways. However, under some practical considerations, the eight combinations and one alternative of zero-option are selected here as the alternatives to be examined during the feasibility study. They are listed in Table 3.2.1.

The option A is called as the zero-option, because no facility installation is made. The options B and C are the initial designs introduced in the overall coastal protection and rehabilitation plan. The option D shortens the length of the sand-retaining jetty to reduce the aesthetic impact to the viewers at the northern beach; this option uses the sand from the riverbed. The option E is the case of shortening the jetty length from the option C using the sand from the seabed. In this case, the crest elevation of the rehabilitated portion of the detached breakwater is lowered to +1.0 m from the original plan of +2.4 m. The option F is introduced to examine the effect of lowering the crest elevation of the rehabilitated breakwaters for the case of river sand; a long jetty is the same as the original plan. The option G is a combination of a short jetty and low crest elevation of the rehabilitated breakwater. The option H increases the beach protection capacity of the detached breakwaters by narrowing the opening width by 100 m; use of a short jetty and the low crest elevation of breakwater rehabilitation are the same as the option G. The option I adds a second jetty at the center of beach fill area to the option F.

Table 3.2.1: Options for shore protection facility installation plan at Mamaia Sud

No	Description	Sand source	Beach fill area [a)] (m)	Breakwater rehabilitation		Length of jetty (m)	Underwater dike (m)	Submerged groins
				crest elev.	length (m)			
A	Zero-option	–	–	–	–	–	–	–
B	Initial plan with river sand	riverbed	1200 x 40	+2.4 m	2@250	210	none	three
C	Initial plan with sea sand	seabed	1200 x 40	+2.4 m	2@250	310	1200	three
D	Short jetty with river sand	riverbed	1200 x 40	+2.4 m	2@250	120	none	three
E	Short jetty and low rehab. with sea sand	seabed	1200 x 40	+1.0 m	2@250	220	1200	three
F	Long jetty and low rehab. with river sand	riverbed	1200 x 40	+1.0 m	2@250	210	none	three
G	Short jetty and low rehab. with river sand	ditto	1200 x 40	+1.0 m	2@250	120	none	three
H	Short jetty and narrow opening with river sand	ditto	1200 x 40	+1.0 m	2@350	120	none	three
I	Two jetties and low rehab. with river sand	ditto	1200 x 40	+ 1.0 m	2@250	210 & 120	none	three

Note: [a)] The beach fill width varies depending on the existing condition of foreshore. Beach fill is planned to provide the beach width of 100 m measured from the edge of the promenade with an additional width around the southernmost zone.

Figures 3.2.1 to 3.2.4 shows the shoreline shapes of the options B, E, G, and H in one year after completion of beach fill operations to illustrate the differences among various options. The beach fill is planned with an almost straight shoreline in parallel to the edge of the promenade, but the shoreline undergoes rapid morphological changes due to alongshore sediment transport and takes a wavy shape. The figures are drawn for the beach fill area only without including the areas of Mamaia Center and Mamaia North, in which three submerged groins are to be built; the layout of the three submerged groins are common for all the options.

Isobaths are drawn in 0.5 m intervals up to –5.0m, and the isobaths of –1.0, –2.0, –4.0, and –5.0 m are shown in thin blue lines. The yellow-colored zone indicates the beach fill area above the mean water level. The light-brown dashed line in Fig. 3.2.2 shows the location of the underwater dike to retain the filled sea sand at the offshore side. The dike is designed to be set along the isobath of –2.0 m approximately. The sand-retaining jetty is shown in dark orange color.

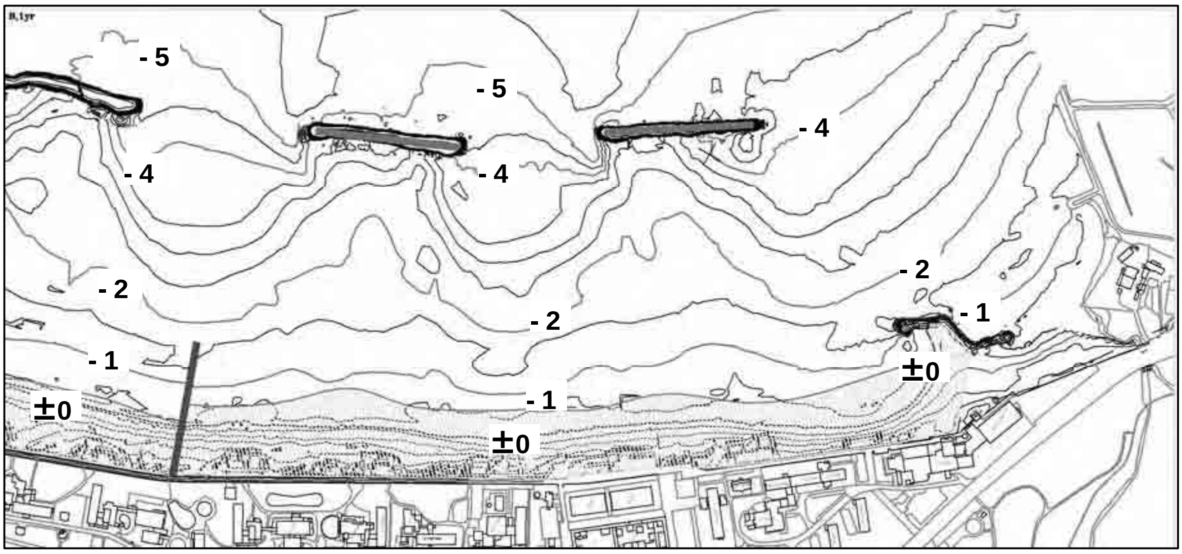


Fig. 3.2.1: Sketch of the option B for shore protection facilities at Mamaia Sud
with the shoreline in one year after the beach fill

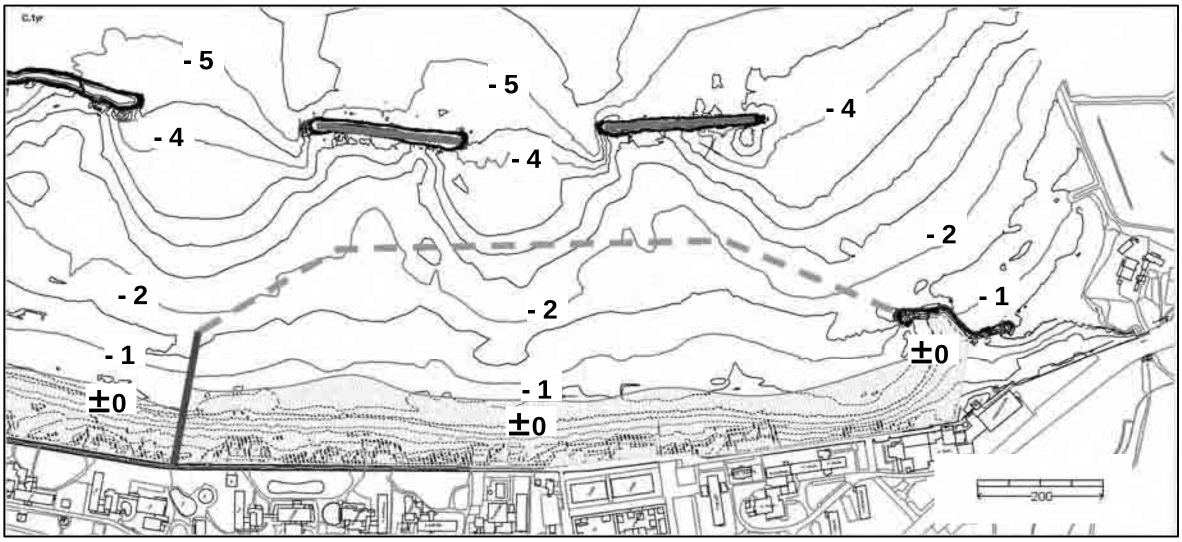


Fig. 3.2.2: Sketch of the option E for shore protection facilities at Mamaia Sud
with the shoreline in one year after the beach fill

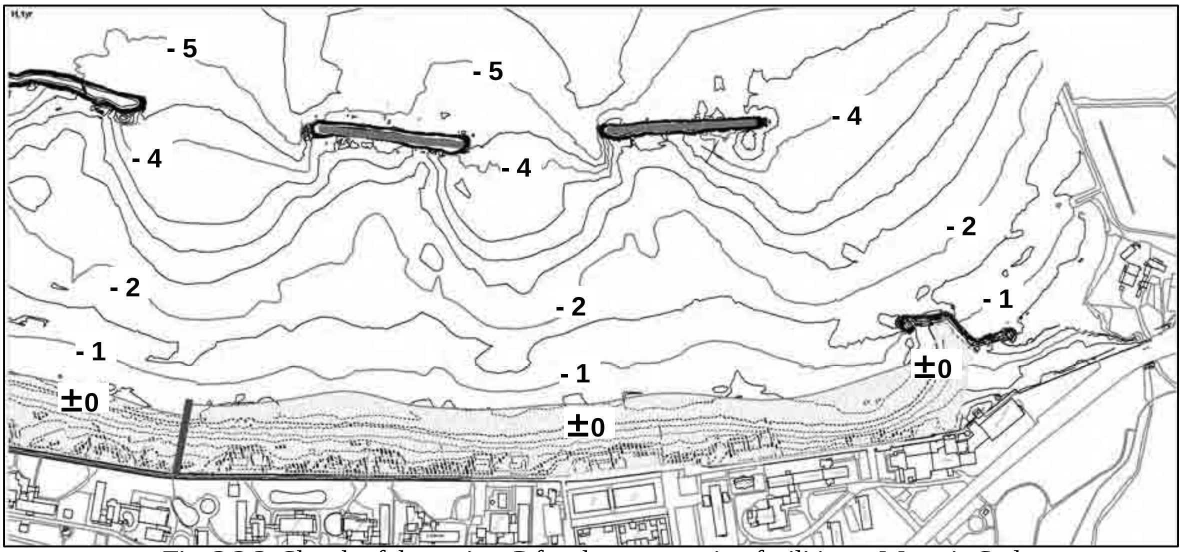


Fig. 3.2.3: Sketch of the option G for shore protection facilities at Mamaia Sud
with the shoreline in one year after the beach fill

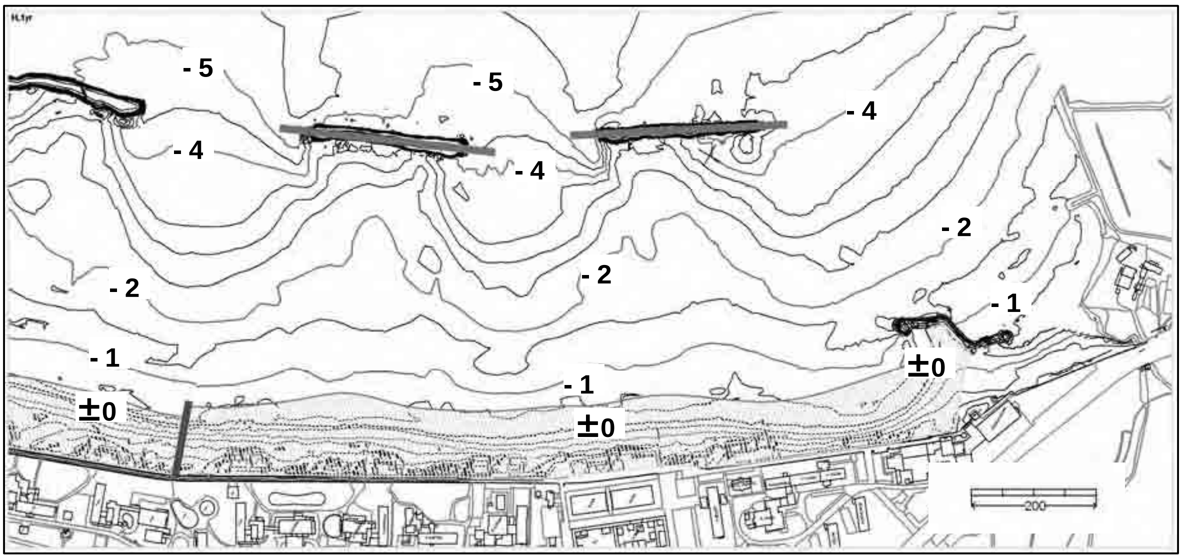


Fig. 3.2.4: Sketch of the option H for shore protection facilities at Mamaia Sud
with the shoreline in one year after the beach fill

3.2.3 Selection of Final Plan for Shore Protection Facilities at Mamaia Sud

(1) Temporal variation of shoreline position after facility installation

All the alternatives listed in Table 3.2.1 have been examined for the future shoreline changes brought out by them. The shoreline position changes have been predicted with the same technique that was employed for prediction of shoreline change without any implementation of coastal protection and rehabilitation projects. The numerical simulation method based on the one-line theory has been briefly introduced in 4.5.1 of Volume 1. The methodology, assumptions employed, computation conditions, and others are described in E.5 and E.6 in Annex E of Volume 3. It should be noted that the simulation is carried out with the assumption that the average wave climate over the past ten years will continue during the project evaluation period.

The option A of "do-nothing" and the other options B to I have different capacity in mitigating future beach erosion. Figures 3.2.5 to 3.2.9 demonstrate the temporal variations of the shoreline positions over the period of twenty years. The baseline is the shoreline reached in February 2006 at the end of the numerical simulation for calibration of the shoreline change model against the records of the past topographic surveys, which is presented in **4.5.3** of Volume 1. The baseline of the shoreline is slightly different from the actual shoreline surveyed recently for the preliminary design of the project at Mamaia Sud. The temporal shoreline position changes are shown at four locations within the beach fill area and one location north of the sand-retaining jetty. The beach fill area extends from the location *x* = 11,600 to 12,800 m. The shoreline positions are the results of numerical simulation with the model employed in the present study. The coordinate *x* is the same as the coordinate of the Constanța Sector employed in **4.5** of Volume 1.

In the option A shown in Fig. 3.2.5, the shoreline retreats greatly in November and December but slightly advances in March, but as a whole it continues to retreat over years and the amount of retreat will exceed 40 m in 20 years. The numerical simulation is made on the assumption of no fixed structures on the landward boundary. In reality, however, the shop buildings such as “Dream Pizza” and “Bavaria Blu Buffet” will be washed away by waves when the beach in front of them disappears.

In the option B with the river sand shown in Fig. 3.2.6, the shoreline at the location *x* = 12,500 m retreat fast at the early stage but the speed of retreat decreases as the time elapses. The sediment removed from this location is transported toward the locations *x* = 11,760 m, where the shoreline shows early advances but later retreat. At the end of a 20-year period, the whole beach area retains a gain of beach width compared with the present one, except for the location around *x* = 12,500 m. Even at this location, the shoreline remains well offshore of the present one, because the beach fill around this area is made to create the beach width of 170 m. The jetty is located at *x* = 11,625 m so that the location *x* = 11,500 m is at the northward of the jetty and experiences alternative shoreline advance and retreat depending on the season.

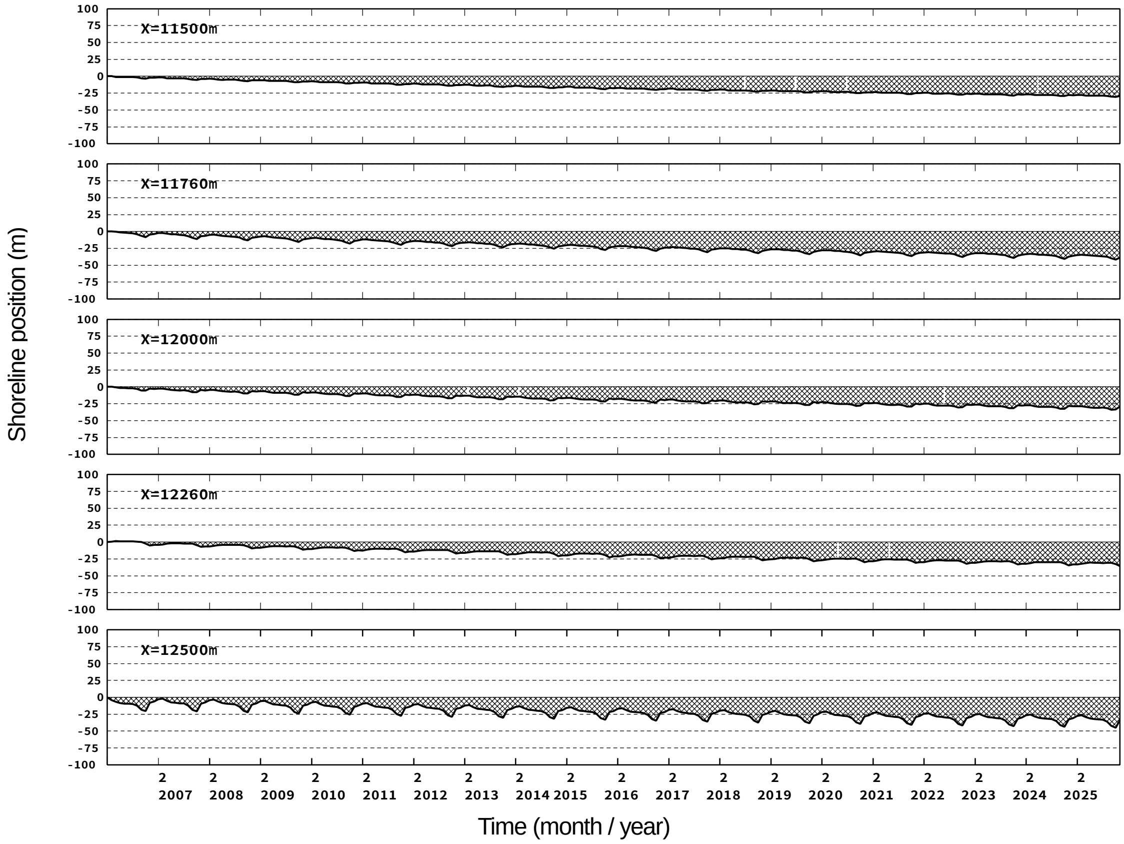


Fig. 3.2.5: Temporal variation of shoreline position in the plan A (zero-option)

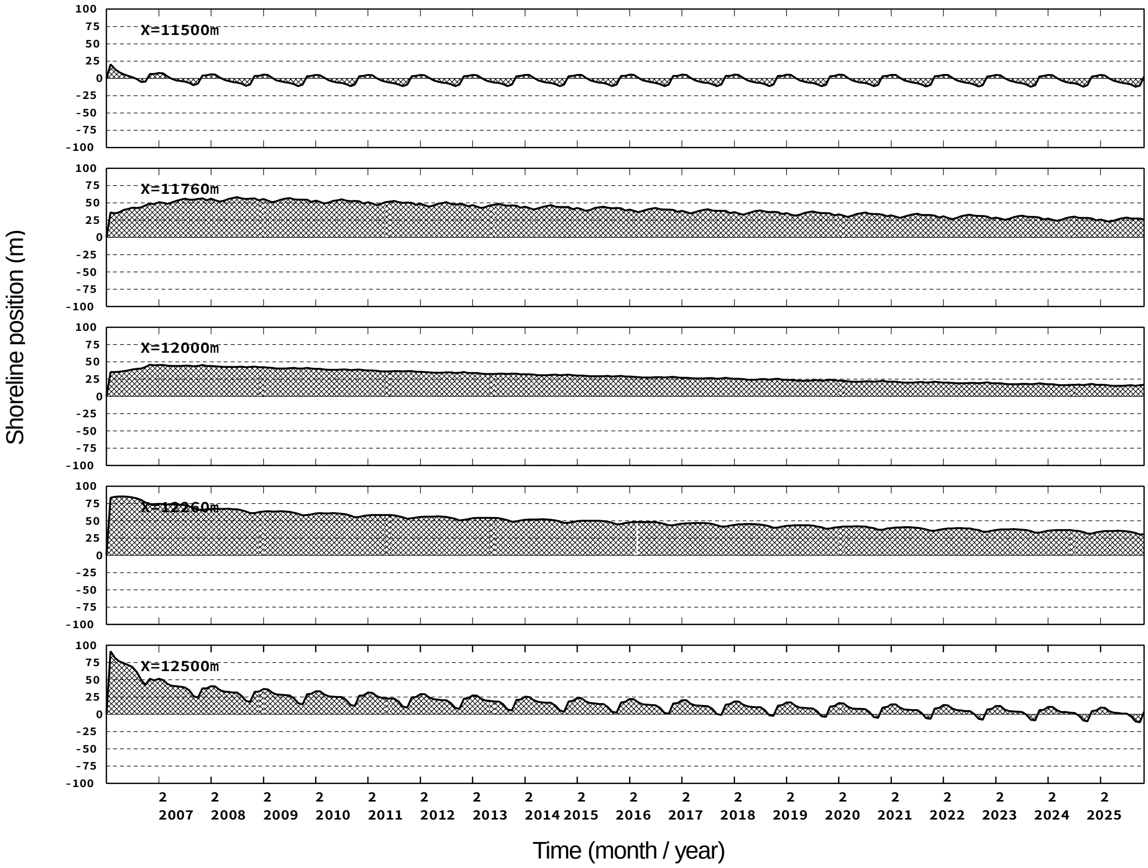


Fig. 3.2.6: Temporal variation of shoreline position in the plan B (long jetty with river sand)

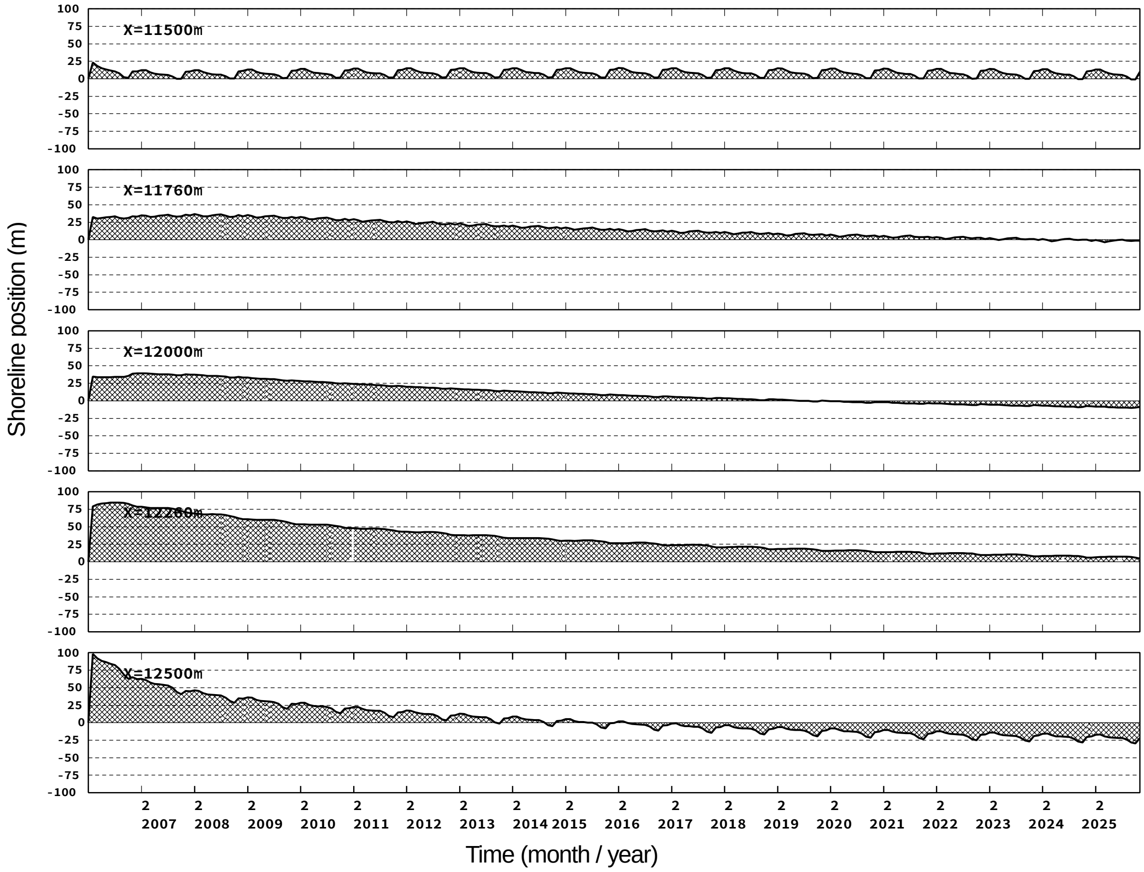


Fig. 3.2.7: Temporal variation of shoreline position in the plan D (short jetty with river sand)

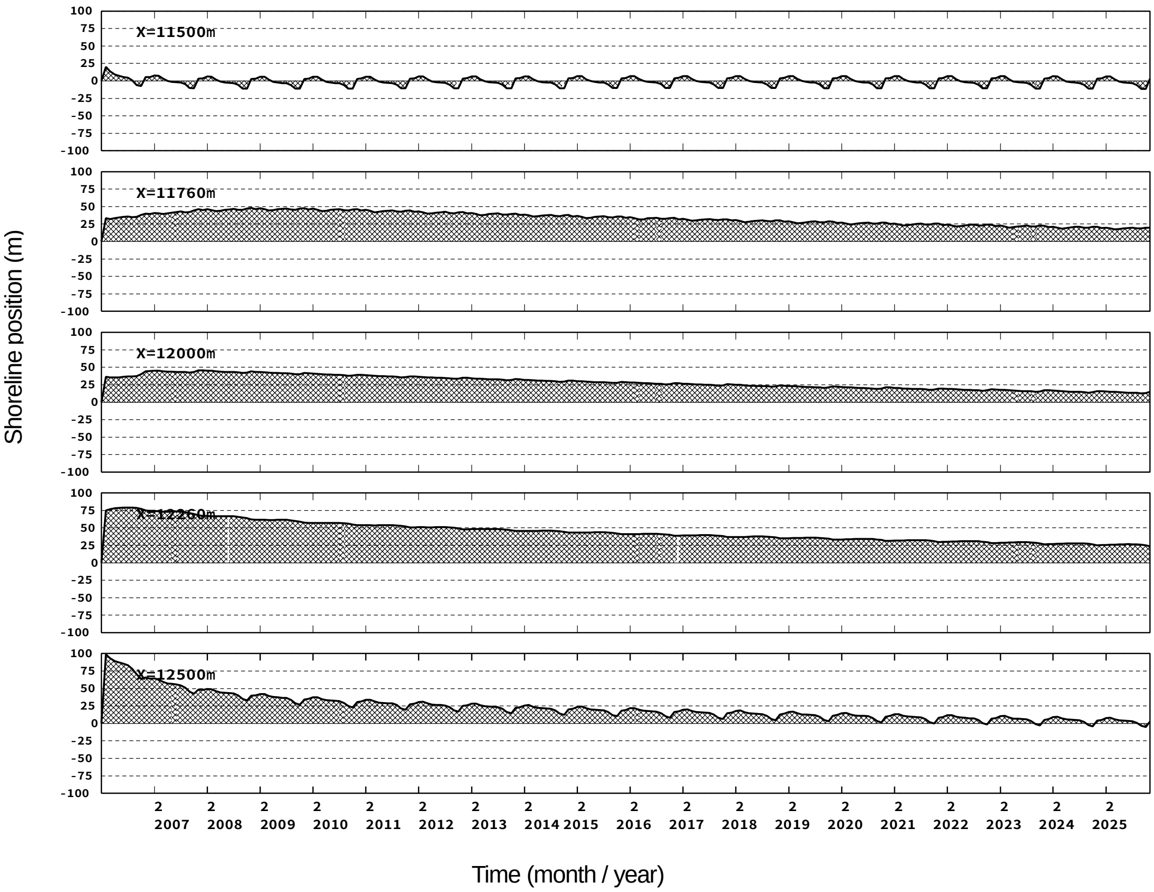


Fig. 3.2.8: Temporal variation of shoreline position in the plan F (long jetty and low crest with river sand)

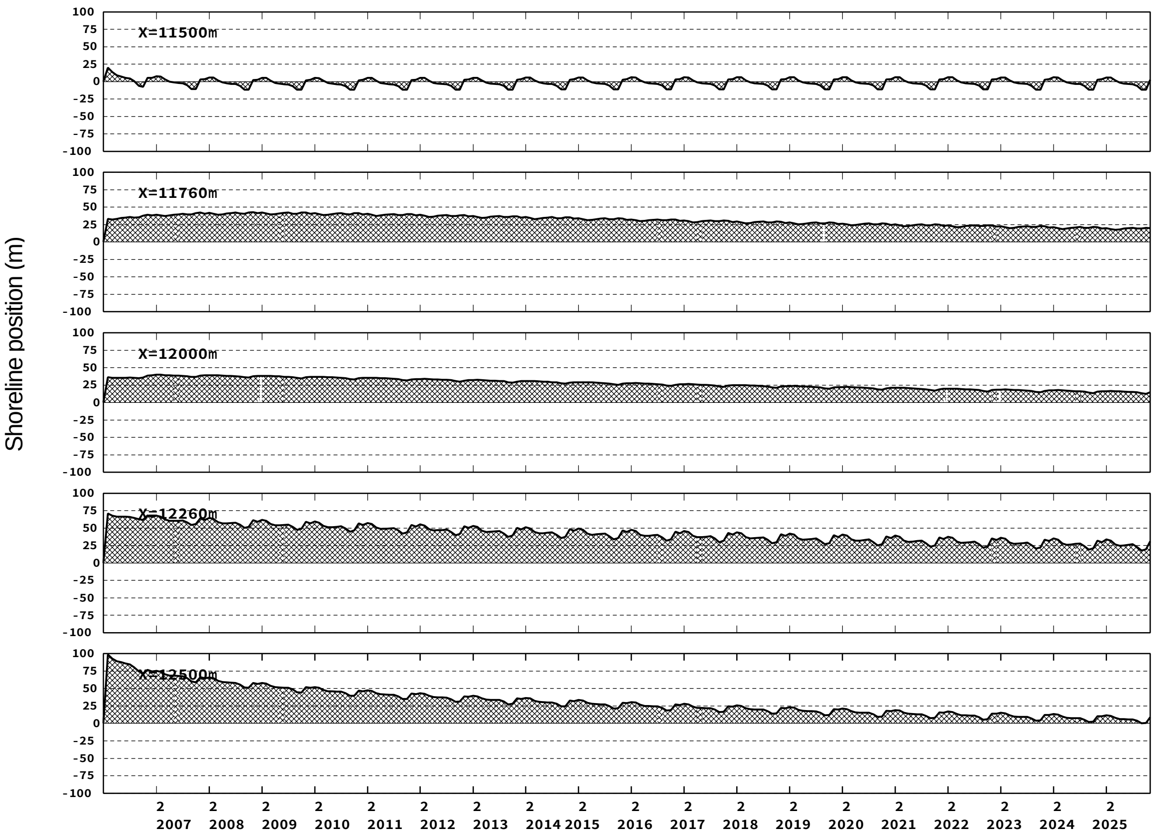


Fig. 3.2.9: Temporal variation of shoreline position in the plan I (two jetties and low crest with river sand)

In the option C with the sea sand, the tendency of shoreline change is almost the same as the option B though it is not shown here. However, seasonal variations of shoreline positions are larger than the option B because of greater mobility of sediment owing to its small grain size.

In the option D with a short jetty using the river sand shown in Fig. 3.2.7, the sand in the beach fill area is easily transported northward beyond the jetty and the location x = 12,500 m loses the filled sand in less than ten years. Thus, the option D cannot be recommended for implementation even though it is less obstructive to the eyes of the viewers at the beach.

In the option E with a jetty of 220 m long using the sea sand, the retreat of shoreline is almost the same as the option C with a jetty of 310 m long using the sea sand. Although the jetty is shortened by 90 m, which is the same as the case of using the river sand (options B and D), the jetty in the option E has the capacity to stop the northward alongshore sediment transport across it.

The option F is a case with lowering of the rehabilitated breakwater crest to +1.0 m from the crest elevation of +2.4 m in the option B. The sand-retaining jetty is set at the same length of 210 m. The wave transmission coefficient, or the ratio of the transmitted height behind the breakwater to the incident height, is estimated as 0.4 instead of 0.2 in the option B; more wave energy is transmitted toward the beach. The temporal variations of the shoreline positions are shown in Fig. 3.2.8. The shoreline retreat is slightly faster than the case of the option B, but the difference is small. It is because the wave energy penetrating through the breakwater gaps is predominant over the energy of waves transmitted over the breakwaters.

In the option G with a jetty of 120 m using the river sand, the crest of the rehabilitated breakwater is lowered to +1.0 m from the condition of +2.4 m of the option D. Similarly with the option D, the option G results in the loss of filled sand in ten years after beach fill around the location x = 12,500 m. The loss of filled sand appears in the whole fill area and the degree of shoreline retreat is slightly greater than the case of the option D.

The option H is an effort to lessen the shoreline retreat by increasing the length of the two detached breakwaters by 100 m each, thus reducing the wave energy causing alongshore sediment transport. The length of the sand-retaining jetty is set at 120 m and the crest elevation of the rehabilitated breakwater is +1.0 m. The shoreline in the area from x = 11,700 to 12,300 m remains beyond the baseline before beach fill, but the shoreline retreat around x = 12,500 m cannot be stopped.

The last option I is to provide an additional short jetty at the location x = 12,310 m in order to mitigate the alongshore sediment transport in the southernmost zone. The results of numerical simulation are shown in Fig. 3.2.9. Compared with the option F shown in Fig. 3.2.8, the shoreline retreat around x = 12,500 m is slightly lessened, but the magnitude of mitigation is only modest. The shoreline at the location x = 12,260 m exhibits appreciable seasonal changes of its position, because it is situated northward of the additional jetty.

The predicted shorelines in twenty years after the beach fill operation are shown in Fig. 3.2.10 to 3.2.12 for the options E, F, and G, respectively. The options E and F maintain the shoreline at the offshore of the present one except for two short stretches behind the southern breakwater, but the option G yields the shoreline being retreated behind the present one over a distance exceeding 1,000 m.

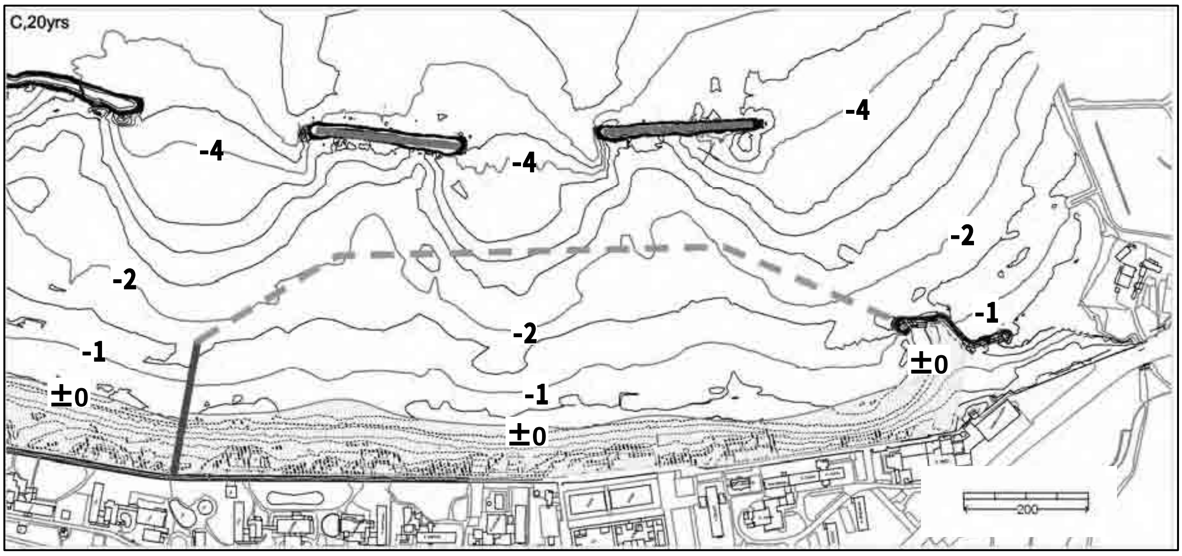


Fig. 3.2.10: Predicted shoreline position in 20 years for the option E

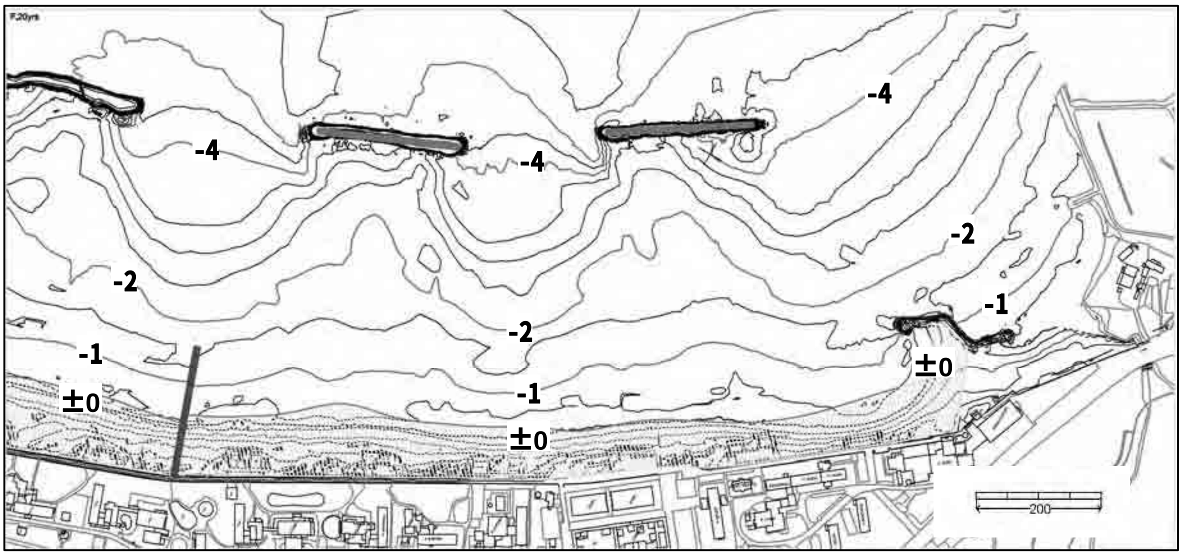


Fig. 3.2.11: Predicted shoreline position in 20 years for the option F

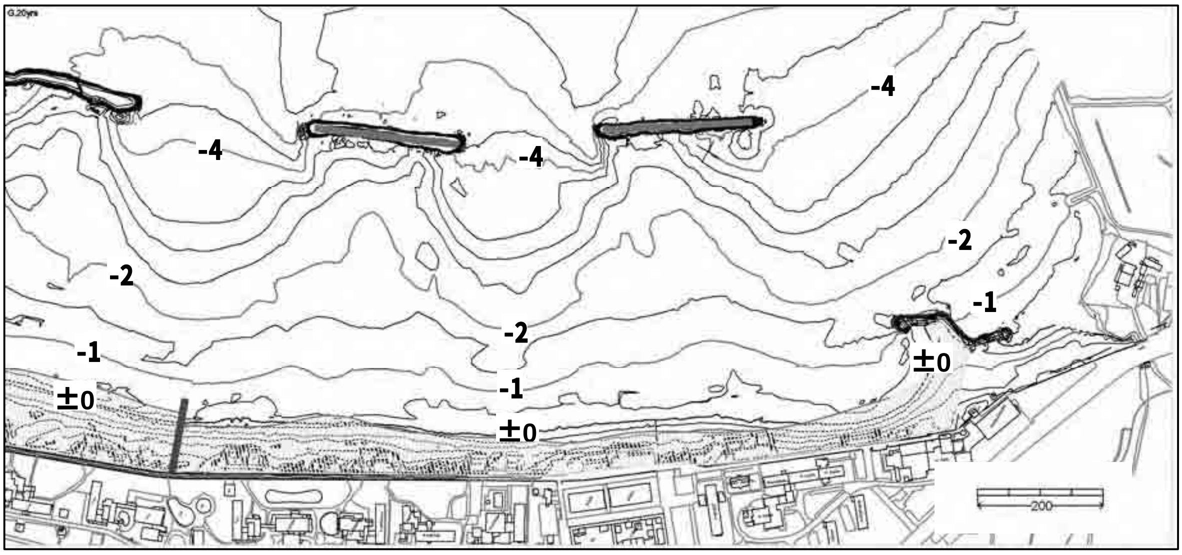


Fig. 3.2.12: Predicted shoreline position in 20 years for the option G

(2) Comparison of shoreline retreat speed among the various options

A quantitative comparison of the shoreline retreat speed is made by estimating the earliest time at which the beach width becomes narrower than the threshold of 75 or 50 m from the edge of the promenade at any location within the beach fill area after the completion of beach fill operation.

As seen in Table 3.2.2, the options B and F with the sand-retaining jetty of 210 m long will maintain the minimum beach width of 75 m for 5.8 to 5.9 years after the beach fill, and the beach will remain wider than 50 m within the period of 20 years. By adding a short jetty at the location x = 12,300 m in the option I, the beach width of 75 m will be maintained for 10.8 years instead of 5.8 years in the case of the option F.

Table 3.2.2: Earliest time of beach width down-crossing the threshold of 75 or 50 m after beach fill

Option	Description	Crest elev. of rehab. breakwater	Length of jetty (m)	Threshold width of 75 m		Threshold width of 50 m	
				Time (year)	Location	Time (year)	Location
B	Initial plan with river sand	+2.4 m	210	5.8	12,460 m	> 20	Not appear
C	Initial plan with sea sand	+2.4 m	310	2.9	12,470 m	> 20	Not appear
D	Short jetty with river sand	+2.4 m	120	3.9	12,440 m	10.9	12,460 m
E	Short jetty and low rehab. with sea sand	+1.0 m	220	2.9	12,470 m	19.9	12,460 m
F	Long jetty and low rehab. with river sand	+1.0 m	210	5.9	12,440 m	> 20	Not appear
G	Short jetty and low rehab. with river sand	+1.0 m	120	3.9	12,440 m	11.8	12,440 m
H	Short jetty and narrow opening with river sand	+1.0 m	120	3.9	12,470 m	11.9	12,460 m
I	Two jetties and low rehab. with river sand	+1.0 m	210 & 120	10.8	12,470 m	> 20	Not appear

In the case of the options C and E using sea sand, the threshold beach width of 75 m will be crossed over in 2.9 years regardless of the jetty length. In the option E, the beach in some location will become narrower than 50 m in 19.9 years. In this sense, the performance of the options using the sea sand is slightly inferior to the options using the river sand.

The options D, G, and H with the short jetty of 120 m long cannot maintain the minimum beach width of 75 m for more than 3.9 years and the beach in some location will become narrower than 50 m in 11 to 12 years. Thus, these options with the short jetty are judged not to have enough capacity for mitigating beach erosion in the Mamaia Sud area.

All the numerical results indicate the critical zone being located around x = 12,420 to 12,480 m, which corresponds to the gap between the southernmost detached breakwater B-1 and the existing jetty in front of Hotel Parc. Because the southerly waves penetrate into this gap without much attenuation while the northerly waves are damped by the detached breakwaters, the beach here is subject to an intensive northward sediment transport and the rate of beach erosion is large.

(3) Optimal facility installation plan at Mamaia Sud

The beach-retaining capacity of the nine options including the plan A of "do-nothing" have been compared hereinabove. Table 3.2.3 summarizes the results of comparison and evaluation of the merits of various options. The grade A is the best and the grade F indicates failure.

Table 3.2.3: Comparison of the options examined and evaluation of their merits for Mamaia Sud

No	Description	Sand source	Breakwater crest elevation	Jetty length (m)	Remarks	Evaluat-ion
A	Zero-option	–	–	–	Excessive erosion occurs with large economical loss.	F
B	Initial plan	river	+2.4 m	210	Good protection capacity, but obstructive view from beach	B
C	Initial plan	sea	+2.4 m	310	Good protection capacity, but too costly	C
D	Short jetty	river	+2.4 m	120	Inferior beach protection capacity and need of early sand supply	D
E	Short jetty and low rehab.	sea	+1.0 m	220	Good protection capacity, but too costly	C
F	Long jetty and low rehab.	river	+1.0 m	210	Good protection capacity, with less obstructive view from beach	A
G	Short jetty and low rehab.	ditto	+1.0 m	120	Inferior beach protection capacity and need of early sand supply	D
H	Short jetty and narrow opening	ditto	+1.0 m	120	ditto	D
I	Two jetties and low rehab.	ditto	+ 1.0 m	210 & 120	Good protection capacity, but additional cost incurred	B'

The "zero-option" A cannot be accepted because the beach erosion at Mamaia Sud will continue with the speed of about 2 m per year and cause a large economical loss on the property and tourist industry.

The options D, G, and H with a sand-retaining jetty of 120 m long cannot maintain the minimum beach width of 50 m in 11 to 12 years after the project implementation. They will require additional supply of sand on the beach in early stage. Thus, the maintenance cost becomes large.

The options C and E use the sea sand for beach fill. The option E with a sand-retaining jetty of 220 m long has a beach protection capacity only slightly inferior to the option C with the jetty length of 310 m. The option E has the crest of the rehabilitated portion of the detached breakwaters at the elevation of +1.0 m above the datum, while the option C has the crest elevation of +2.4 m. The ocean view from the beach is less obstructive in the case of the option E than the option C. Thus the option E is adopted as the candidate plan for the case using the sea sand. Even though the construction cost of the option E will be much higher than the option using the river sand, a preliminary design is carried out as will be described in **3.4** of this volume.

The options B, F, and I using the river sand are equipped with the sand-retaining jetty of 210 m long. They provide a good beach protection with almost the same performance. The option B has the crest elevation of +2.4 m for the rehabilitated breakwaters, while the options F and I have the elevation of +1.0 m. Form the aesthetic viewpoint, the options F and I are more favorable than the option B. Between the options F and I, improvement of the beach protection capacity of the option I over the option F is only slight and does not seem to justify the increase in the construction cost for an additional short jetty. Therefore, the option F is selected as the optimum plan for the coastal protection and rehabilitation works at Mamaia Sud.

In the preliminary design for the shore protection facilities at Mamaia Sud based on the option F, additional construction of three supplementary submerged groins of 70 m long each are planned at the locations around x = 12,000, 12,100, and 12,400 m as a means to enhance the beach protection capacity, although the quantitative evaluation has not been carried out.

3.3 Project Component "A" Using River Sand

3.3.1 Structural Components and Their Layout

(1) General

The project component "A" at Mamaia Sud using the river sand of the Danube for beach fill is composed of the following works and facilities:

1) Beach fill works with the sand volume of 224,000 m^3,
2) Rehabilitation of two existing detached breakwaters (250 m long each),
3) Construction of one sand-retaining jetty (200 m long),
4) Construction of three submerged groins (100 m long each),
5) Construction of three supplementary submerged groins (70 m long each), and
6) Construction and removal of a temporary access road.

The layout of the above facilities is shown in Figs. 3.3.1 (1) and (2).

(2) Beach fill works

The beach fill is planned with the shoreline width of about100 m from the promenade over the distance of 1,200 m as shown in Fig. 3.3.2. At the southern end, the beach width is increased to be joined with the existing small jetty. At the northern end, the beach fill is extended beyond the sand-retaining jetty so as to provide a smooth transition toward the northern side of the beach.

As discussed in **E.7.3** of Annex E in Volume 3, the backshore portion of the beach fill is set horizontal at the elevation of DL+2.3 m. Then at the location of about 100 m from the promenade, it descends with the gradient of 1/20 toward the elevation of DL±0.0 m or the shoreline. In the inshore zone below the shoreline, the beach fill is given the gradient of 1/60 until the slope meets with the existing seabed. The dashed lines in orange color indicate the toe position of the new nearshore slope by beach fill. Figure 3.3.3 at the end of this sub-section shows typical profiles of the filled beach.

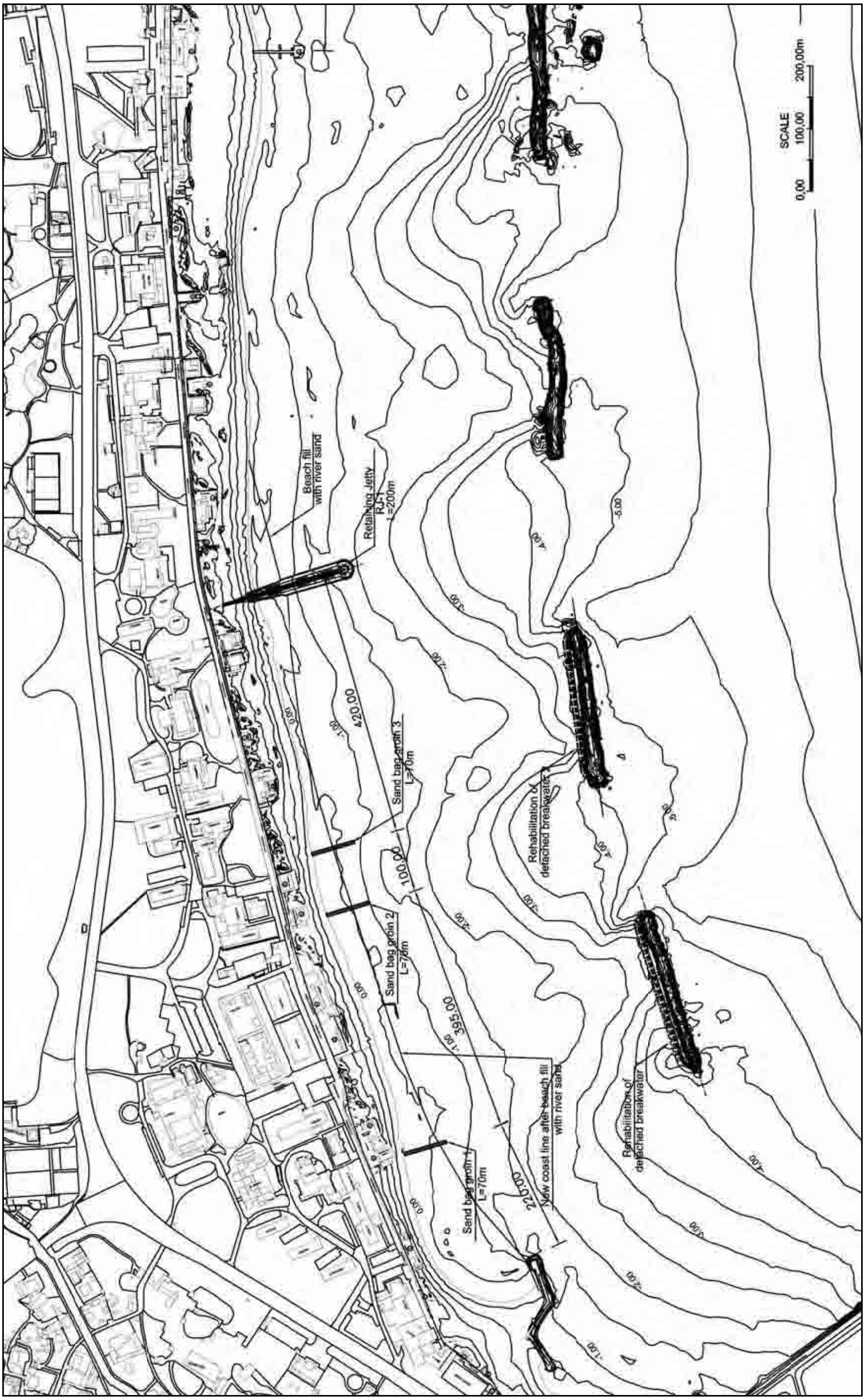


Fig. 3.3.1 (1): General layout of shore protection facilities at Mamaia Sud with river sand (southern part)

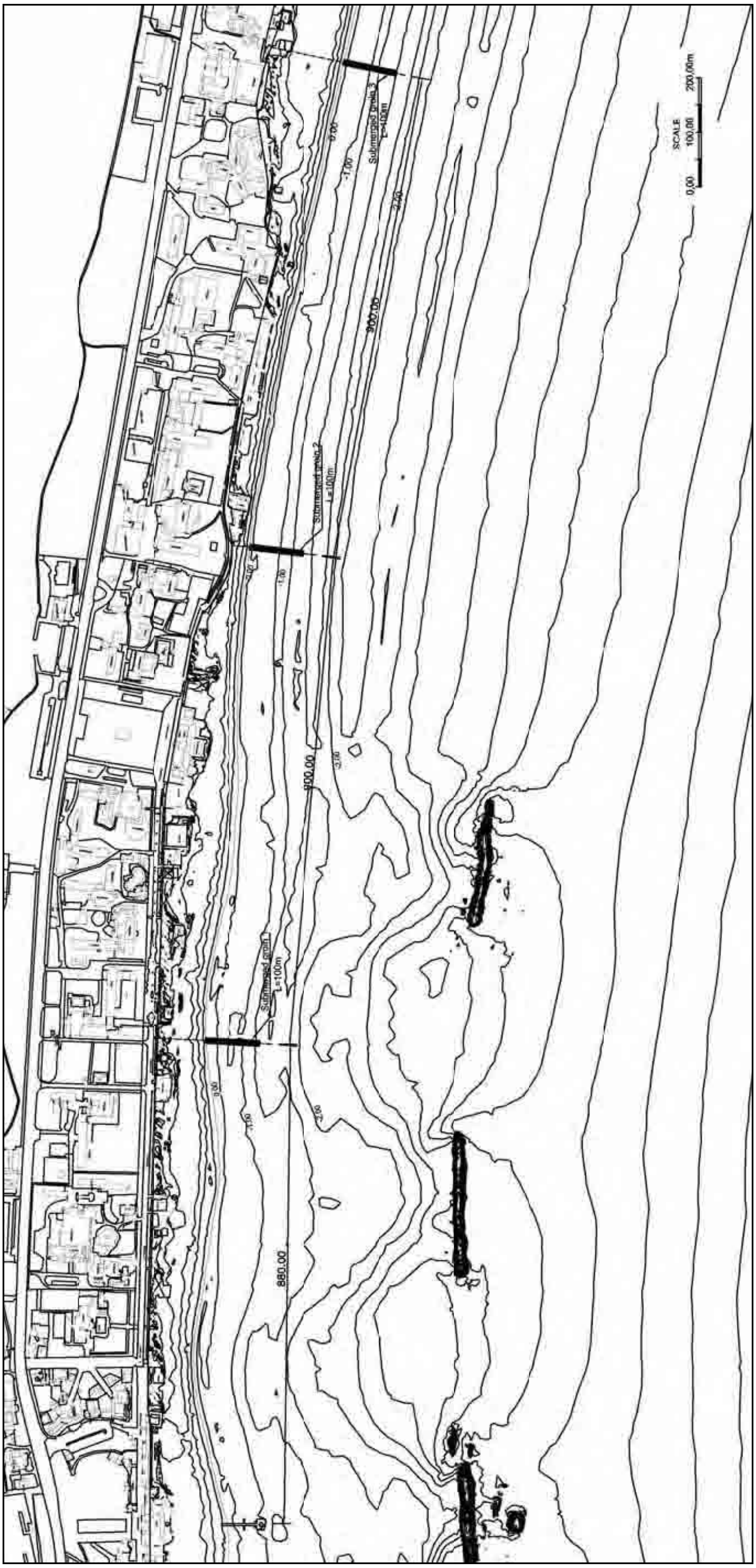


Fig. 3.3.1 (2): General layout of shore protection facilities at Mamaia Sud with river sand (northern part)

The filled beach is expected to maintain a minimum width of 50 m for 20 years, according to the results of the numerical simulation of future shoreline change discussed in **3.2.3** of this volume.

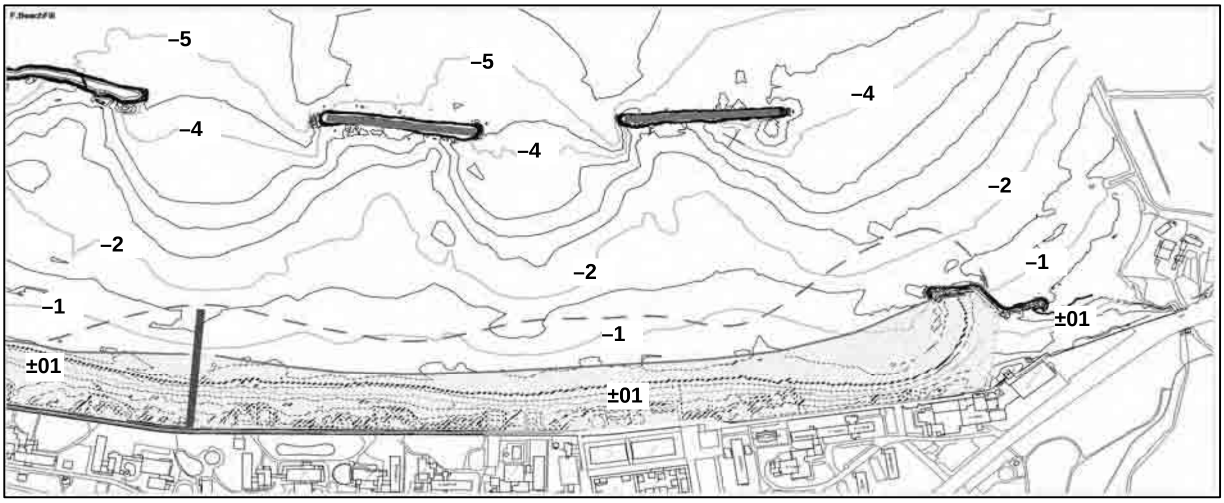


Fig. 3.3.2: Area of beach fill with river sand at Mamaia Sud

(3) Rehabilitation of existing detached breakwaters

Two existing detached breakwaters, which were built between 1988 and 1990 and have been deteriorated by wave actions, are rehabilitated by being provided with rubble mounds at their onshore sides and 4.5-ton stabilopods. Figure 3.3.4 shows the area of rehabilitation for the breakwater No. 1, which is located at the southern side. A typical cross section of breakwater rehabilitation is shown in Fig. 3.3.5. (Figs. 3.3.4 to 3.3.10 are listed at the end of this sub-section.)

The rubble mound is built with stones of 10 to 200 kg in weight up to the elevation of DL–2.4 m. It will be protected with armor stones of 0.5 to 1.0 t for a thickness of 1.5 m. A sheet of geotextile with the weight of 1000 g/m^2 is spread below the rubble and armor stones. Stabilopods are placed in two layers. The rehabilitated breakwater will have the crest width of 20 m at the mean sea level.

The quantities of materials for rehabilitation of the two detached breakwaters are estimated as follows:

- Rubble stones: 3,708 m^3
- Stone blocks 0.5 to 1.0 t: 11,206 m^3
- Geotextile: 6,666 m^2
- Stabilopods: 2,808 pieces

(4) Sand-retaining jetty

A rubble mound jetty of 200 m long is built at the location of 1200 m from the southern end of the project area to mitigate the northward alongshore transport of the filled sand. The base of the jetty is 10 m away from the promenade and the head of the jetty is 210 away from the promenade. The general layout of the sand-retaining jetty is shown in Fig. 3.3.6 and longitudinal section is shown in Fig. 3.3.7. The cross sections at five locations of the jetty are shown in Fig. 3.3.8. Its extension length has been discussed in **E.7.4** of Annex E of Volume 3.

The crest elevation at the backshore is set at DL+2.5 m, which is higher than the beach fill by 0.2 m. The crest of the jetty is provided with a walkway of 3 m wide made with cast-in-situ concrete of 0.5 m thick so that people can enjoy walking over it. The elevation of the walkway is DL+2.5 m for the inner 80 m from its base, then gradually descends to DL +1.5 m, and remains so for the outer 80 m.

The core of jetty is built with rubble stones of 50 to 200 kg in weight with the crest of DL+ 1.0 m. The side slopes are armored with stone blocks of 200 to 700 kg. The round head portion of the jetty is protected with two layers of 4.5-ton stabilopods. The armored head portion has the crest elevation at DL + 3.35 m.

The quantities of materials for construction of the sand-retaining jetty are estimated as follows:

- Crushed stones:	319 m^3
- Stone blocks of 300 to 700 kg:	3,617 m^3
- Rubble stones of 50 to 200 kg:	5,557 m^3
- Concrete:	303 m^3
- Stabilopods of 4.5 ton:	296 pieces
- Geotextile:	4,822 m^2
- Sand excavation:	127 m^3

(5) Submerged groins

Three submerged groins with the length of 100 m each are built in the area of Mamaia Center and North. They are given the function of decreasing the longshore currents induced by breaking waves. They are expected not to stop the alongshore sediment transport completely but to slow down the transport rate.

As shown in Fig. 3.3.8, they will be constructed by placing two layers of sand-filled geotextile bags (2.0 m x 2.0 m x 0.7 m) and their crests are set at DL–0.5 m. The geotextile bags are made of vinylchloride cloth and covered with polyester meshed nets. Three bags are placed as the lower layer and two bags are on the top layer. Placement of sand bags is made on the trench dug to the elevation of DL–1.9 m. In the shallow inshore zone, the trench is dug to the elevation of DL–1.2 m and one layer of three sand bags are place. Sand bag groins will be extended offshore from the beach with a mobile crane, which move on a temporary stone layer on top of sand bags; the rubble stones will be taken out from the offshore end after completion of the groin.

The quantities of materials for construction of the three submerged groins are estimated as follows:

- Number of geotextile sand bags:	444 pieces
- Sand excavation:	1,534 m^3
- Rubble stones:	1,764 m^3

(6) Supplementary submerged groins

Under the beach fill, three supplementary groins are to be built as the precautionary facilities to slow down the progress of the retreat of filled beach. As shown in Fig. 3.2.11, the numerical simulation for shoreline change yields a prediction that two narrow stretches of areas behind the breakwater B-1 may experience a shoreline retreat behind the present location in 20 years. When the filled beach will have significant retreat in future and the filled sand over the submerged groins will be washed out, then the submerged supplementary groins will function to reduce the alongshore sediment transport and the rate of beach retreat around them.

The supplementary submerged groins are constructed with five layers of small sand bags as shown in Fig. 3.3.9. Empty polypropylen bags with the size of 2.65 m by 1.30 m are filled with sand and they are given the thickness of 0.3 m. The sand bags are placed on the trench of 1.0 m deep below the existing seabed. Their crest elevation vary from DL+0.50 m to DL–0.45 m depending on the elevation of the existing seabed conditions, but they are all buried under the filled beach.

The quantities of materials for construction of the three supplementary submerged groins are estimated as follows:

- Number of polypropylene sand bags: 1,545 pieces
- Sand excavation: 3,208 m^3
- Rubble stones: 471 m^3

(7) Temporary access road

Beach fill works and construction of the sand-retaining jetty can be executed from land side by transporting construction materials from the southern end of Mamaia Beach. A temporary road will be made on the beach from the area of Hotel Parc, by placing gravel and rubble stones. After completion of the works, gravel and stones will be removed.

For the execution of three submerged groins at Mamaia Center and North, existing streets transversal to the beach from the main road will be used. After completion of these groins, these streets will be rehabilitated.

The quantities of materials for constructing the temporary access road are estimated as follows:

- Rehabilitation of existing roads: 4,970 m^2
- Rubble stone for road from land side: 3,686 m^3

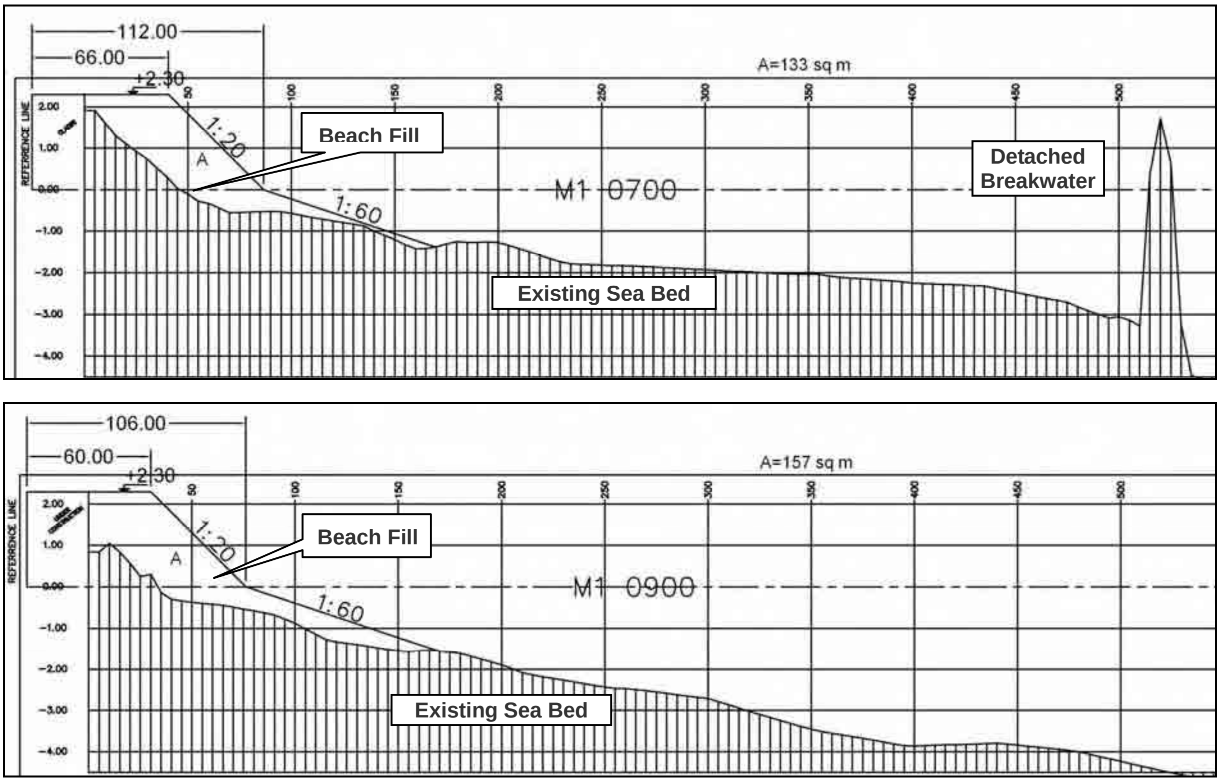


Fig. 3.3.3: Examples of beach fill profile (M1-0700 and M1-0900 are the locations at the distances of 700 and 900 m from the southern baseline)

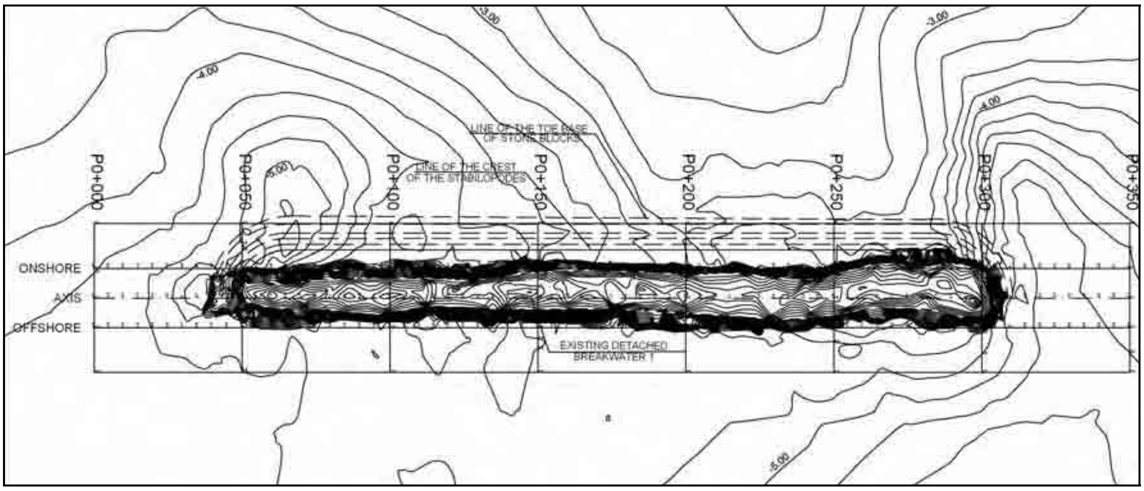


Fig. 3.3.4: Plan of breakwater rehabilitation

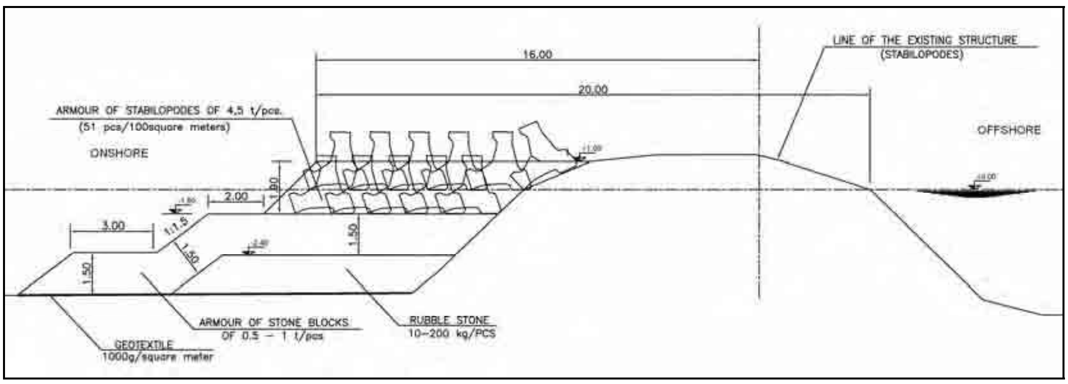


Fig. 3.3.5: Typical cross-section breakwater rehabilitation

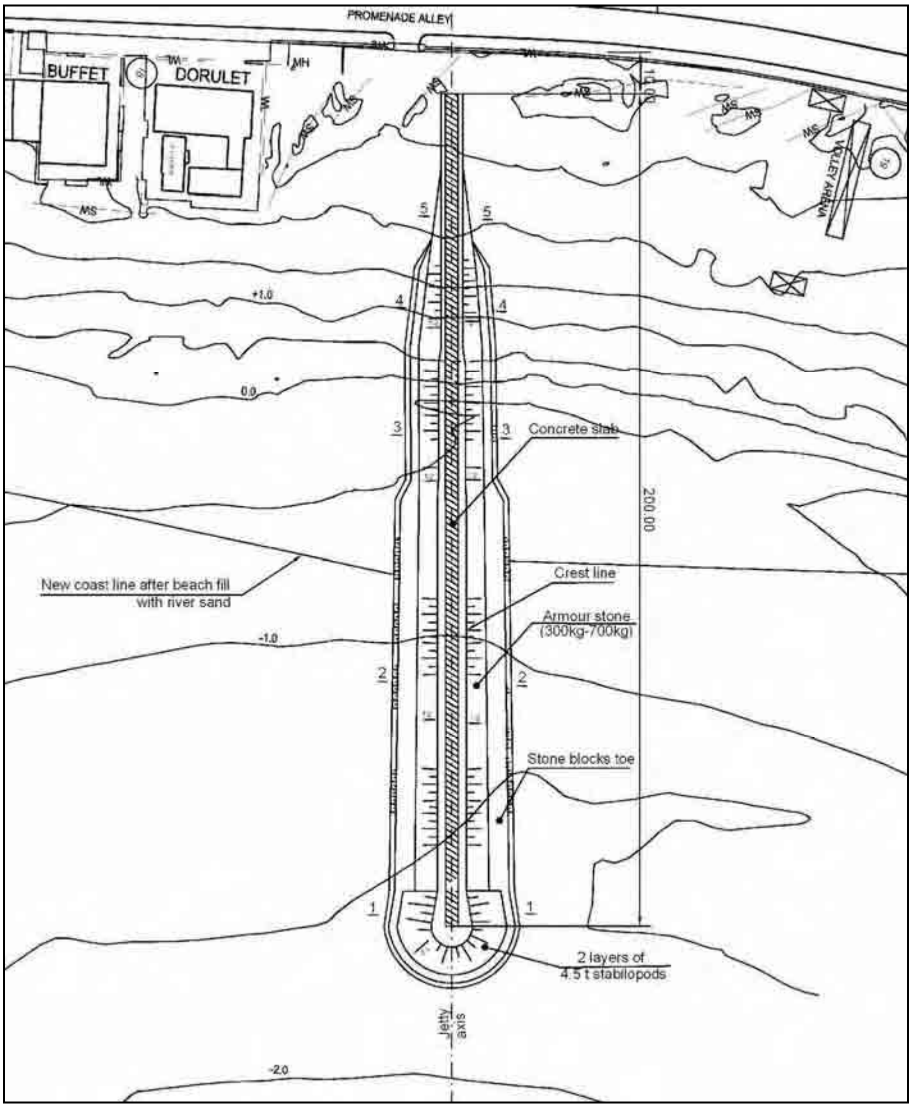


Fig. 3.3.6: Plan shape of sand-retaining jetty

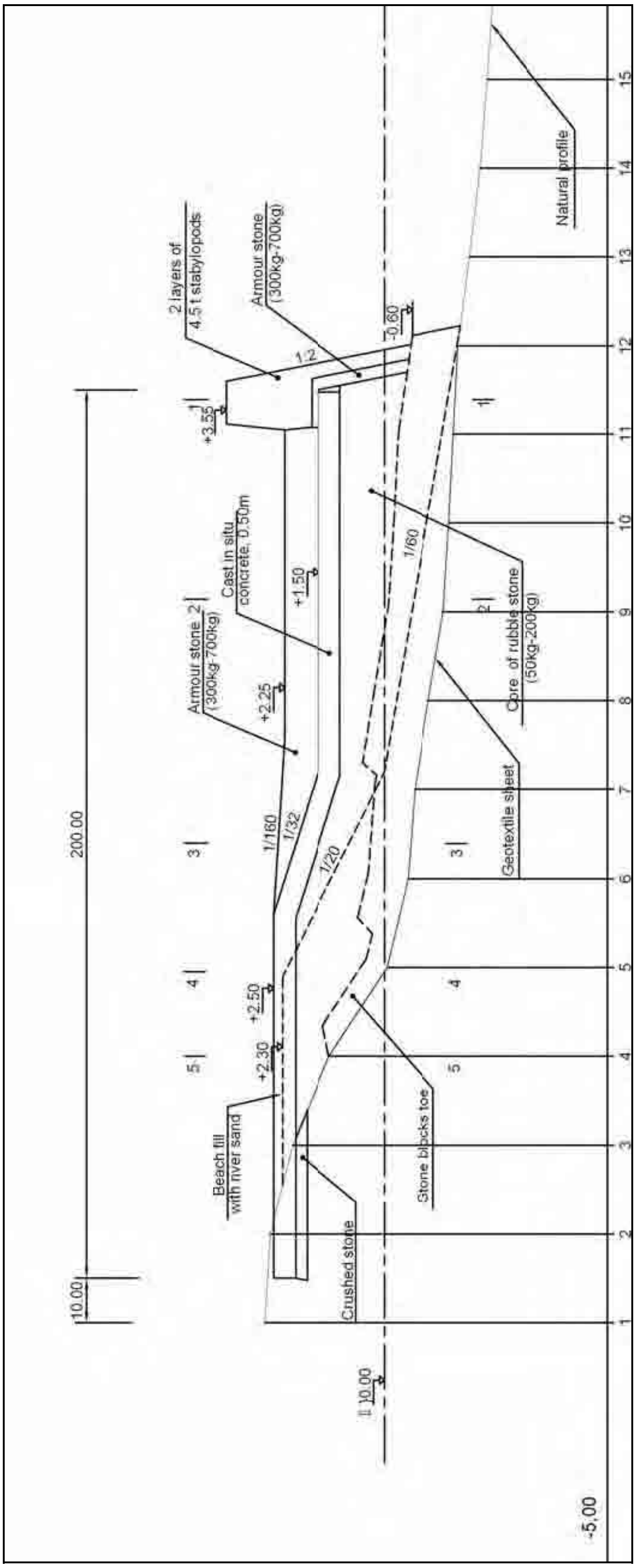


Fig. 3.3.7: Longitudinal section of sand-retaining jetty (the numbers at the bottom are arranged with the equal distance of 20 m)

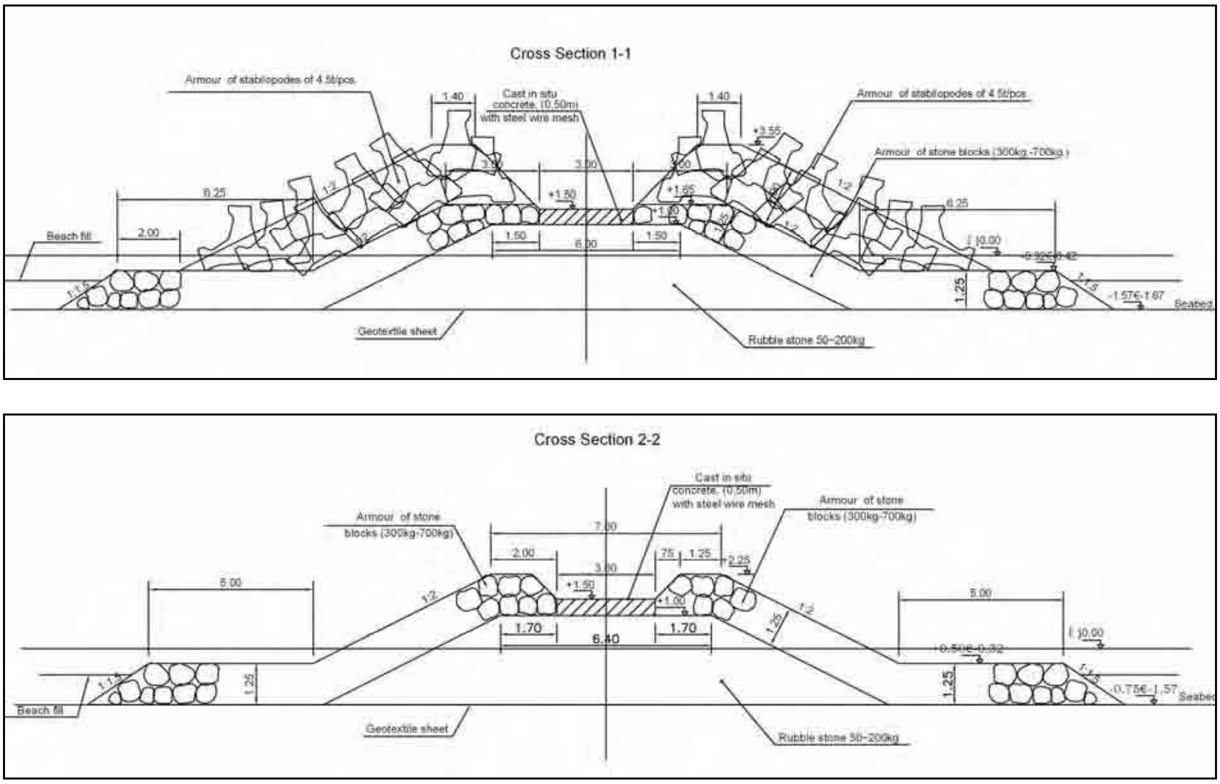


Fig. 3.3.8 (1): Cross sections 1-1 and 2-2 of sand-retaining jetty

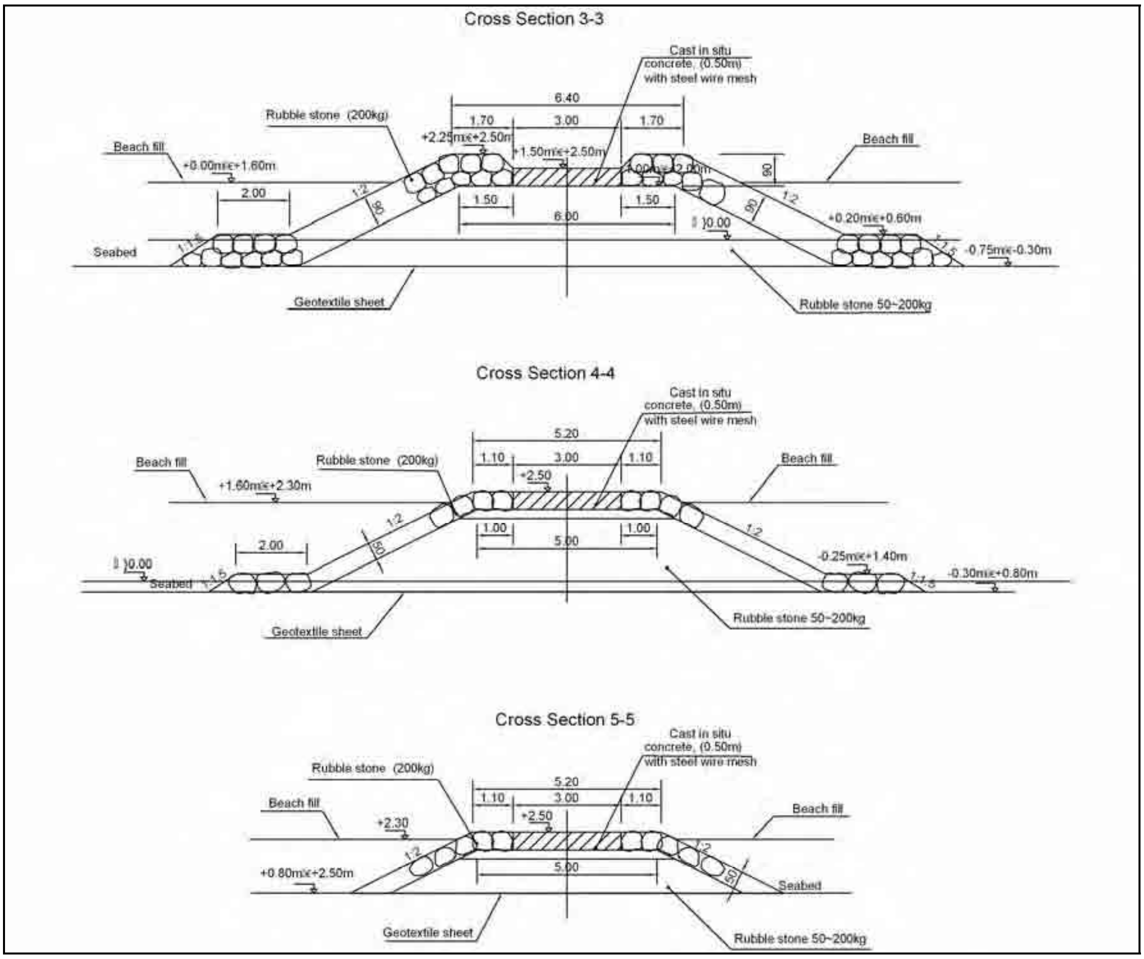


Fig. 3.3.8 (2): Cross sections 3-3, 4-4, and 5-5 of sand-retaining jetty

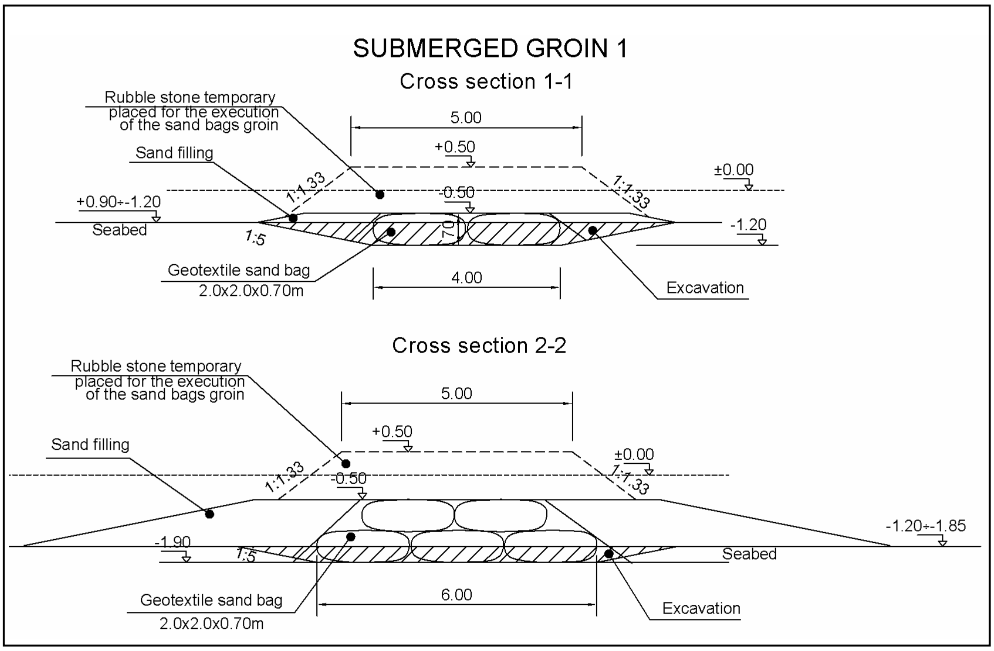


Fig. 3.3.9: Cross sections of submerged groin

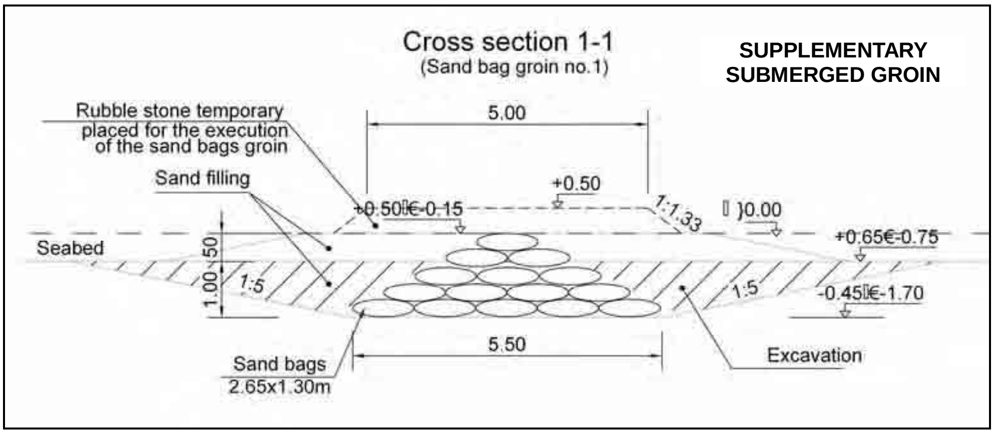


Fig. 3.3.10: Standard cross section of supplementary submerged groin

3.3.2 Implementation Schedule and Construction Plan

(1) Execution schedule

Because of the uncertainty of the exact data when the fund for the Project is secured and the Project Implementation Unit (PIU) is established, the implementation schedule is counted from the year after the provision of the fund. Execution of the construction works is planned to begin in July of the first year and to be completed in December of the second year. The schedules of execution, equipment mobilization, and labor mobilization are listed in Tables E.1.1 to E.1.13 in Appendix **E.1** of this volume. The schedule of construction works is summarized below.

The first works are the rehabilitation of two existing breakwaters. The breakwater B-1 will be rehabilitated during the period from early August to mid-November of the first year. The breakwater B-2 will be rehabilitated during the period from mid-May to the end of August of the second year. Because they are marine works only, little impacts on summer tourism are expected.

The sand-retaining jetty will be built during the period from the beginning of October of the first year to the end of February of the second year. At the same time, three supplementary submerged groins will be built in the area to be filled by sand.

Three submerged groins will be built during the period from December of the first year to mid-May of the second year.

Beach fill works are executed in two steps in the period from mid-March to mid-May and the period from mid-September to mid-November, avoiding the season of summer tourism.

(2) Equipment mobilization

Beach fill sand is mined by a dredger of floating crane barge with grab bucket, which has the productivity of 160 m^3/h. Three convoys each composed of 4 barges (1,200 m^3 capacity) carrying the mined sand is transported from the mining site around Cochirleni via the Danube – Black Sea Canal to the quay at Basarabi. From there 25-ton dump trucks with the capacity of 15 m^3 transport the sand to Mamaia Beach. At the peak of beach fill works, 194 transports will be required for which 50 trucks will run along the roads four times a day. Sand placement on beach is made with assistance of 3 bulldozer of 180 HP.

For marine works for rehabilitation of existing breakwaters, 4.5-ton stabilopods are fabricated at the Agigea area of South Constanța Port and transported to the construction site by a 1000-ton barge towed by a tugboat of 2 x 300 HP. They are installed on the breakwater by a floating crane of 15 ton capacity. The tugboat and floating crane also work for installation of geotextile sheets.

3.3.3 Cost Estimate

(1) Project cost

The project cost is estimated as 11.53 million Euro, among which the net construction cost is 9.26 million Euro, based on the market price in the summer of 2006. The works-wise cost breakdown is listed Table 3.3.1, while the currency-wise cost breakdown is listed in Table 3.3.2.

Table 3.3.1: Works-wise cost breakdown of project cost at Mamaia Sud using river sand

(units: million Euro)

No.	Item	Quantity	Amount
1	Construction works		
	Beach fill	224,000 m^3	4.72
	Rehabilitation of detached breakwaters	2 @ 250 m	2.81
	Sand-retaining jetty	200 m	0.66
	Submerged groins	3 @ 100 m	0.64
	Supplementary submerged groins	3 @ 70 m	0.13
	Temporary access road	1 unit	0.30
	Net construction cost		9.26
2	Management and monitoring cost		0.84
3	Engineering Service		0.65
4	Taxes and public charges		0.23
5	Base cost		10.98
6	Contingency		0.55
7	TOTAL		11.53

Note: 1) The engineering service fee is estimated as 7% of the net construction cost.
2) The taxes and public charges are estimated as 2.5% of the net construction cost.
3) The contingency is estimated as 5% of the total cost in 7).
4) All the cost is based on the market price in the summer of 2006.

Table 3.3.2: Currency-wise cost breakdown of project cost at Mamaia Sud using river sand

(units: million Euro)

No.	Item	Foreign Cost	Local Cost	Total Cost
1	Material	0.37	1.64	2.01
2	Equipment	0.00	5.34	5.34
3	Labor Cost	0.85	1.06	1.91
	Skilled	0.85	0.77	1.62
	Unskilled	0.00	0.29	0.29
4	Management (MIU) and monitoring cost	0.25	0.59	0.84
5	Engineering Service	0.39	0.26	0.65
6	Taxes and Duties	0.00	0.23	0.23
7	Base Cost	1.86	9.12	10.98
8	Physical Contingency (Base Cost ×5%)	0.09	0.46	0.55
9	TOTAL	1.95	9.58	11.53

(2) Management and monitoring cost

The management cost is mainly reserved for the project management (implementation) unit with the salary and wages of the personnel, operational cost, etc. It is tentatively estimated as 1,000 Euro per month for one staff on average. As shown in Fig. 8.2.1 in **8.2** of this volume, PIU is proposed to be composed of 11 professional staff. With addition of the wages of supporting staff and operational cost, etc. the management cost is estimated as 15,000 Euro per month. Because the Project Component “A” will be completed in two years of 2007 and 2008, the total maintenance cost will be 360,000 Euro. After 2009, PIU works for the Component “B.”

The monitoring cost includes the environmental and physical monitoring: the latter refers to the measurements of beach morphology, waves, water level and other physical conditions. The environmental monitoring is discussed in **6.2** and **6.3** of this volume, while the latter is dealt with in **6.4**. The annual environmental monitoring cost is estimated at about 40,000 Euro during the construction phase and at about 9,000 Euro during the operational phase. Thus, the environmental monitoring cost for the period of 2007 to 2010 is 98,000 Euro (= 2@40,000 +2@9,000).

The cost of monitoring the physical conditions is composed of capital investment and annual monitoring, which are listed in Table 6.4.1 in **6.4** of this volume. The capital investment is for purchase of one set of side-scanning sonar "Sea Bat 8125" with the price of 500,000 Euro and the establishment of sixteen (16) new benchmarks with the estimated cost of 2,500. The former is a foreign cost, while the latter is a local cost. One-half of this capital investment is allocated to each project component for convenience of simplicity. Thus, the share of the foreign cost of the Component "A" is 250,000 Euro.

The annual monitoring listed in Table 6.4.1 is not limited to the project site alone but covers the whole coast from Năvodari to Vama Veche. However, the overall monitoring is indispensable for the integrated coastal zone management of the Southern Romanian Black Sea shore. The total cost of annual physical monitoring is 64,700 Euro, which may be shared by the two project components. Thus, the share of the annual monitoring cost for the Component "A" is 32,350 Euro.

The physical monitoring cost is about 381,000 Euro (˜ 251,250 + 4@32,350) for the period of 2007 to 2010. The total cost of the management and the environmental and physical monitoring is thus estimated as 839,000 Euro.

(3) Maintenance cost

The present project of coastal protection and rehabilitation at Mamaia Sud does not foresee any significant maintenance work except for the environmental and physical monitoring. Breakwaters, jetties, and groins will function for scores of years even though they may deteriorate or experience subsidence to some extent. Existing shore protection facilities reviewed in **5.4** of Volume 1 are examples of long durability even though many of them have been deteriorated.

Among the facilities to be installed, a facility susceptible to destruction is the submerged groins made of sand bags. The geotextile cloth of the bags can be deteriorated by long exposure to ultraviolet lights and/or damaged by malicious human deeds, resulting in the leakage of filled sand and loss of their integrity. If the damage is found in future, repair works should be undertaken with the financial resources available at that time.

The filled beach is not a permanent structure, but it will be gradually deformed by wave and current actions with a certain volume of filled sand transported northward beyond the sand-retaining jetty. Nevertheless, the shoreline retreat of the filled beach is estimated not to exceed 50 m in 20 years. When the shoreline retreat will become excessively large, a new rehabilitation project should be planned and implemented. Regular monitoring of beach morphology is thus the important work to be continued for many years after the project implementation.

The present project has no plan of daily operation after its completion. The filled beach area together with existing beaches will be preserved and maintained by ANAR – DADL as described in **8.1.3 (4)** of this volume. By the reasons explained in the above, the present project cost estimate does not include the maintenance cost. Nevertheless, ANAR – DADL should maintain a reserve fund for possible future necessity of additional supply of fill sand in case of unexpected excessive shoreline retreat.

3.4 Project Component "A" Using Sea Sand

3.4.1 Structural Components and Their Layout

(1) General

The project component "A" at Mamaia Sud using the sea sand around Midia Port for beach fill is composed of the following works and facilities:

1) Beach fill works with the sand volume of 379,000 m^3,
2) Construction of underwater dike of 1,230 m long
3) Rehabilitation of two existing detached breakwaters of 250 m long each,
4) Construction of one sand-retaining jetty of 210 m long,
5) Construction of three submerged groins of 100 m long each,
6) Construction of three supplementary submerged groins of 70 m long each, and
7) Construction and removal of a temporary access road.

The layout of the above facilities is shown in Figs. 3.4.1.

Compared with the case of using the river sand, the project using the sea sand has the following differences:

1) An increase of the sand volume by 155,000 m^3,
2) Provision of underwater dike, and
3) Extension of sand-retaining jetty by 10 m.

The three submerged groins in Mamaia Center and Mamaia Nord are the same, and so are the three supplementary groins in the beach fill area. In the following sub-sections, only the beach fill with sea sand and the underwater dike are described.

(2) Beach fill works

The sea sand around Midia Port is of fine grain size with the overall median diameter of 0.10 mm, but one sediment sample taken just south of the south breakwater indicated the median diameter of 0.15 mm without any fraction of silt and clay. When this sea sand of good quality is available with a large volume of reserve and used as the fill sand, the filled beach will have the inshore slope of about 1/140 (refer to Table E.7.7 of **E.7.3** of Annex E of Volume 3). Such a small gradient of the filled beach necessitates an underwater dike to retain the filled sand within the fill area.

The beach fill is designed with the backshore elevation of DL+2.3 m and the foreshore slope of 1/30. The inshore portion is given variable slopes with the elevation of the fill toe at DL–1.0 m along the underwater dike. Figure 3.4.2 shows the location of the underwater dike on the isobath map.

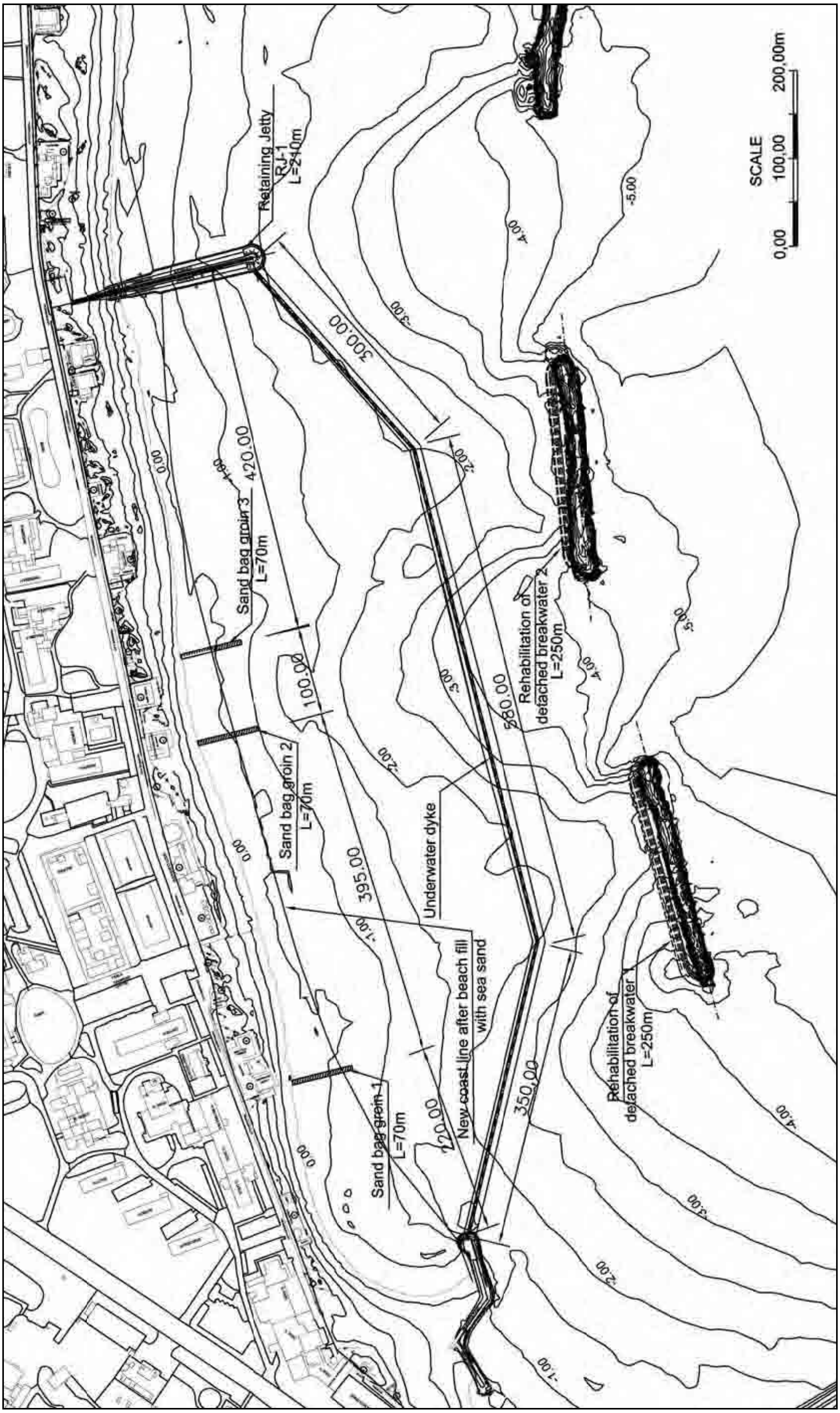


Fig. 3.4.1: General layout of shore protection facilities at Mamaia Sud with sea sand (southern part)

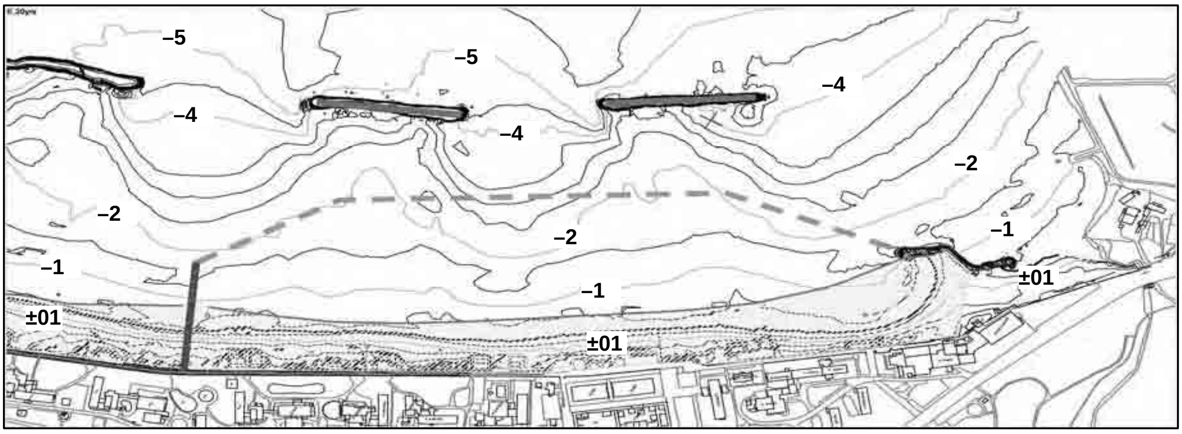


Fig. 3.4.2: Area of beach fill with sea sand at Mamaia Sud

Examples of beach fill profiles are shown in Fig. 3.4.3.

(3) Underwater dike

The alignment of the underwater dike is principally designed to follow the isobath of –2 m, but it is composed of three straight lines as shown in Figs. 3.4.1 and 3.4.2 for easiness of construction works. The underwater dike is constructed with rubble stones and its crest elevation is set at DL–0.5 m. A geotextile filter is placed on the onshore slope to prevent the filled sand from being washed out through gaps of rubble stones. To keep the filter in place, sand bags are used as armor units. Figure 3.4.4 shows two cross sections of the underwater dike.

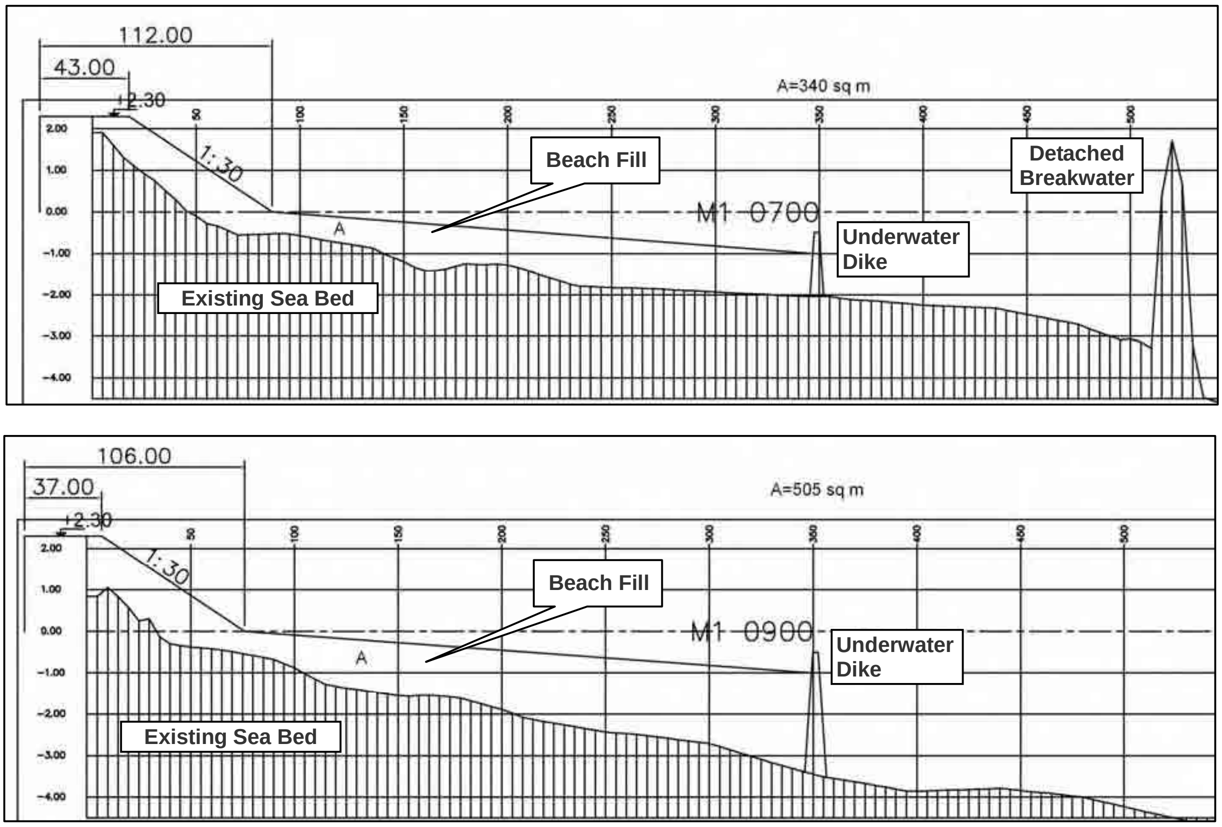


Fig. 3.4.3 Examples of beach fill profile with underwater dike at Mamaia Sud using sea sand

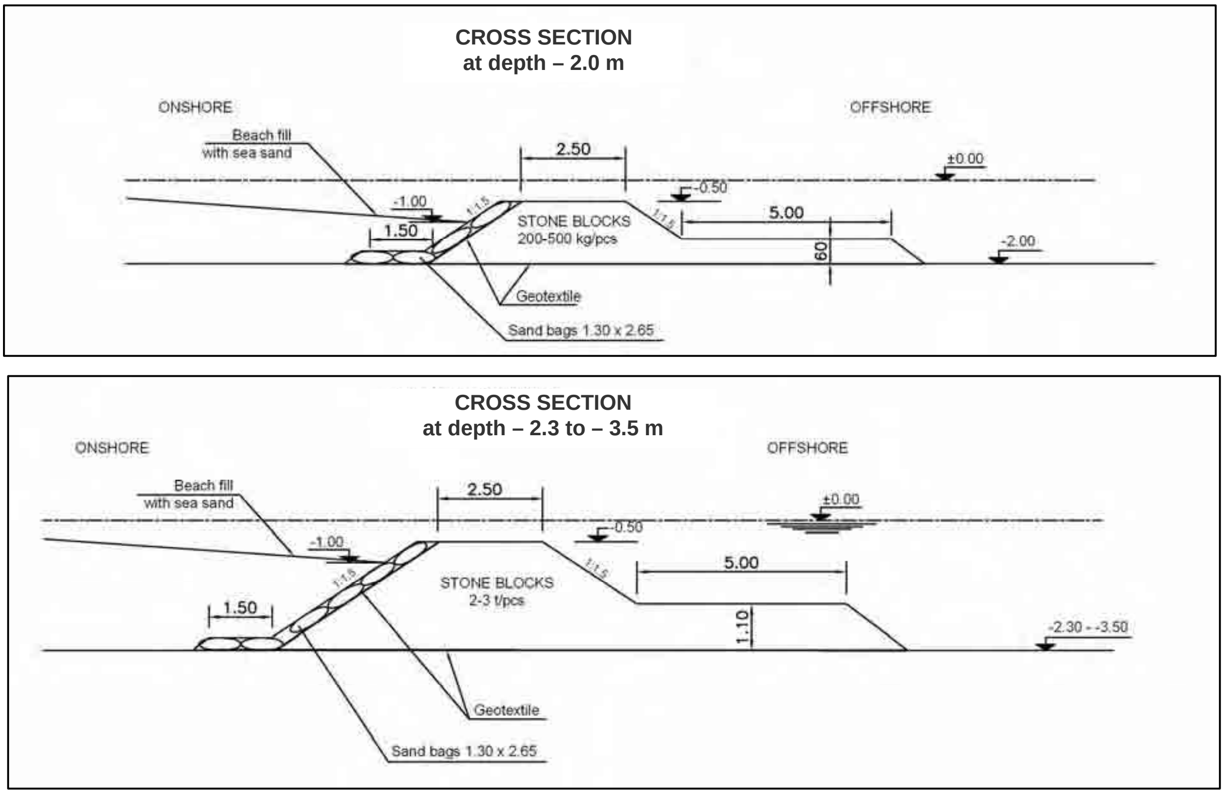


Fig. 3.4.4: Examples of cross section of underwater dike

3.4.2 Implementation Schedule and Construction Plan

(1) Execution schedule

Execution of the construction works is planned to begin in July of the first year and to be completed in December of the second year. The schedules of execution, equipment mobilization, and labor mobilization are listed in Tables E.2.1 to E.2.3 in Appendix **E.2** of this volume. The schedule of construction works is almost the same as that of the case using the river sand, except for the construction of the underwater dike and the mining and transport of sea sand.

The first works are the rehabilitation of two existing breakwaters. The breakwater B-1 will be rehabilitated during the period from early August to mid-November of the first year. The breakwater B-2 will be rehabilitated during the period from mid-May to the end of August of the second year. Because they are marine works only, little impacts on summer tourism are expected.

The sand-retaining jetty will be built during the period from the beginning of October of the first year to the end of February of the second year. At the same time, three supplementary submerged groins will be built in the area to be filled by sand.

Three submerged groins will be built during the period from December of the first year to mid-May of October.

The construction of the underwater dike will be executed during the period from December of the first year to May of the second year.

Beach fill works are executed in one step in the period from early September to December of the second year.

(2) Equipment mobilization

Beach fill sand is mined by a trailing suction hopper dredger with the hopper capacity of 2,650 m^3. Once her hopper is filled, she will navigate to the offshore of the detached breakwaters and eject the sand through a floating pipeline activated by the pumps equipped inside her. Sand placement on beach is made with assistance of 3 bulldozer of 180 HP.

For marine works for rehabilitation of existing breakwaters, 4.5-ton stabilopods are fabricated at the Agigea area of South Constanța Port and transported to the construction site by a 1000-ton barge towed by a tugboat of 2 x 300 HP. They are installed on the breakwater by a floating crane of 15 ton capacity. The tugboat and floating crane also work for installation of geotextile sheets.

The underwater dike is also constructed from sea side. Stone blocks are loaded on a 1000-ton barge, which is towed by a tugboat to the construction site. Sand bags for the protection of the inside slope are prepared at Mamaia and moved by 16-ton trucks to the Agigea area for marine transportation. A floating crane will handle installation of stone blocks and sand bags. All equipments are those employed for breakwater rehabilitation works, which will be completed before the start of underwater dike construction.

3.4.3 Cost Estimate

(1) Project cost

The project cost is estimated as 18.97 million Euro, among which the net construction cost is 15.74 million Euro. The works-wise cost breakdown is listed Table 3.4.1, while the currency-wise cost breakdown is listed in Table 3.4.2.

Compared with the project cost with the case of using the river sand, the project using the sea sand will require the cost 1.66 times that of the former case or an increase of 7.46 million Euro.

Table 3.4.1: Works-wise cost breakdown of project cost at Mamaia Sud using sea sand

(units: million Euro)

No.	Item	Quantity	Amount
1	Construction works		
	Beach fill	379,000 m^3	8.94
	Underwater dike	1,230 m	2.23
	Rehabilitation of detached breakwaters	2 @ 250 m	2.81
	Sand-retaining jetty	210 m	0.69
	Submerged groins	3 @ 100 m	0.64
	Submerged small groins	3 @ 70 m	0.13
	Temporary access road	1 unit	0.30
	Net construction cost		15.74
2	Management and monitoring cost		0.84
3	Engineering Service		1.10
4	Taxes and public charges		0.39
5	Base cost		18.07
6	Contingency		0.90
7	TOTAL		18.97

Note: 1) The engineering service fee is estimated as 7% of the net construction cost.
2) The taxes and public charges are estimated as 2.5% of the net construction cost.
3) The contingency is estimated as 5% of the total cost in 7).
4) All the cost is based on the market price in the summer of 2006.

Table 3.4.2: Currency-wise cost breakdown of project cost at Mamaia Sud using sea sand

(units: million Euro)

No.	Item	Foreign Cost	Local Cost	Total Cost
1	Material	1.55	2.16	3.71
2	Equipment	3.99	3.27	7.26
3	Labor Cost	2.40	2.38	4.78
	Skilled	2.40	1.47	3.87
	Unskilled	0.00	0.90	0.90
4	Management (PIU) and monitoring cost	0.25	0.59	0.84
5	Engineering Service	0.66	0.44	1.10
6	Taxes and Duties	0.00	0.39	0.39
7	Base Cost	8.85	9.22	18.07
8	Physical Contingency (Base Cost ×5%)	0.44	0.46	0.90
9	TOTAL	9.29	9.68	18.97

(2) Management and monitoring cost

The management cost is mainly reserved for the project management (implementation) unit with the salary and wages of the personnel, operational cost, etc. The monitoring cost includes the environmental and physical monitoring, which are discussed in **6.2** to **6.4** of this volume. The management and monitoring cost of the Project Component "A" for the case of using the sea sand is the same as the case using the river sand, which has been discussed in **3.3.3 (3)** of this volume. The total cost of management and monitoring is 839,000 Euro.

(3) Maintenance cost

The present project cost estimate does not include the maintenance cost, as explained in **3.3.3 (3)** of this volume.