ENVIRONMENTAL IMPACT ASSESSMENT STUDY

OF TARGET CONTENTS

2nd CONSTRUCTION STAGE OF THE BRAJDICA CONTAINER TERMINAL

AT THE PORT OF RIJEKA

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A.1.1 TYPE OF PROJECT OF NATIONAL IMPORTANCE

A.1.2 REASONS AND OBJECTS RELATING TO ECONOMIC AND SPATIAL DEVELOPMENT
A.1.1 TYPE OF PROJECT OF NATIONAL IMPORTANCE

The Port of Rijeka is today a port of national importance for national and international public traffic intended predominantly for cargo traffic.

The Spatial plan of the Primorsko-goranska County defines that the Port of Rijeka is a port of special (international) economic interest for the Republic of Croatia.

LEGAL PROVISIONS

Pursuant to the Maritime Domain and Seaports Act (Official Gazette 158/03), the port implies seaport, i.e. sea and with sea directly connected land space with developed and undeveloped quays, breakwaters, devices, plants and other facilities intended for accommodation, anchoring and protection of vessels, yachts and boats, embarkation and disembarkation of passenger and loading and unloading of cargos, goods storage and other handling, production, blending and finishing of goods and other economic activities being interrelated with theses activities in economic, traffic or technological terms.

Port area is the seaport area including one or more sea and land spaces (port basin) used for performing port activities under management of the Port Authority respectively concessionaire and the port area border is the border of the maritime domain. According to the purpose the ports are servicing, the ports shall be divided into:

- ports open for public traffic
- ports for special purposes.

Port open for public traffic is seaport that every natural and legal person may use under equal conditions according to the port’s purpose and limits of its available capacities. Ports open for public traffic can be open for international traffic and ports open for national traffic pursuant to the provisions of the Maritime Code. Port can include one or more basins.

In terms of size and importance for the Republic of Croatia, the ports open for public traffic shall be divided into:

- Ports of special (international) economic interest for the Republic of Croatia
- Ports of County’s importance
- Ports of local importance

Consistently with the “Decision on Criteria for Classification of Ports Open for Public Traffic” (Official Gazette 31/96) the criteria for classification of ports open for public traffic into ports of special (international) economic interest for the Republic of Croatia are:

- Average throughput over 3,000,000 tons of cargo per year with representation of transit traffic in structure of the entire traffic with 10% in the period 1985 – 1990 or average passenger traffic over 500,000 passengers per year with 10% passenger in international traffic in the period 1985 – 1990 for the port in which exclusively passenger traffic takes place;
- Railroad and road connection with hinterland respectively connection with airports;
- Installed port capacities for traffic of 5,000,000 tons of cargo per year according to the main cargo groups respectively developed quays and piers for accommodation of vessels long more than 130 m and of 6 m draft;
At least five regular shipping lines per month respectively at least three international lines per year for the port in which passenger traffic takes exclusively place.

Consistently with the “Ordinance on Classification of the Port of Rijeka” (Official Gazette No. 37/96):

- In terms of size and importance the Port of Rijeka shall be classified into port of special (international) economic importance for the Republic of Croatia.

- The port of Rijeka is the port open for international traffic.
A.1.2. INVESTMENT REASONS AND OBJECTIVES RELATING TO ECONOMIC AND SPATIAL DEVELOPMENT

The maximum throughput on Brajdica was realized in the year 1989. The result recorded in that year was 52,031 TEUs. Political-economic and safety situation (breakup of former state, war of independence, establishment of Croatia) have led to a drastic decline in throughput of 7,000 TEUs in the year 2000. Since then the Brajdica throughput has recorded abrupt growth so that already in the year 2003 the throughput data of 28,000 TEUs was recorded with tendency and forecasts of further accelerated growth. In the first six months of this 2004 year, the throughput of 27,575 TEUs was realized.

Stagnation and decline in throughput of the BRAJDICA CONTAINER TERMINAL during the mentioned 10 years (1990 - 2000) have resulted in technical-technological stagnation and decline. Reloading capacities for throughput in stated period were not sufficient, but there was a lack of capital investment and regular maintenance was reduced to minimum. Transtrainers put in operation in the year 1991 were not put in complete technological and operating function because of decline in throughput to level on which this type of storage equipment is not cost-effective in both operating-technological and financial terms.

Since the year 2000 the "BRAJDICA" has given notice of return to its maximal realized results and further growth and development:

1. Two new "Samsung' stacking cranes have been installed in addition to existing "Metalna" crane and in this way installed reloading capacity is competitive with adjacent ports, with possibility to provide services to biggest vessels coming into the Adriatic sea.

2. A feeder service has been established with the biggest Mediterranean ports (Gioa Tauro, Malta) and weekly liner calls of big world ship operators (ZimLine, CMA-CGM) have been agreed.

3. The throughput was increased to 28,000 TEUs in the year 2003 with tendency of growth.

4. Two "Belotti Tiriton" storage mobile cranes have been purchased.

5. The "BRAJDICA" is directly connected to Rijeka-Zagreb motorway with the road D - 404.

6. Realization of purchase of new storage mechanical appliances (RO-RO tractors, semi-trailers and trailers, fork-lifts for full and empty containers) is in progress.

Development plans at level of the Port Authority of Rijeka relating to Brajdica container terminal are defined:

The Brajdica is to be integrated in technical-technological and organizational terms in frame of existing possibilities being estimated to a throughput of 120,000 TEUs per year.

For that purpose, it is necessary to develop appropriate projects based on:
o Construction of second quay pier respectively extension of existing quay from 328 meters to 624 meters in length and obtaining of sea depth along the quay edge up to 14.5 meters

o Construction of appropriate storage area behind the Kosterna pier with appropriate infrastructure and superstructure.
A.2. PHYSICAL PLANNING DOCUMENT DATA

A.2.1. PHYSICAL PLANNING STRATEGY AND PROGRAM OF THE REPUBLIC OF CROATIA

A.2.2. PURPOSE OF THE RIJEKA MUNICIPALITY SEA STUDY

A.2.3. PRIMORSKO-GORANSKA COUNTY’S SPATIAL PLAN

A.2.4. CITY OF RIJEKA SPATIAL PLAN

A.2.5. CITY OF RIJEKA CENTRE DETAILED PLAN – BASIC CONCEPT
The planned project refers to the 2nd construction stage of the Brajdica Container being a part of the Port of Rijeka. This construction stage implies extension of terminal, i.e. quay intended to be constructed by sea filling in a total area of 43 000 m².

As there is a matter of complex of importance for the Republic all documents for physical planning valid for this area have been analyzed for the planned project and analyzed space, specifically:

1. PHYSICAL PLANNING STRATEGY AND PROGRAM OF THE REPUBLIC OF CROATIA
2. PURPOSE OF THE RIJEKA MUNICIPALITY SEA STUDY
3. PRIMORSKO-GORANSKA COUNTY’S SPATIAL PLAN
4. CITY OF RIJEKA SPATIAL PLAN
5. CITY OF RIJEKA CENTRE DETAILED PLAN – BASIC CONCEPT
Fig. 1 Location of Brajdica Container Terminal
Fig 2 Planned Project – Quay Filling
A.2.1. PHYSICAL PLANNING STRATEGY AND PROGRAM OF THE REPUBLIC OF CROATIA

(Ministry of Physical Planning, Construction and Residence; Physical Planning Institute, 1999, Official Gazette 50/99)

The Port of Rijeka is included in the Physical Planning Strategy and Program of the Republic of Croatia adopted by the Parliament in May 1999 (Official Gazette 50/99) and it is assigned to the aggregate traffic-geographical infrastructural complex of national importance within the system of the Bay of Kvarner.

Space projects of priority have been directed along following lines:

- technological and organizational improvements (economy, infrastructure)
- use of reserves of existing structures for activities
- directing construction to areas with sufficient capacities of existing infrastructure and construction of necessary infrastructure in order to create conditions for development, specially in refit areas
- execution of those systems and sections on which the inclusion in the European development systems depends and those with multiple generative development effects.

In the “Physical Planning Strategy of the Republic of Croatia” under the chapter 4.4.1.4 has been stated:

Maritime Traffic

Revitalization of maritime traffic in Croatia, concerning high indentedness and length of the coast, is of high need of Croatia and adjacent countries, specifically on international and national level. Further development of ports and maritime connections must be based on needs of the State (implying its connections with other countries) and within the country depending on needs of individual areas, in the first place islands and economic activities of the country (oriented to ecologically acceptable economy).

Technologies for transport, reloading and port handlings are developing today in way that the ports are increasingly becoming specialized for particular purposes and particular types of cargos. The first specialization level is introduction of unit of cargo from port to port and the final form is automated cargo monitoring from consignor to consignee including all actions and changes of transport branch. Croatian ports as well as whole Croatian traffic system is in this segment on very low level and it has to be capacitated for possibilities known already today and applied in developed world as better and as soon as possible.

..................
The first principal leading Croatian port on the coast has to continue to be the indented port system Rijeka (Rijeka, Urinj, Bakar, Omišalj, Bršica-Raša and others) with essential international importance.

Proceeding from commitment for Adriatic development of Croatia, maritime traffic must be more significantly present in general economic movements of the country.

Objectives and straights of maritime traffic development:

- Revaluate Adriatic traffic value and to evaluate exceptional geotraffic advantages of Adriatic traffic straight giving the opportunity to include area of Croatia in principal traffic flows and in the way to improve Croatian coastal and ferry navigation,

- Reorganize and to improve Croatian ports in technological terms, to connect them in a better way with the world/coast hinterland and mainland and to promote use of Croatian ports as very convenient for implementation of business activities and to attract in this way as many as possible traffic flows (commodities) from the Central Europe (to all Croatian ports, especially port of Rijeka and port of Ploče). Requirements for new spaces are important only in three ports: Rijeka, Split and Ploče,

- Provide for simple reproduction and to stop further cut in value of merchant fleet and its falling behind, in quantitative and qualitative terms, other maritime nations and (purchasing new types of floating crafts) to upgrade significantly and/or to specialize the international fleet and services supporting it as well as to make the liner fleet capacitated to meet transport needs in the first line of Croatian economy,

- Improve follow-up of technical and technological changes in maritime traffic (use of containers, unit cargos etc.),

- Improve legislation in order to obtain fresh capital injections in ports for general economic activity with the purpose to involve small investment systems in exploitation of maritime traffic too.

The objectives and guidelines for maritime traffic development have been stated in the “Physical Planning Program for the Republic of Croatia” under the chapter 3.1.3 Maritime Traffic:

Under new conditions Croatia is facing, the development of maritime traffic has to rely on advantages the Croatia disposes taking into consideration the special need for better connection of islands and based on systematic approach to following segments:

- Port development has to be planned on level of economy and traffic needs as a whole and to establish spatial requirements for necessary extension and modernization ..............
Spatial planning of maritime traffic has to take place applying provisions of relevant laws, specially those regulating ports as a part of maritime domain. When reconstructing or constructing new facilities the projects have to be carried out pursuant to the highest technological, economic and ecological criteria and mutual impact of traffic road-railway-sea corridors on relatively narrow near shore/island area has to be investigated.

Document development priorities are:

- strategic plan for development of all ports
- general development plan for Port of Rijeka and Port of Ploče system

Port connection with quay background infrastructure has to be improved.

Parallel with development of large maritime infrastructure the technical-technological characteristics of vessels and accompanying port handling have to be improved as a priority.

Under the chapter **4.4 Maritime Economy** has been stated:

Croatia has in its further development to use advantages of it position on the Mediterranean Sea in a better and more systematic way with orientation to tourist and maritime economy.

The country’s maritime orientation has to be specially promoted relying on:

- maritime traffic and shipping,
- port economy (including auxiliary economic activities and free zones) …..

Economic interests and programs have to be prepared including wider impacts specially relating to development of settlements along the coast than relating to littoralization process and impacts of other activities as well as including environmental impacts whereby environment of quality is regarded as essential advantage and specific phenomenon of Croatian maritime economy.

For this purpose borders of maritime domain and acceptable load of maritime area (land and water area), criteria for location of economic activities have to be established systematically.

Especially is important to evaluate and preserve quality of sea and coastal area on wider areas...

Under the chapter **5.1 Environmental Protection** has been stated:

Croatia has to improve the existing quality of environment and in further development to eliminate causes of pollution as well as to provide for coordination of the future development with objectives for achieving total quality of life.
It is of particular importance to implement environmental protection according to sectors-field pursuant to laws and regulations and in conformity with the Environmental Protection Strategy taking into consideration systematic measures for preventing adverse impact and stimulating procedures for environment preserving and improving.

Croatia shall, at all levels, apply the signed international agreements and conventions, specially agreements and conventions relating to sustainable development, biological heterogeneousness and human settlements and in addition within management of larger spatial entireties belonging to European systems (the Adriatic Sea, the Danube region) and establish protection system of total values.

(5-2)
Features of Croatia area and past development emphasize following aspects:

- It is important to establish integral management approach to larger entireties at global level whereas a special importance has been attached (among others) to the Adriatic Sea due to ecological importance for the State as a whole.................

(5-3)
Application of environmental protection principles within the physical planning is based on up-to-date principles and standards for environmental protection and quality of environment must be the basic criterion for physical planning.

The baseline circumstances have to be established for the purpose of more efficient planning:

- loading and past endangered condition of the space respectively degree of preserved quality and acceptable (base) space capacities,

- condition, deficiencies and necessary level of equipment with technical infrastructure,

- natural and created values to be preserved by introducing specific protection category and planned measures for use of the space,

- regulations, agreements and conventions valid for specific area and specific type of spatial resource.

CONCLUSION:

THE PLANNED PROJECT, I.E. THE 2ND CONSTRUCTION STAGE OF THE BRAJDICA CONTAINER TERMINAL BEING WITHIN THE SYSTEM OF THE PORT OF RIJEKA IS NOT CONTRARY TO THE PHYSICAL PLANNING STRATEGY AND PROGRAM OF THE REPUBLIC OF CROATIA.
PHYSICAL PLANNING STRATEGY AND PROGRAM OF THE REPUBLIC OF CROATIA

Fig. 3 Physical Planning Strategy and Program of the Republic of Croatia
A.2.2. PURPOSE OF THE RIJEKA MUNICIPALITY SEA STUDY

(Ministry of Environmental Protection, Physical Planning and Housing-and-public-utilities Affairs – Department for the Adriatic, Rijeka 1992)

Within the «Rijeka Project» the Institute for Development, Physical Planning and Environmental Protection has asked from the Department for the Adriatic - Ministry of Environmental Protection, Physical Planning and Housing-and-public-utilities Affairs to develop the Purpose of the Rijeka Municipality Sea Study. The Study has been conceived in way to serve as model for drawing up municipal physical plans for coastal and insular municipalities.

The «sea purpose plan» (sea use) implies a development of plan corresponding to familiar term for land «land purpose plan» (land use).

Taking into consideration the existing condition, planed programs as well needs and wishes of Rijeka citizens to have approach to the sea in the city being situated on the sea and to use it for swimming and leisure, the proposal for organization and use of coastline and sea in the Municipality of Rijeka has been made.

The most important construction project on the coastline is construction of big Port of Rijeka on the open coastline in front of the town centre protected with two breakwaters towards the south. The Port of Rijeka was constructed in the year 1912 within its outlines and at that time it was perfectly balanced with size of the town, traffic connection with hinterland, quay depths in conformity with vessel size of that period (approx. 5 000 DWT), surfaces and type of wharf side warehouses. Today is not so easy to achieve such harmony as city's needs have been increased largely on the restricted area. Construction of big industrial plants along the sea self has contributed significantly to such situation, whereas there was no need for many of those plants or by changing to other production program there was no need for coast any more.

Development of the Port of Rijeka has registered seven stages.

The seventh construction stage of these basins is container terminal quay and RO-RO ramp at the Brajdica. The construction started in the year 1976 and is still going on. The quay is not protected, an it is exposed to waves from south.

Extension of the Keršovani pier to the breakwater has been proposed as well as division of the present Rijeka basin into Eastern part: town port (passenger traffic, car ferries, fishery port) and Western part (with expansion towards the shipyard «3. maj» as western border). Foundation on wells and by prefabrication of port surface (platform) above that, large new land areas, high quay depths (25-309 m), flexibility for possible modification would be obtained at acceptable price in the cargo port. The entrance on Eastern part of the basin would be placed by removing of a toe part of the big breakwater. It was necessary to protect the water area by extension of the Sušak breakwater.
In the future the «Brajdica» container terminal shall be moved to new location (present Refinery Miaka) as temporary location. Further sea filling cannot be accepted, as already past filling are laying on too big depths.

There are interests and bare necessitates to considering possibility of construction of town beach on the eastern side of present coast line of the Brajdica embankment. It has been proposed to construct promenades and other sport-leisure facilities on this area that would be open to citizens ............

...................

Proposals made in this Study have taken into consideration to the full contest the existing occupancy with port-industrial facilities on the coast line of the Municipality of Rijeka. Maybe some of facilities may be considered impractical or unrealizable at the first impression, but when proposing new facilities the fact has been taken into account that Rijeka is a town situated on the sea and that sea advantage has to be use as much as possible.
Fig. 4 Excerpt from the Purpose of Rijeka Municipality Sea Study – Proposal for use of coastline and sea
A.2.3. PHYSICAL PLAN OF THE PRIMORSKO-GORANSKA COUNTY

(Institute for Development, Physical Planning and Environmental Protection of the Primorsko-goranska County, Rijeka, 2000, Official Gazette. 14/00)

ANALYSIS OF TEXTUAL PART OF THE PLAN

The Physical Plan of the Primorsko-goranska County adopted in the Assembly of the Primorsko-goranska County in July 2000, the Port of Rijeka with system of ports in the Bay of Kvarner has also further the role of significant traffic-economic factor and is one of generators of future development in the Primorsko-goranska County.

However, when it comes to Brajdica container terminal at Rijeka, some lacks of clarity can be noted in the textual part of the Plan. Although it is clear that this terminal is an integral part of the Port of Rijeka, it is not fully clear whether this is: Brajdica port basin or Sušak port basin or Brajdica port terminal. Namely, in the part of the text specifying the review of traffic system in the County (volume 1 Space Use and Protection Bases, chapter III Space Condition), the Brajdica container terminal has been stated as a new port basin (or terminal?) constructed in the last thirty-odd years and belonging to the Port of Rijeka, however as separate part of the port on the Sušak area. Therefore, (we presume) that for Brajdica (in the same text) also name Sušak port basin has been used often.

In the volume 1 SPACE USE AND PROTECTION BASES, chapter III SPACE CONDITION, has been stated among others:

1.6. INFRASTRUCTURE SYSTEMS

1.6.1.1. TRAFFIC SYSTEM CONDITION

Maritime and land infrastructure (ports, road and railroad network) and infrastructure of air traffic and oil pipeline make the traffic system backbone of the County. Integral parts of these traffic infrastructures are their terminals for passenger and freight traffic: ports and port terminals, bus terminals, road commodity terminals, railway, passenger and goods stations, marshaling yards, airports and crude oil terminals.

The existing conditions of these traffic infrastructures and auxiliary capacities are characterized by:

- technological inferiority to world standards,
- adverse technical condition,
- non-homogeneity – logical differences within one traffic branch and necessary connection of two or more traffic branches and in this respect
- insufficient utilization level of existing capacities in almost all traffic subsystems.

The past development of single traffic subsystems has been constructed and extended on screen and matrix of realized and partly assigned already in the past century. From ‘50s to ‘90s of this century a basic part of road and railroad network and mostly port have been partly reconstructed and modernized.

In the past thirty-odd years, important traffic infrastructure and terminals have been constructed:

- airports (Krk - Omišalj and Mali Lošinj)
port terminals (Bršica, Brajdica, Bakar, Omišalj)
- Adriatic oil pipeline and Omišalj oil terminal
- ................

The County, City of Rijeka and Port of Rijeka shall provide to Croatia and a big part of Europe for prestigious maritime connections with the World and offer their tourist services of high quality on littoral, insular area as well as area of the Gorski Kotar. Concisely, on the threshold of the 21st century:

a) the condition of the County’s traffic infrastructure system is characterized by:

- railway lines and stations have remain at the improved built-up level and needs in the late 19th century,
- the Port of Rijeka and port terminals have in a large part retained basic characteristics
- and capacities being required in the early and middle part of this century,
- the road network is mainly «modernized» road network from macadam period in the late past century

b) the indications of the evaluation of development of the County’s traffic system in the recent 20-30 years are:

- ................
- the Port of Rijeka with new port basins, terminals and free zones (Bršica, Brajdica, Bakar, Škrljevo, Omišalj) has very good starting elements for a sustainable and long-term development with priority task to complete the equipment, to organize work and business operations.

Although the present condition of the County’s traffic infrastructure system is at the level of improvement and modernized system of road and railway network in the late 19th century and basic port infrastructures are at the level of early and middle part of this century, the evaluation of the recent traffic system development indicates to optimistic possibilities and nearly completion of a part of the road system with high level of services specially modernization and improvement of operations in all port basins of the Port of Rijeka and other seaports of the County as well as airports and pipeline system. It remains to define the solution and preparation and development of fast railway lines towards hinterland (Zagreb and Europe), connection with area in Istria (Čićarija) and area along the coast (Dalmatia). And especially very important issues for Croatian, County and Rijeka is increasing of traffic in the Port of Rijeka and tourism in all parts of the County and in this sense prosperity of this region and the state as a whole.
1.6.1.2. MARITIME TRANSPORT

In order to get an insight in the condition of maritime transport in the Primorsko-goranska County we shall classify the ports according cargo types and sizes as well as importance of the cargo and maximum capacity of existing ports shall be determined according to the possibilities for calling of vessel sizes.

Division of ports:

a) According to types of cargos

- commercial port used for cargo reloading,
- ferry port,
- general cargo port,
- bulk cargo port,
- liquid gas cargo port,
- container and RO-RO vessel port,

- marinas and leisure ports,

Container and RO-RO Vessels Port

Specialized terminal for container and RO-RO vessels has been built within the Port of Rijeka.

The depth along the quay amounts to 12.0 meters and two container vessels and one Ro-Ro vessel can be accommodated along the quay.

Necessary stacking area with container reloading and loading equipment is situated in the close vicinity.

Terminal capacity is 100.000 TEUs (in the final construction stage).

The chapter 2 PROBLEMS AND POSSIBILITIES FOR DEVELOPMENT IN THE SPACE states among others:

At international and national level the prime function of the Primorsko-goranska County is to integrate wider area of the Danube region with the Adriatic and Central European area with South-Eastern Europe. These two important routes are intersecting on the area of the City of Rijeka – very important area burdened with natural specific conditions and inherited built structures resisting to all interests for centuries.

...............
However, the traffic infrastructure (railway, roads, port) is very old; the present imbalance of economy is mainly attributed to it. At the level of traffic supply and demand the following problems can be noted:

- Inappropriate traffic solutions and outdated technology of port capacities
- Inhomogeneity of complete traffic system, bad relation between some traffic branches in mutual completion specially railway-road-vessel-aircraft relation.

The chapter 3 ECONOMIC DEVELOPMENT BASES states among others:

3.3.1. TRAFFIC AND CONNECTIONS

Lately the County’s maritime transport is subject to organizational and technological transformations with elimination of war consequences, political and economic changes and previous traffic policy failures. The process of adaptation of maritime transport to new technological requirements, economic and market changes and property restructuring shall be of a longer duration.

The Port of Rijeka is the leading Croatian port for international traffic. It has been extended to more dislocated specialized terminals, but it throughput has been reduced from 18.1 million tons in the year 1991 to 10.6 million tons in the 1994 due to the war and slow adaptation. The freight structure has become worse and a high portion of bulk and liquid cargos (approx. 70 %) has remained. The port is connected with the hinterland with outdated land traffic routes and the port’s capacities are significantly outdated with too large number of employees. Within its development the port has to stop negative tendencies, to improve its technological level, to extend capacities and reduce costs, to develop (duty) free zone and extend its area, to modernize organization of operations and gradually increase total throughput. For that reason land traffic routes toward the hinterland have to be updated, number of port berths and terminals has to be increased, smaller ports of specific purpose have to be used and competitiveness toward Trieste and Koper has to be increased. Relating to new capacities within the development concept it is necessary to construct terminals with modern port technology and up-to-date equipment.”

CONCLUSION (textual part of the Plan - Volume 1):

The Brajdica container terminal belongs to more important specialized terminals of the Port of Rijeka. It is of the recent date and in terms of location it belongs to the Sušak port basin. Although special importance has been given to this terminal in the description of area condition and it has been analyzed as separate port location, this terminal has been not mentioned any more in the next volumes (parts of the Plan) being evident from following excerpts:

In the volume 2 PHYSICAL DEVELOPMENT PLAN, under the chapter 3 ORGANIZATION AND BASIC PURPOSE AND USE OF THE SPACE stays:
3.1.1.5.5. Traffic Zones

Traffic zones are spaces in which in addition to economic function the traffic function is prevailing. They have an important role as they make unique traffic-functional entirety of the traffic system. Their complexity in form of terminal specialized in traffic-technological terms (railway, port, truck etc.) shall be developed also in the future through introducing new tariff system for «free zones». This regulations shall include also the basins of the port complex Rijeka, Raša-Bršica, Bakar, Omišalj and detached area of Škrljevo. The zones along the border crossing Rupa, Pasjak, Brod na Kupi, Delnice and airports on the islands Krk and Lošinj shall make a supplement to this system.

Such zones of importance for traffic system of the area of the Primorsko-goranska County are already formed and have to be conceived developed on the locations in the future:

- Rijeka-Sušak port traffic and storage area with maritime, bus and railway terminals for passengers and specialized commodity terminals, technical-technological and traffic operational complexes for switching, servicing and power supply,

- port of Bakar zones ............

- port zones and zones of Omišalj oil terminal

- port zone within the petrochemical complex at Omišlj

- ..................

In the chapter 5 SURVEY OF ECONOMIC AND SOCIAL ACTIVITIES OF IMPORTANCE FOR THE COUNTY AND THE STATE is stated:

5.1. STRUCTURES AND PROJECTS OF IMPORTANCE FOR THE STATE

5.1.3.1. TRAFFIC STRUCTURES

a) Maritime structures with appertaining structures and devices for accommodation, custody and loading of ships – existing:

- Seaport open for international traffic of special international importance:

  1. Port of Rijeka (with basins of Rijeka, Raša-Bršica, Bakar, detached zone Škrljevo and Omišalj basin)

In the chapter 7 GUIDELINES FOR DEVELOPMENT OF INFRASTRUCTURE SYSTEMS has been stated:

7.1.3.1. PORT FOR PUBLIC TRAFFIC OF SPECIAL INTERNATIONAL IMPORTANCE

a) Port of Rijeka

Port of Rijeka is open for public traffic and of special (international) interest for the Republic of Croatia and in spatial terms performs operations on three basins (Rijeka, Bakar and Raša-
Bršica) and one detached area (Škrljevo).................the port shall be developed within existing area through extension of new quays, introduction of new, modern reloading technologies and better internal and external connection to traffic routes of high category.

Rijeka basin – it shall be more significant developed on its western part whereas the middle part connected with the city is intended for establishment and development of land-maritime terminal for passenger transport in international and national traffic and shall be partly capacitated for accommodation of tourist liners. The future development of the port has to be seen through modernization of existing capacities and introduction of up-to-date technologies. New technologies: container, RO-RO and multimodal technologies require new spaces and port reloading operative areas along quays. New terminal for general cargos, RO-RO and container traffic has to be necessarily developed for existing and new ship generations. The time necessary for construction of such terminals is one decade, therefore is necessary to start with preparatory works and construction of new port capacities of modern technologies immediately. ......................

In the volume 3 PROVISIONS FOR IMPLEMENTATION under the chapter 6 TERMS AND CONDITIONS FOR DEFINING TRAFFIC AND OTHER INFRASTRUCTURE SYSTEMS IN THE SPACE has been specify:

6.1.2. Seaports

Article 80

The Plan defines network of seaports open for public traffic and ports for special purposes of special state-(international) and county-importance.
Ports have to be developed mainly on the existing locations in order to obtain efficiency and complete traffic and economic system by application of Physical Planning Program for the Republic of Croatia.
The position and importance of ports, anchorages and navigable waterways has been shown in the graphic presentation 1. Space Use and Purpose (see the Attachment No. )

Article 81

The Port of Rijeka is open for public traffic and is of special (international) importance for the Republic of Croatia. It is composed of three basins (Rijeka, Bakar and Raša – Bršica) and one detached area (Škrljevo).

- Rijeka basin – shall be developed more significantly on its western part whereas the middle part connected with the city is intended for establishment and development of land-maritime terminal for passenger transport in international and national traffic and shall be partly capacitated also for accommodation of tourist liners.
Fig. 5 Excerpt from Physical Plan of the Primorsko-goranska County-
- Space/Area Use and Purpose
Fig. 6 Excerpt from Physical Plan of the Primorsko-goranska County-Space/Area Use and Purpose – Key
ANALYSIS OF GRAPHICAL PART OF THE PLAN

The area of present Brajdica container terminal is in the cartographic projection No. 1. SPACE/AREA USE AND PURPOSE defined as «AREAS FOR DEVELOPMENT AND PLANNING OF SETTLEMENTS» (yellow color), whereas the whole Rijeka basin is ranked among areas for development and planning of spaces/areas outside settlements respectively «AREAS of INFRASTRUCTURE SYSTEMS » (white color).
A.2.4. PHYSICAL DEVELOPMENT PLAN OF THE CITY OF RIJEKA

(Institute for Architecture of the Faculty of Architecture, University at Zagreb City of Rijeka – City Government Department for development, town planning, ecology and land management, Rijeka, 2003, Official Gazette)

ANALYSIS IF TEXTUAL PART OF THE PLAN

In the chapter 2 SPATIAL DEVELOPMENT AND PLANNING OBJECTIVES has been stated:

2.2.2. Selection of Physical Development Structure

Selection of the physical development structure for the City makes conditions for organization of urbane space and has an influence on character of the future environment. Processes of space «disintegration» according to the criterion of administrative-territorial division have influenced the changes according to the plans being inherited.

Spatial structure of the City depends partly on historical development and status of standards relating to city’s function. Selected spatial structure that positioning of inhabitants and required facilities spreads to depth of city’s areas and a part of costal belt opens to the city and public functions and programs, where possible

Following factors are essential when reflecting the spatial-development structures:

- planned targets of spatial plans of larger area
- constructed urban structures respectively built-up of urban area in general
- built-up of traffic and infrastructure network
- separated tendencies in economy during the past decade in the City of Rijeka and its catchments area and anticipation of their further development
- changes in the activity structure occurred during the past decade and anticipation of their further development.

Results of analysis of a part of previous mentioned factors indicate to significant increase of the role and representation of tertiary and quarterly activities and peripherisation of secondary activities on the area of the City. The spatial model accepting further development in such set model can be shown in simplified manner in following strata:

A/ littoral conditional production and ports facilities on (partly) reduced areas; outside the administrative-territorial area of the City, development of production economy within the existing (Kukuljanovo) respectively new zones;

B/ systematization of existing zones for business purposes and development of new ones directly connected to city’s motorway;

RIJEKAPROJEKT d.o.o.
C/ opening of the City towards the sea and activation of coastal belt for littoral programs of public and leisure nature;

D/ transformation of so called beltway into city’s motorway with intersections in which radial traffic routs are connecting to the motorway in direction of city centre – depth of metropolis area – connection to corridor of future Adriatic-Ionian motorway;

E/ development of compact zones of the same (residence, health service, business etc.) or complex purpose with accent to disburdening of the city centre;

F/ redevelopment for urban facilities in abandoned or devastated areas; GI preservation and protection of all environmental and heritage parts of value.

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Ad C/ Within one of the fundamental spatial problems, opening of the town towards the sea, this Plan gives a special importance the area of Delta and Brajdica as areas of the town that can, in the best way, open already defined urban tissue and life lines of force of the city’s center towards the sea . ...........

The chapter. PHYSICAL DEVELOPMENT PLAN specifies:

3.1.1. Functional Division of the City of Rijeka Area

3.1.2.9. Port

The traffic function represents also the modeling factor of the spatial development of the town. Traffic integration is markedly noticeable on the area of the town. Road traffic has a great importance for the city, but railway and maritime traffics have to be considered as subsystems which improvement shall enable more homogenous functioning of the city as a whole and conditions being necessary for this are: redefinition of railway intersection concerted with development of the port anticipating gauge redoubling of existing line and city “beltway” at lower elevation heights, relocation of the freight port and establishment of land-maritime passenger terminal.

This Plan treats the areas for port activity situated on the area of the City of Rijeka as a part of port system from Bršica to Omišlj.Reloading of general cargo and containers as cargos of high values at any port and development of Rijeka as passenger port and these are bases of development perspective on which development of Rijeka segment of the port system is and have to be planned and on which appropriate spatial solutions shall be set up.

This Plan divides the port area into: A. Freight port and B. Passenger port.

A. Freight Port

Due to its location in the town the freight port has to be intended mainly for reloading of general cargo. Acceptable solution for creating new port areas being incorporated in this Plan is the systematization of the Zagreb pier and its intended development into specialized terminal supported by the road (D-403) and railway line along its north edge. Such solution has multiple factors not only referring to functioning of the port system than also referring to all activities especially production area along the street M. Barca. In respect of present condition it emphasizes entrance into zones directly from the motorway (national respectively city category), than far more to the west specially in their centers of gravity having as
consequence reduction of longitudinal travels and possibility to reform traffic accesses (specially for heavy freight vehicles) and traffic regime from Mlaka to including the shipyard «3.maj».

The Container terminal is located on the South Brajdica, i.e. area from the planned road D-404 to the sea.
The access by railway is good and the access by road of optimal traffic and technical standard shall be provided by construction of the connection road D-404 and section of the city motorway through the valley of Draga.

Activities directed to redevelopment of the Delta area shall lead to functioning of the terminal as a detached technical, operational but also as spatial entirety in respect of the rest of the port system. By construction of the road D-404 the complete railway infrastructure of Brajdica shall be situated in terms of space on the area of the South Brajdica and in such way it shall remain in distinct function of container terminal. In this context it can be expected accelerated importance loss of other railway facilities and warehouses (shelter) for timber situated on the area of the North Brajdica (i.e. between the Cindrićeva street and the planned D-404 road) for complete port system and need to redevelop them together with other structures. For that reason, this Plan defines the area of the North Brajdica as construction settlement area.

It is realistic to expect that the issue to establish one location for container terminal shall be open probably before achieving working capacity and in light of the Zagreb pier terminal construction. **By cession of the port function on the South Brajdica this Plan determines that this area has to be developed for attractive, city programs for which the need, i.e. construction settlement area can take place soon.**

The **RESOLUTION on Adoption of the Physical Development Plan for the City of Rijeka**, under the chapter **II: IMPLEMENTATION PROVISIONS** states:

**2.1. Structures of Importance for the Republic of Croatia**

**Article 15**

Within the area of the project as from this Plan the following structures have been defined as structure of importance for the Republic of Croatia:

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**B. Traffic structure with appertaining facilities, devices and installations:**

a) **Maritime structures:**

- port open for public traffic of special importance:

  Port of Rijeka (Rijeka basin)

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5. **Conditions for Determination of Corridor or Routes and Areas of Traffic and Other Infrastructure Systems**

5.1.2.1. Seaport

**Article 143**

The Port of Rijeka is open for public traffic and is of special importance for the Republic of Croatia and within the project of this Plan it is composed of the Rijeka basin.

This Plan anticipates extension of the Rijeka basin by construction of new port areas from the Bratislava pier to the construction area marked as K2-7 (Commercial entity «Torpedo»).

The anchorage area and navigable waterways of the Port of Rijeka shall be determined according to the cartographic survey No. 1 and 1.2.

**Article 144**

The area marked with IS-23 (Brajdica) may be used as area of infrastructure system until construction of the area marked with IS-9 (Rijeka basin). Sea filling is allowed on the area marked with IS-23 in accordance with cartographic survey No. 1.

**Article 145**

The borders of port area are determined by this Plan according to criterion for demarcation of areas for different purposes, concept for spatial extension of the port and concept for spatial organization of complete city area and specially city center in conformity with cartographic survey No. 3.3.
Fig 7 Physical Development Plan for the City of Rijeka – Area Use and Purpose
Fig 8 Physical Development Plan for the City of Rijeka – Area Use and Purpose – Key (1st Part)
Fig 9 Physical Development Plan for the City of Rijeka – Area Use and Purpose – Key (2nd Part)
Fig. 10 Physical Development Plan for the City of Rijeka – Area Use and Purpose
Fig. 11 Physical Development Plan for the City of Rijeka – Area Use and Purpose – Key
Fig. 12 Physical Development Plan for the City of Rijeka – Area Use and Purpose
Fig. 13 Physical Development Plan for the City of Rijeka – Area Use and Purpose – Key
ANALYSIS OF GRAPHICAL PART OF THE PLAN

- In the cartographical survey No. 1. AREA USE AND PURPOSE, the area of the Brajdica Container terminal is determined as «AREA OF INFRASTRUCTURE SYSTEM (IS) of NATIONAL AND COUNTY IMPORTANCE». A part of water area bordered on this land area is determined as «SEA WITHIN THE PORT AREA FRAMEWORK» (refer to graphical Appendix No. 1 Excerpt from the PHYSICAL DEVELOPMENT PLAN of the City of Rijeka).

- In the cartographical survey No. 1.2. TRAFFIC PLAN, no purpose has been determined on the area of the Brajdica Container terminal (there are no marks neither symbols for the port) neither the navigable waterway has been plotted on it (refer to graphical Appendix No. 2 Excerpt from the PHYSICAL DEVELOPMENT PLAN of the City of Rijeka).

- In the cartographical survey No. 3.3. AREA OF SPECIAL USE RESTRICTIONS – LANDSCAPE, WATERS AND SEA, area of the Brajdica Container terminal is not determined as «PORT AREA» (refer to graphical Appendix No. 3.3 Excerpt from the PHYSICAL DEVELOPMENT PLAN of the City of Rijeka).
A.2.5. DETAILED URBAN DEVELOPMENT PLAN of the CITY OF RIJEKA CENTRE - BASIC CONCEPT

(Institute for Development, Physical Planning and Environmental Protection of the Primorsko-goranska County)

This Plan includes whole port area in the City of Rijeka including freight port on the Western part of the City and Brajdica Container terminal on the Eastern part of the City. In an effort to create conditions for continuation of historical development and return the identity and status to Rijeka it has had during the history, restructuring of existing facilities has been proposed in favor of revival of up-to-date economic, social and cultural activities. Therefore, the full attention has been paid precisely to the City of Rijeka – Port of Rijeka relation.

In the part of the Plan II EVALUATION OF SPATIAL DEVELOPMENT POSSIBILITIES, chapter 6.6 Area Purpose has been stated:

In the centre of the City of Rijeka it is possible to identify three global areas according to characteristic representation with facilities assigned for work, public functions and residence:

- The area of the very center of the City containing the highest activity concentration of the central area,
- Area of the larger center of the City assigned mainly to residence and auxiliary facilities in function of city center and residence,
- Working zone in function of transport and industrial activity.

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PORT-TRANSPORT AND INDUSTRIAL ZONE

Port-transport and industrial working zone in the centre of the City occupies the area between the factory «Torpedo» in the west, streets Krešimirova and Zvonimirova in the north and Brajdica (container terminal) in the east. A part of passenger port between the pier De Francheschi («ex. Otokar Keršovani») and the Riva Boduli pier (ex. Trieste quay) is in function of the City and shall be excluded from this zone.

The area of the working zone is divided according to the purpose into several global space-functional entireties:

A. Port Activities Zones

- Rijeka port basin-west assigned for freight port with an area of approx. 43.00 ha,
- Sušak port basin (Delta-Brajdica-port of Baroš) assigned for warehouse and timber reloading and container and RO-RO terminal with an area of approx. 31.00 ha.

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Today the development of port and industrial activity on the mentioned areas is rendered more difficult by following restricting factors:

- lack of space
- vicinity of city agglomeration
- uneconomical use of space (port activities on two detached locations in the town, oil refinery on two locations etc.)

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SPATIAL CONFLICT

The programs which are devastating the space entity and cannot be operated in the centre of the city shall be deemed as unfavorable programs.

PORT

Position of the port on selected location and restricted spatial possibilities make development of the port self but also of the city self impossible. The port with its extension towards the east and west has prevented the access to the sea to the city. The railway line for port cargo transport connects the east and west part of the port and in such way cuts also the small access to the sea that inhabitants of Rijeka had had.

In the chapter 6.9 TOWN-PLANNING-ECONOMIC ANALYSIS has been stated:

C. THE BIGGEST PORT AND EUROPEAN TRAFFIC-TRADE CENTER

The Port of Rijeka has had the prime importance for development of the city.

As part of the port separate the center of the city from the sea they present south border of the centre. The Delta and Brajdica, today parts of the port, situated closed to the very centre of the city represent potential space for development of it central functions. .......... 

............

The Delta and Brajdica zones are exclusively business-port zones and these are the most precious spaces that after relocation of the port would be used for future construction zone in the first line for business accommodation.

In the part of the Plan III PLANNED ORGANIZATION AND DEVELOPMENT OD THE SPACE has been stated:

7.0. Space Development and Organization Concept

............

Since beginning of the abrupt industrialization in Europe and on these areas by the end of the 19th century until the present day, the prosperity of the city has been evaluated through development of the port and industry, however consequences of such development in the area are tragic for urban morphology of the city. Through development of the port and sea filling Rijeka as the city has lost the town coastal line due to continuous conquering of the sea towards Delta and Brajdica. After construction of oil refinery on Mlaka, shipyard on
Kantrida and railway line the city has been reduced to narrow frames of contact with the town port and in this way also that thin line of littoral characteristic of the coastal town has been disrupted.

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7.2. AREA PURPOSE

7.2.1. PORT– CITY OF RIJEKA and CITY OF RIJEKA – PORT

Major breakthrough in city planning is severing of relations between the port and the city.

The assessment of existing zones for port and industrial activities has confirmed the possibility of optimal space and technological development of port activity on the space of Rijeka west basin.

In this way the existing port areas (Delta, port of Baroš, part of handling port quay between piers O. Keršovani and V. Nazor and to the later sage also Brajdica) shall be left to the City for construction of new urban structures and facilities and the access to the sea shall be provided for the City of Rijeka. The term SEASIDE TOWN shall be attributed again to Rijeka.

7.2.1.1. FREIGHT PORT WITH SPECIALIZED TERMINALS

The new spatial-technological concept for development of port activities on areas of city centre (Study made by the «Rijekaprojekt – niskogradnja”) is planned on quay background areas west of the V. Nazor pier to the factory «Torpedo». The area of 70 ha shall be obtained «capturing» new areas on the sea and relocation of the INA – Oil refinery Rijeka from the Mlaka area. The area of the freight area shall be compressed, but possibility shall be given for expansion to west part of Split quay.

On the area of the existing freight port the terminals for bulk cargo and light general cargos shall be arranged and terminal for heavy cargos and possibly container and RO-RO terminal shall be planned on the new captured area in west part of the port.

7.2.1.2. CONTAINER AND RO-RO TERMINAL ON BRAJDICA

Consistently with the spatial-technological concept for development of port activities the CONTAINER AND RO-RO TERMINAL ON BRAJDICA SHALL BE CONSIDERED AS A TEMPORARY SOLUTION due to numerous spatial, technical and traffic restrictions.

Further sea filling is allowed only for forming the eastern embankment line of the handling quay which shall enable accommodation of another container vessel.

Upon the Split quay shall be finally constructed respectively another location shall be found the container and RO-RO terminal shall be relocated from Brajdica (relocation has to occur until the year 2012) and the area shall be left to the city for construction of new urban structures and programs.
Fig. 14 Excerpt from the Detailed Plan for CITY OF RIJEKA CENTRE – Basic Concept-AREA DEVELOPMENT AND ORGANIZATION CONCEPT
Fig. 15 Excerpt from the Detailed Plan for CITY OF RIJEKA CENTRE – Basic Concept-AREA DEVELOPMENT AND ORGANIZATION CONCEPT - Key
Fig. 16 Excerpt from the Detailed Plan for CITY OF RIJEKA CENTRE – Basic Concept-SPATIAL PROJECTS
CONCLUSION:

Upon analysis of valid spatial planning documentation that should determine the planned project, i.e. the 2nd construction stage of the Brajdica container terminal at the Port of Rijeka, specific lacks of logic and lacks of coordination have been noticed in two overarching plans: Physical Plan of the Primorsko-goranska County and Physical Development Plan of the Promorsko-goranska County between themselves so too in respect of harmonization between textual and graphical part of the said plans.

Based on such data it was not possible to make unambiguous conclusion whether the planned project is in accordance with the valid spatial-planning documents.

Therefore, the draft of this Study contains detailed excerpt from the mentioned Plans as well as comments and conclusions for individual plan segments in order that the competent Ministry (Ministry of Environmental Protection, Physical Planning and Construction) could take a stand towards the subject matter and give its opinion about harmonization of intended project with special-planning documents.

At the request on statement and possibility to institute the proceedings for environmental impact assessment of intended project, the Directorate for Physical Development of the Ministry of Environmental Protection, Physical Planning and Construction gave the opinion (Class 350-01/05-02/143 dated 29 March.2005) in which the subject project is considered consistent with valid special-planning documents (refer to the Attachment 1).
A.3. DESCRIPTION OF PHYSICAL ENVIRONMENT AND AREAS UNDER IMPACT OF WORKS

A.3.1. LOCATION OF PLANNED WORKS

A.3.2. PHYSICAL-FUNCTIONAL ENTITIES AND INTENDED USE OF AREAS WITHIN THE CITY OF RIJEKA

A.3.3. PORT-INDUSTRIAL COMPLEX

A.3.4. NATURAL CONDITIONS ANALYSES

A.3.5. EVALUATION OF EXISTING LOCATION LOADS
A.3.1. LOCATION OF PLANNED WORKS

By integration of domestic traffic system and its inclusion into international traffic flows, as well as in connecting of Panon and Adriatic Croatian areas and connecting of Danube area and Adriatic, special importance has the Port of Rijeka (over Karlovac to Zagreb, respectively from Zagreb towards Budapest and Croatian Danube area).

Croatia makes the most part of its imports and exports over the Port of Rijeka, and it represents the most important port for realization of goods transit over the Croatian traffic system. Transit over the Rijeka port has been especially pointed out towards Hungary, Slovakia, Bohemia, Austria, Slovenia and Bosnia and Herzegovina.

By modernization of the railways from Zagreb (Sisak) to Rijeka and with construction of the motorway from Karlovac to Rijeka, along with the canalization of river Sava from Šamac to Sisak and construction of channel from Vukovar to Šamac, the Port of Rijeka becomes very important for goods flows from Danube area to Adriatic. Its gravitational area has been therefore expanding towards southern and central Germany, and also towards Bulgaria and Romania.

The geo-traffic position of the Rijeka port has also a special importance for the shortest natural barrier – Risnjak, which divides the Port of Rijeka over the valley of Kupa to Panon Croatia and the whole Panon lowlands which includes several states and a considerable number of bigger cities. Those are central and eastern Croatia, whole Hungary, northern Bosnia and Herzegovina, Vojvodina, parts of Slovenia, Austria, Slovakia and Romania.

The Port of Rijeka is positioned at the uttermost northern part of Adriatic, at spot where the sea makes the deepest entrance into European land. According to it’s geo-traffic position, it represents the natural and the most convenient exit to the Adriatic sea, as for areas of Panon lowlands so for Europe as a whole.

Owing to such a position, the Port of Rijeka, as part of the North-Adriatic port system, has been the participant to traditionally gravity areas in central European countries (Croatia, Hungary, Bohemia, Slovakia, Austria, Slovenia, Western Ukraine, Southern Poland and Southern Germany). The surface of named areas makes about 600,000 km², with cca 70 millions of inhabitants.

The essential comparative advantage of the North-Adriatic ports regarding the competitive North-Seas and Baltic ports consists in the shortest maritime connection of Central Europe with Mediterranean, as well as with the countries of Near and Far East, via Suez Channel.

Important elements of the Rijeka port geo – traffic position are the physical characteristics of its location and traffic connections of the port and the inland.

According to its position in opened, deep and maritime favorable Kvarner Bay, the port of Rijeka has very convenient development conditions. Development renders possible also the size of the port acquatory, sea depth and the coastal quayside.
Taking into consideration that modern transport technologies demand wide surfaces, the most of new port capacities was built outside the old port core in the city, so the port facilities are nowadays extended from Rackog over Bakar Bay to Omisalj, along the coastal line of almost 100 km.

The port of Rijeka has been connected with inland by two railway tracks, road linking and the pipeline. The railway traffic goes over Rijeka-Zagreb and Rijeka-Ljubljana, and it connects the port to the European railway net. The road traffic goes on directions towards Zagreb, Lubiana and Dalmatia. The pipeline connects the port of Rijeka with domestic oil – refineries, Hungary and Yugoslavia.

Geographical and geo-traffic position of Rijeka, determined the explicitly maritime orientation of the named city and marked the economy of entire region. It has been developed as the biggest national cargo port and important passenger port, the main seat of leading cargo and passenger vessels, and as a port support are acting numerous service companies. From total employed persons within transport and traffic activities in the County Primorsko-Goranska, in sector of maritime traffic and activities on cargo transshipment has been employed cca 50 percent of all employees.

Photo 1. Panorama of the area
A.3.2. PHYSICAL-FUNCTIONAL ENTITIES AND INTENDED USE OF AREAS WITHIN THE CITY OF RIJEKA

A considerably number of limiting factors at central and wider city areas determined selection of areas for single uses. Therefore in the City of Rijeka could be identified three global areas, divided according to their characteristics:

- working zones along the coastal line
- residential quarters on hills
- recreation within the coastal line

Central city contents are located in the central city area, at contact of Delta with residential zones. In this area are also situated all important city public contents which are forming the city urban physiognomy, and which represent the main orientation in the city urban structures.

Almost all of work activities are positioned in working zones along the coastal “city” line and the “port”, which doesn’t guarantee rationally course of technological processes and traffic connections.

Photo 2. Area view of the port zone
The important element of area organizing are the non built areas which are intended as parks and other green surfaces.

The container terminal of Brajdica in the port basin Sušak has been positioned southern of the residential part of the city, in separate port – operative zone.
Photo 4. Position of the Rijeka basin and Susak basin in the Port of Rijeka
Photo 5. Division of the Susak basin
A.3.3. PORT-INDUSTRIAL COMPLEX

In the port of Rijeka the Susak basin, together with industrial contents, makes the port – industrial complex, inside which has been positioned the container terminal Brajdica.

The port – industrial zone of Susak basin in the port of Rijeka has been extended on 18 ha. Within the mentioned zone are the contents of the Susak basin, as follows:

- a part of the port “Port Baros” - works with limitations
- oil terminal on “Delta” - under demolition - doesn’t work
- warehouses for timber on “Delta” – terminate with works – moving in Rijeka basin
- marshalling gauges – in function
- business – administrative buildings
- container terminal (1st phase) Brajdica
- warehouses for timber on Brajdica
- closed warehouses on Brajdica

There are no plans for further expansion of mentioned port – industrial complex of the Susak basin. It has been planned the reassignment of the following areas:

- Porto Baros
- Delta
- Partly Brajdica

into city – port contents intended for the city of Rijeka needs.
It has been planned the termination of construction for container terminal (1st phase) Brajdica.
Photo 7. Port area - terminals

Photo 8. Port area – terminals
A.3.4. NATURAL CONDITIONS ANALYSES

A.3.4.1. GENERAL METEOROLOGICAL, MAREOGRAPHIC AND CLIMATE DATA

The container terminal Brajdica is positioned at coastal line of the city, left from river Rjecina delta, almost parallel to the coastal line, in form of vertical wall, without the waves protecting facilities. In the second development phase, it’s expansion has been foreseen on such a manner to create the leveled embankment parallel to the coastal line, which will terminate with vertical wall from the side of the sea, as pier for berthing of container ships.

This pier should be of open type, length of cca 600 m, in form and performance according to basic design.

Such a pier should serve for berthing of opened type vessels, respectively submitted to influence of the sea dynamics and especially deep sea waves, as the foreseen pier depth will be cca 30 m.

In the elaborate herein, it was made the study on wind-wave climate for terminal location, based on presently knowledge about theoretical foundations, as well as adequate measuring data, all necessary for elaboration of the environmental impact study. The results herein are shown at levels of prognoses and necessities for issuing of location permit regarding the construction of the container terminal II nd phase. Because of good research and measurements at very close locations, this data can be considered as statistically reliable.

A.3.4.1.1. DOMINANT WINDS ON TERMINAL BRAJDICA AREA

As the winds will have impact on performance of port operations and ship loading with additional power from one side, and on creation of surface waves from the other side, it’s necessary to know the climate regarding winds within the port, as well as the force of the wind from every single direction, and its dynamical characteristics. To define mentioned, it’s necessary to have knowledge of the wind climate for wider Adriatic area, and than to base on measuring data from the closest meteorological stations.

We will present here the available wind measurements data for closer locations, as there are no measurements on the very same position of Brajdica terminal.

The closest positions on which the measurements and statistical data about winds are systematically performed, are locations: Rijeka – Martinscica, 10 m above the soil level, in the point with peak elevation h = 20m, on distance of 2,5 km easterly from position of the new port wharf, and the meteorological station Rijeka in the city of Rijeka - peak elevation 104 m, on distance of cca 2 km NW (data reliable also for location of terminal Brajdica).

A.3.4.1.1.1. TYPE OF WINDS REGARDING DIRECTION AND FREQUENCY OF APPEARANCE

Cyclone and anti-cyclones are basic bars which direct the general atmosphere circulation, so also above the area of the Adriatic sea. However, the circulation of the air above the Adriatic sea, has been conditioned with other factors, as local circulation - land – sea, influence of sea temperature topography and sim. The ancient
experience shows that some winds at Adriatic appears rarely, and some frequently, as well as that exists considerable differences between the wind regime at open sea and the one at the coastal and island areas.

It has to be said that Adriatic belongs to seas where calms and weak winds prevails in considerably percent of time, as shown from further statistics (as middle value could be taken 2 to 2,5 Bf).

However, the basic issue consists in fact that over the Adriatic aquatory, or on its surroundings, are frequently going through the cyclones, which cause considerably change of winds during the day time, not only causing the intensity changes, but also a direction of winds.

Under the influence of anti-cyclones fetch, the winds on Adriatic can reach considerably intensiveness and duration period, which all together renders possible expecting of winds from all directions, during the whole year.

The results of long-term wind controlling and measurements has been shown in table 1, where are presented the names of winds and their average annual frequency of appearance (13) for eight principal wind directions.

<table>
<thead>
<tr>
<th>Smjer</th>
<th>C</th>
<th>Brzina vjetra</th>
<th>1 i 2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>= 9 Bf</th>
<th>Po smjene</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (tramontana)</td>
<td>1,3</td>
<td>1,4</td>
<td>2,4</td>
<td>4,1</td>
<td>1,4</td>
<td>0,3</td>
<td>0,3</td>
<td>0,2</td>
<td>11,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE (bura)</td>
<td>0,5</td>
<td>0,5</td>
<td>1,7</td>
<td>1,5</td>
<td>3,4</td>
<td>2,2</td>
<td>1,4</td>
<td>0,2</td>
<td>11,4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (levanat)</td>
<td>0,6</td>
<td>0,6</td>
<td>1,7</td>
<td>2,6</td>
<td>1,4</td>
<td>0,7</td>
<td>0,5</td>
<td>0,2</td>
<td>8,1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE (Šiloko)</td>
<td>0,4</td>
<td>0,5</td>
<td>1,2</td>
<td>2,4</td>
<td>2,9</td>
<td>3,6</td>
<td>1,7</td>
<td>1,0</td>
<td>13,7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S (jugo)</td>
<td>1,3</td>
<td>1,4</td>
<td>2,2</td>
<td>2,6</td>
<td>3,4</td>
<td>1,2</td>
<td>0,3</td>
<td>0,2</td>
<td>12,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW (lebic)</td>
<td>1,8</td>
<td>1,8</td>
<td>1,5</td>
<td>1,4</td>
<td>0,9</td>
<td>0,3</td>
<td>0,3</td>
<td>0,2</td>
<td>8,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W (pulenat)</td>
<td>1,8</td>
<td>1,8</td>
<td>2,2</td>
<td>2,9</td>
<td>0,7</td>
<td>0,3</td>
<td>0,2</td>
<td>10,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW (maestral)</td>
<td>2,5</td>
<td>2,6</td>
<td>8,0</td>
<td>6,2</td>
<td>3,9</td>
<td>0,7</td>
<td>0,3</td>
<td>24,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Po jakosti</td>
<td>10,2</td>
<td>10,6</td>
<td>20,9</td>
<td>23,7</td>
<td>18,0</td>
<td>9,3</td>
<td>5,2</td>
<td>1,6</td>
<td>0,3</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Annual average frequency of wind speed-direction groups

From the above shown table is visible that the most frequent ones are three main groups: from south direction (S and SE), bura (N and NE) and maestral (NW), from which the first two are very important regarding their speed, and the third one regarding its periodically frequency.
Furthermore, it has been noticed that the winds could be classified regarding their time of appearance. Considering the climate, the year at Adriatic is divided on two regimes: summer one (IV – IX month) and winter one (X – III month).

Bura and Jugo are dominant winds on Adriatic in the cold period of the year, and maestral expressively during the summer time.

**On bura in general**

Bura is a strong, sudden and cold wind, which appears at eastern cost of the Adriatic. Usually, this type of wind appears in different countries (e.g. New Land, Black sea at Novorosijsk, on Tehuantepec and other).

It has been noticed that it starts there where exist low mountain barrier, which divides warm areas from the cold ones.

In our country, this barrier makes Dinaric mountains, so bura usually appears with the highest force in Croatian maritime region, and goes more weak towards the southeast.

Based on 10 – years controlling (1949 – 1958) /12/, it has been received the average number of periods with bura during the cold and worm period of the year, shown in table 2. From the same could be visible its frequent appearance during the winter time.

Regarding the speed of the wind, it often reaches the storm size.

<table>
<thead>
<tr>
<th>Station</th>
<th>Yearly</th>
<th>Winter</th>
<th>Summer</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. Lošinj</td>
<td>55.2</td>
<td>40.6</td>
<td>14.60</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Pula</td>
<td>59.7</td>
<td>41.3</td>
<td>18.4</td>
<td>69</td>
<td>31</td>
</tr>
<tr>
<td>Rijeka</td>
<td>76.3</td>
<td>50.7</td>
<td>25.6</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Rab</td>
<td>51.2</td>
<td>35.4</td>
<td>15.8</td>
<td>69</td>
<td>31</td>
</tr>
<tr>
<td>Senj</td>
<td>177.4</td>
<td>117.5</td>
<td>59.9</td>
<td>64</td>
<td>36</td>
</tr>
<tr>
<td>Zadar</td>
<td>16.7</td>
<td>14.0</td>
<td>2.7</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>Šibenik</td>
<td>86.5</td>
<td>60.9</td>
<td>25.6</td>
<td>71</td>
<td>29</td>
</tr>
<tr>
<td>Split</td>
<td>147.6</td>
<td>97.3</td>
<td>50.3</td>
<td>66</td>
<td>34</td>
</tr>
<tr>
<td>Hvar</td>
<td>37.4</td>
<td>27.9</td>
<td>9.6</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Palagruža</td>
<td>54.4</td>
<td>41.7</td>
<td>12.7</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>Korcula</td>
<td>49.2</td>
<td>36.5</td>
<td>12.7</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Lastovo</td>
<td>54.2</td>
<td>44.5</td>
<td>9.7</td>
<td>82</td>
<td>18</td>
</tr>
<tr>
<td>Dubrovnik</td>
<td>89.0</td>
<td>61.2</td>
<td>27.8</td>
<td>69</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 2. Average number of periods with bura during the cold and worm period of the year

**On jugo in general**
Jugo is the wind of the worm cyclone sector, with the seat westerly from Adriatic or on the very same
Adriatic. It brings relatively worm air from southern countries to Adriatic area, and which, during its
passage through Mediterranean, gets rich with humidity so above our islands and the coast comes the
condensation causing rainfalls belonging to the highest in Europe.

<table>
<thead>
<tr>
<th>Station</th>
<th>Yearly</th>
<th>Winter</th>
<th>Summer</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. Lošinj</td>
<td>34.2</td>
<td>25.2</td>
<td>9.0</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Pula</td>
<td>22.4</td>
<td>14.9</td>
<td>7.5</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Rijeka</td>
<td>18.0</td>
<td>14.1</td>
<td>3.9</td>
<td>78</td>
<td>22</td>
</tr>
<tr>
<td>Rab</td>
<td>72.5</td>
<td>53.4</td>
<td>19.1</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Senj</td>
<td>21.6</td>
<td>16.0</td>
<td>5.6</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Zadar</td>
<td>42.1</td>
<td>28.9</td>
<td>13.2</td>
<td>69</td>
<td>31</td>
</tr>
<tr>
<td>Šibenik</td>
<td>53.9</td>
<td>37.1</td>
<td>16.8</td>
<td>69</td>
<td>31</td>
</tr>
<tr>
<td>Split</td>
<td>135.2</td>
<td>86.5</td>
<td>48.7</td>
<td>64</td>
<td>36</td>
</tr>
<tr>
<td>Hvar</td>
<td>107.2</td>
<td>70.0</td>
<td>37.2</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td>Palagruža</td>
<td>104.5</td>
<td>71.8</td>
<td>32.7</td>
<td>69</td>
<td>31</td>
</tr>
<tr>
<td>Korcula</td>
<td>42.5</td>
<td>30.6</td>
<td>11.9</td>
<td>72</td>
<td>28</td>
</tr>
<tr>
<td>Lastovo</td>
<td>98.7</td>
<td>69.9</td>
<td>28.8</td>
<td>71</td>
<td>29</td>
</tr>
<tr>
<td>Dubrovnik</td>
<td>116.4</td>
<td>79.5</td>
<td>36.9</td>
<td>68</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 3. Average number of periods with jugo during the cold and worm period of the year
at characteristic Adriatic positions

From above could be visible that at position of Rijeka, in cca 78% of cases, jugo appears during the winter
time, and in 32% during the summer time, while bura appears in 67% at winter time, and 33% during
the summer time.

Winds regarding the force and direction

The usual classification of winds is the one made by Beaufort scale of winds, shown at table 4.

<table>
<thead>
<tr>
<th>Beaufort wind scale</th>
<th>Wind descriptive terms</th>
<th>Wind speed</th>
<th>Waves height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km/h</td>
<td>m/s</td>
<td>kt</td>
</tr>
<tr>
<td>0 Bf</td>
<td>&lt; 1</td>
<td>0-0.2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>1 Bf</td>
<td>light air</td>
<td>1-5</td>
<td>0.3-1.5</td>
</tr>
<tr>
<td>2 Bf</td>
<td>light breeze</td>
<td>6-11</td>
<td>1.6-3.3</td>
</tr>
<tr>
<td>3 Bf</td>
<td>gentle breeze</td>
<td>12-19</td>
<td>3.4-5.4</td>
</tr>
<tr>
<td>4 Bf</td>
<td>moderate breeze</td>
<td>20-28</td>
<td>5.5-7.9</td>
</tr>
<tr>
<td>5 Bf</td>
<td>fresh breeze</td>
<td>29-38</td>
<td>8.0-10.7</td>
</tr>
<tr>
<td>6 Bf</td>
<td>strong breeze</td>
<td>39-49</td>
<td>10.8-13.8</td>
</tr>
<tr>
<td>7 Bf</td>
<td>near gale</td>
<td>50-61</td>
<td>13.9-17.1</td>
</tr>
<tr>
<td>8 Bf</td>
<td>gale</td>
<td>62-74</td>
<td>17.2-20.7</td>
</tr>
<tr>
<td>9 Bf</td>
<td>strong gale</td>
<td>75-88</td>
<td>20.8-24.4</td>
</tr>
<tr>
<td>10 Bf</td>
<td>storm</td>
<td>89-102</td>
<td>24.5-28.4</td>
</tr>
<tr>
<td>11 Bf</td>
<td>violent storm</td>
<td>103-117</td>
<td>28.5-32.6</td>
</tr>
<tr>
<td>12 Bf</td>
<td>hurricane</td>
<td>&gt;=108</td>
<td>&gt;=32.7</td>
</tr>
</tbody>
</table>

Table 4. Beaufort wind scale (WMO 1956) 10 m above the sea level
Regarding the above, in meteorology are as standard recognized four classes of winds:

<table>
<thead>
<tr>
<th></th>
<th>Moderate wind</th>
<th>strong wind</th>
<th>stormy wind</th>
<th>hurricane wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bf</td>
<td>1 2 3 4 5</td>
<td>6 7</td>
<td>8 9 10</td>
<td>11 12</td>
</tr>
</tbody>
</table>

As visible, the wind classification according to Beaufort goes from 0 to 12. The wind of 12 Bf hasn’t been noticed at Adriatic, but anemometer measurements shows that during the squalls of bura at area of Senj, could be expected speeds higher than 50 m/s. ADEQUATE VALUES ARE VALID ALSO FOR RIJEKA, especially at Martinscica.

**Stormy and hurricane winds at Adriatic**

Controlling and measuring of stormy and hurricane winds (very strong winds) at Adriatic, unfortunately wasn’t, until recently, systematically followed, therefore there aren’t adequate data for a longer period of time.

In literature are known the works of L. Klescenko (1970) who, in general data of Mediterranean characteristic storms gives figures also for Adriatic. His results are deducted from weather maps of pressure gradients, namely with indirect method. It’s interesting to us to conclude that for northern and central Adriatic, the calculated wind speeds were the highest from the NE direction, and they comes up to 32 m/s, and for the south Adriatic from the same direction 34 m/s, while a duration period for such storms lasts at least 12 hours. Those speeds were found once from serial data taken during 24 years. Moreover, it was calculated that also the SE winds can reach speeds of 30 m/s.

From other published literature could be deduced that on north and south Adriatic, as very strong wind, most usually, appears bura, and that it embraces an area up to 50 – 60 km from the sea side. Its average per hour, measured in Triest, comes to 32 m/s, and in Senj 29 m/s.

On south Adriatic could also appear the hurricane wind of 11 Bf, from south directions.

The recent systematical data are given for the first time as the wind rose for eight main directions, along with the belonging forces (14). The data were made based on 20 – years monitoring (1957 – 1976) at meteorological stations on the coast, islands and from the ships, and for north Adriatic they are graphically shown as table 5 herein.

**A.3.4.1.2. ANALYSES OF WIND CLIMATE AT CLOSER LOCATION OF THE RIJEKA PORT**

The anemographic station Rijeka - Martinscica started to work at the end of the year 1968. It processed data for period 1969 – 1979 and 1985 – 1988, on appearance and duration of the strongest winds, alongwith the elaboration of their long – term division (1).
Table 5. Wind characteristics
<table>
<thead>
<tr>
<th>Town</th>
<th>Maximal Wind Class (class 1-12)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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</table>

Table 6. Number of days with maximal wind blows

Table 6a. Number of days with maximal wind blows - continuation
Data on wind speed are very interesting - 8 Bf (17.2 – 20.7) m/s, which belongs to category of stormy winds, and they have been classified into classes of 2 hours each. Because of importance and usefulness of the quoted data, where the total number of measurement days is divided by months and classes, the results are clearly shown in the table 6. and 6a.

The statistics of representing single directions, made by the same source for winds of at least 11 m/s, which is adequate to force of at least 6 Bf, has been shown in table no. 7.

<table>
<thead>
<tr>
<th>Direction</th>
<th>N</th>
<th>NNE</th>
<th>NE</th>
<th>ENE</th>
<th>E</th>
<th>ESE</th>
<th>SE</th>
<th>SSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQ (%)</td>
<td>10,0</td>
<td>61,4</td>
<td>352,7</td>
<td>408,8</td>
<td>27,0</td>
<td>9,0</td>
<td>13,7</td>
<td>24,4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Direction</th>
<th>S</th>
<th>SSW</th>
<th>SW</th>
<th>W</th>
<th>WNW</th>
<th>NW</th>
<th>NNW</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQ (%)</td>
<td>39,7</td>
<td>26,7</td>
<td>11,7</td>
<td>2,3</td>
<td>1,3</td>
<td>2,0</td>
<td>5,0</td>
</tr>
</tbody>
</table>

Table 7. Frequency of directions (%) of strong and stormy winds at area of Martinscica

The strongest winds on this area are blowing from NE quadrant. That is bura, which here has a direction ENE and NE, sometimes NNE.

In the table No. 6. are given the number of days with duration period of 2, 4, 6,...24 hours of the wind with stormy force.

The first class /1/ - which has the highest values in all months - includes mainly cases of appearance of one or few squalls above 17 m/s, duration period of which is usually few seconds, so this data are treated separately. Summing up of classes 2 - 12, we receive data showing that area of Martinscica has annually average of 43,7 (12%) days with appearance of stormy wind which lasted at least two hours uninterruptedly, with momentary wind speed = 17 m/s, from which 31,1 day in cold period of the year and 12,6 in the warm part. Very interesting measuring data for our analyses, coming from the same source, are shown in table No. 8. where is presented a statistics with stormy wind (bura), in duration period more than 24 hours at area of Martinscica for 15 - year period, and where are also given data on maximal momentary speed. From those data is visible that the highest was 46,7 m/s (170 km/hour).

Based on cited data, authors made the calculations of expected maximal wind speeds, using Gumbel's division defined by function of probability.

\[ P(x) = \exp\left\{-\exp\left[\frac{(x - \alpha)}{\beta}\right]\right\} \]

Which general solution has linear shape

\[ x = \alpha + \beta y \]

Where \( a \) and \( B \) are parameters from empirical data.
Table 8. Situation with stormy wind (bura) duration period more than 24 hours, at area of Martinscica, during the period of 15 years (1969 - 1979, 1985 - 1988). There are presented dates and time of start and finish of the appearance, total duration period in hours and minutes, and maximal momentary speed registered in every situation.

<table>
<thead>
<tr>
<th>START</th>
<th>FINISH</th>
<th>DURATION</th>
<th>v max</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.02.1969...</td>
<td>05.02.1969...</td>
<td>43h 20m</td>
<td>46.7</td>
</tr>
<tr>
<td>03.04.1969...</td>
<td>06.04.1969...</td>
<td>78h 40m</td>
<td>27.8</td>
</tr>
<tr>
<td>19.12.1969...</td>
<td>20.12.1969...</td>
<td>30h 00m</td>
<td>41.7</td>
</tr>
<tr>
<td>16.09.1970...</td>
<td>18.12.1970...</td>
<td>51h 01m</td>
<td>31.7</td>
</tr>
<tr>
<td>02.01.1971...</td>
<td>03.01.1971...</td>
<td>27h 02m</td>
<td>40.6</td>
</tr>
<tr>
<td>15.10.1971...</td>
<td>17.10.1971...</td>
<td>50h 27m</td>
<td>36.5</td>
</tr>
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<td>33h 20m</td>
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<tr>
<td>12.01.1972...</td>
<td>14.01.1972...</td>
<td>34h 09m</td>
<td>25.7</td>
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<td>31.9</td>
</tr>
<tr>
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<td>46h 47m</td>
<td>41.3</td>
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<td>33h 19m</td>
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<td>28.12.1972...</td>
<td>29.12.1972...</td>
<td>32h 33m</td>
<td>32.5</td>
</tr>
<tr>
<td>24.01.1973...</td>
<td>26.01.1973...</td>
<td>46h 04m</td>
<td>31.1</td>
</tr>
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<td>11.10.1975...</td>
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<td>42h 25m</td>
<td>29.7</td>
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<td>17.12.1975...</td>
<td>19.12.1975...</td>
<td>45h 36m</td>
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<tr>
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<td>18.09.1977...</td>
<td>40h 14m</td>
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</tr>
<tr>
<td>18.02.1975...</td>
<td>20.02.1975...</td>
<td>37h 35m</td>
<td>26.9</td>
</tr>
<tr>
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<td>21.02.1975...</td>
<td>40h 45m</td>
<td>28.0</td>
</tr>
<tr>
<td>08.01.1985...</td>
<td>10.01.1985...</td>
<td>42h 28m</td>
<td>33.2</td>
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<td>13.03.1985...</td>
<td>44h 52m</td>
<td>25.6</td>
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<td>20.11.1985...</td>
<td>99h 34m</td>
<td>35.0</td>
</tr>
<tr>
<td>27.09.1987...</td>
<td>29.09.1987...</td>
<td>43h 30m</td>
<td>31.4</td>
</tr>
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<td>26.10.1987...</td>
<td>28.10.1987...</td>
<td>38h 59m</td>
<td>21.1</td>
</tr>
<tr>
<td>08.12.1987...</td>
<td>10.12.1987...</td>
<td>50h 00m</td>
<td>30.2</td>
</tr>
<tr>
<td>13.02.1988...</td>
<td>14.02.1988...</td>
<td>40h 45m</td>
<td>27.5</td>
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<td>24.04.1988...</td>
<td>25.04.1988...</td>
<td>27h 18m</td>
<td>29.9</td>
</tr>
<tr>
<td>14.07.1988...</td>
<td>16.07.1988...</td>
<td>34h 00m</td>
<td>22.5</td>
</tr>
<tr>
<td>21.11.1988...</td>
<td>24.11.1988...</td>
<td>77h 56m</td>
<td>36.9</td>
</tr>
</tbody>
</table>
From above shown could be deducted a recurrent period $T$ (in years) in which are to be expected repetition of some wind appearance, from all directions. The results of this calculation are shown in table No. 9. The same was shown in tables 10, 11 and 12, for three interesting directions NE, SE and SW.

<table>
<thead>
<tr>
<th>T (years)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>25</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (%)</td>
<td>50</td>
<td>80</td>
<td>90</td>
<td>95</td>
<td>96</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>V</td>
<td>37.7</td>
<td>42.0</td>
<td>44.9</td>
<td>47.6</td>
<td>48.5</td>
<td>51.1</td>
<td>53.8</td>
</tr>
</tbody>
</table>

Table 9. Expected maximal wind squall $V_t$ (ms$–1$) and adequate probabilities that the same will not be exceeded for recurrent period of $T$ years received by Gumbel divisions of extremes, from wind speed data measured by anemograph, at location Martinscica (1969–1988).

<table>
<thead>
<tr>
<th>T (years)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>25</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (%)</td>
<td>50</td>
<td>80</td>
<td>90</td>
<td>95</td>
<td>96</td>
<td>98</td>
<td>99</td>
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<tr>
<td>V</td>
<td>37.3</td>
<td>421.5</td>
<td>44.3</td>
<td>47.0</td>
<td>47.8</td>
<td>50.4</td>
<td>53.0</td>
</tr>
</tbody>
</table>

Table 10. Expected maximal wind squall $V_t$ (ms$–1$) and adequate probabilities $p$ (%) that the same will not be exceeded for recurrent period of $T$ years for directions of NE quadrant received by Gumbel divisions of extremes, from wind speed data measured by anemograph, at location Martinscica (1969–1988).

<table>
<thead>
<tr>
<th>T (years)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>25</th>
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<tbody>
<tr>
<td>P (%)</td>
<td>50</td>
<td>80</td>
<td>90</td>
<td>95</td>
<td>96</td>
<td>98</td>
<td>99</td>
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<tr>
<td>V</td>
<td>22.7</td>
<td>24.9</td>
<td>26.3</td>
<td>27.7</td>
<td>28.1</td>
<td>29.5</td>
<td>30.8</td>
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</table>

Table 11. Expected maximal wind squall $V_t$ (ms$–1$) and adequate probabilities $p$ (%), that the same cannot be exceeded for recurrent period of $T$ years for directions of SE quadrant received by Gumbel divisions of extremes, from wind speed data measured by anemograph, at location Martinscica (1969–1988).

<table>
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<tr>
<th>T (years)</th>
<th>2</th>
<th>5</th>
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<th>20</th>
<th>25</th>
<th>50</th>
<th>100</th>
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</thead>
<tbody>
<tr>
<td>P (%)</td>
<td>50</td>
<td>80</td>
<td>90</td>
<td>95</td>
<td>96</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>V</td>
<td>20.9</td>
<td>27.2</td>
<td>31.5</td>
<td>35.5</td>
<td>36.8</td>
<td>40.8</td>
<td>44.7</td>
</tr>
</tbody>
</table>

Table 12. Expected maximal wind squall $V_t$ (ms$–1$) and adequate probabilities $p$ (%), that the same cannot be exceeded for recurrent period of $T$ years for directions of SW quadrant received by Gumbel divisions of extremes, from wind speed data measured by anemograph, at location Martinscica (1969–1988).
Taking into consideration that the basin of Martinscica, with its position, has been exposed more to the winds of north-east and south-west directions because of land orography respectively its openness toward the sea, and because, as hereinafter shown, the strongest and the most usual winds are of named directions, in the cited work was performed the separate calculation of expected maximal speeds for the winds from NE quadrant, SW and SE. The entering data for those calculations were maximal annual speeds for winds blowing only from that directions. In the NE quadrant were put directions N, NNE, NE, ENE and E (bara), while the direction S was included into SE quadrant. For the SW quadrant were observed the SSW, SW, and WSW directions. The NW quadrant wasn’t separated because there are almost not the winds with notable speed.

The calculation results are given in the tables as follows, and all 4 functions are given also in diagrams at paper of probability (table 13). At abscissa axis is positioned the reduced variant $y$ (linear scale) and by it the probability $p(x)$ as well as the reverse period $T$ (double logarithm scale). At ordinate axes are marked values of variable $x$ (maximal wind squall).

Table 13. Theoretical curve of maximal wind squall

The evaluated speed values could be compared with the measured ones, respectively it could be seen in which reverse periods they appear. The absolutely measured extreme for the whole period 50 ms$^{-1}$ independently on direction also for NE quadrant, for SW quadrant is 43,8 ms$^{-1}$, and for SE 29,7 ms$^{-1}$. 
The speed of $50 \text{ ms}^{-1}$ will on average appear once in 50 years, (from NE direction). The speed of $43.8 \text{ ms}^{-1}$, beside the direction from SW quadrant (registered on 29th October 1976), could be expected once in 100 years, and in the same reverse period from SE directions could appear a wind speed of the most $30 \text{ ms}^{-1}$.

Consequently, dominant and the strongest winds at area of Martinscica are from the NE quadrant (comparison in table 10), while considerably lower speeds could be expected from other directions. Moreover, it should be mentioned that the maximal wind squall on January 17th 1987, was more than $50 \text{ ms}^{-1}$, because that anemograph cannot register higher values. Taking into consideration mentioned fact and already said (missing data on some years), it could be concluded that the calculation with more exact data would give some higher maximal wind speeds, from the expected ones. This data should be the basic data on which has to be counted for terminal Brajdica project.

Within research works for montage of drilling rigs at location Martinscica - Zurkovo, in /2/ has been shown the analyses of winds and waves for the named area. It has been also shown for us interesting frequency of appearance of strong and stormy wind as well as maximal number of days with wind appearance, for 22 – years period (1949 – 1970), based on measuring at meteorological station Rijeka (peak elevation 104 m). Systematically presented results are given in Table 14 (hour forces).
Table 14. Frequency of direction and average wind speed

It’s visible that in cited period it was an yearly average of 38 days with strong wind (=6Bf), and six days with stormy wind (=8Bf).
Regarding the wind squalls, for necessity of Splitska obala expansion project in the port of Rijeka, the “RHMZ” elaborated data from anemograph in Martinscica for period 1969 – 1980 (data received from “Rijekaprojekt”, Rijeka).

From afore mentioned data on twelve – years average, it has been received the picture of frequency and wind acting, as follows:

Winds of 11 m/s (40 km/s, 22 knots - 6 Beaufort’s) and strongest, appears 148 days yearly.

Winds of 17 m/s (61 km/s, 33 knots - 7/8 Beaufort’s) and strongest, appears 40 days yearly.

If taken that in calm are on average 39 days yearly (data from meteorological station Rijeka), it comes out that winds up to 11 m/s (from 1-6 Beaufort’s), which are not separately elaborated, appears 217 days in the year.

When winds of 11 m/s (Beaufort’s) and stronger, shown by directions, we reach data as follows:

Winds from I and IV quadrant (north winds) appears:
From 11 m/s (6 Beaufort’s) and stronger 128 days, and of 17 m/s (6/8 Beaufort’s) and stronger 35,5 days.

Winds from II and III quadrant (south winds) appears:
From 11 m/s (6 Beaufort’s) and stronger 19 days, and of 17 m/s (7/8 Beaufort’s) and stronger 4,5 days.

The most part of north winds is bura (NNE, NE and ENE), and a smaller part are other winds.

Based on twelve-year registration of winds in Martinscica (Greevo), it was made the enclosed rose (picture No 15.) of maximal wind intensity. It’s known that position and ship configuration near the coast, has dominant influence on intensity of the littoral bura.

In concrete case, we are first of all interested in data about number of days of wind appearance and their duration period, for which we suppose to cause troubles, stoppages and delay of works at location of Brajdica, and those are strong north winds (bura) of 8 Beaufort’s (17,2 – 20,7 m/s) and more, and south winds speed 10,8 – 13,8 m/s (6 Beaufort’s) and stronger.

The north winds of 17 m/s (7/8 Beaufort’s) and stronger, in duration period longer than 2 hours, appears 39,7 days yearly, in total duration of 382 hours yearly.
If added plus 20% for winds of those speeds, which lasted less than 2 hours, so they were not separately presented, we receive in total the north wind duration period of 17 m/s (7/8 Beaufort’s) and stronger 420 hours or 17.5 days yearly.

The north wind from NNE, NE and ENE (bura) direction, speed of 23 m/s (82 km/h - 44 knots, (9 Beauforts) and stronger, in shorter or longer duration period, appears 27 days yearly.

South winds of 11 m/s (6 Beaufort’s) and stronger, in duration period longer than 3 hours, appears 11 days yearly.

Total duration of south winds with such a force comes to 65.5 hours yearly. When added more of 30% for the winds of such forces, which had duration period less than 3 hours, and therefore were not taken into consideration, we receive a result for total south winds duration period of 11 m/s (6 Beaufort’s) and stronger, of 85 hours or 3.5 days yearly.

A duration of south winds with force of 11 m/s (6 Beaufort’s) according to directions:
The uninterrupted (continually) duration of those winds and forces at longest are 21 hours during the day.

The highest frequency of south winds appears in the last quarter of the year, in October, November and December. The lowest frequency is during the summer period, in July, August and September.

The maximal intensity of the south winds has been considerably weaker from the north ones. The characteristics of Rijeka basin south part are small differences of maximal squalls from single directions. SE and S reach the same speed, and SSE and SSW approximately the same (93 to 94 km/h, 10 Bf). Some higher intensity has the SW (97 km/h).

Winds registered at Meteorological station Rijeka (Kozala) are also elaborated within the same source. The hydro-meteorological institute SRH, made a wind rose according to frequency and forces in Beauforts, for period controlled from the year 1955 to 1969.

Based on said data, it was made the table of frequency and wind force (Table 16), as values per hour.

![Wind Frequency Table](image)

Furthermore, in the paper of author D. Drecun 1981, from maritime meteorological center Split: “The climate characteristics of East Adriatic”, were presented measurements of winds at station of Rijeka for period 1949 – 1976, namely 27 years. They are shown in the Table 17, from which is visible the average frequency and force from single directions given per month, and as yearly average. It’s obvious that the more frequent winds are bura (cca 36 %) and “lebica” (cca 21 % of the year). The average number of
days with the strong wind = 6 Bf, is 38, while the stormy wind = 8 Bf appears 6 days yearly which is the same result as in previously shown data from table 14.

<table>
<thead>
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<td>1</td>
<td>9</td>
<td>2</td>
<td>4</td>
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</tr>
<tr>
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<td>6</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
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<td>2</td>
<td>82</td>
<td>2</td>
</tr>
<tr>
<td>%</td>
<td>7</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 17. Wind – average frequency (in o/o) and force (in Beaufort’s) Rijeka - average number of days with strong and stormy wind, during 27 years of measurement from 1949 -1976

For necessity of Marina Icici Project, the “RHMZ” (19) presented a recurrence number for the strongest, strong and stormy winds of south directions, according to years of appearance in period from 1957 to 1980 at hydro – meteorological station Rijeka, as shown in table 18. It’s visible that it was registered appearance of jugo of 10 Bf, as the strongest wind.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>DIRECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SE - SSE</td>
</tr>
<tr>
<td>1957</td>
<td>7 Bf 5x</td>
</tr>
<tr>
<td>1958</td>
<td>7 Bf 8x</td>
</tr>
<tr>
<td>1959</td>
<td>8 Bf 1x</td>
</tr>
<tr>
<td>1960</td>
<td>8 Bf 1x</td>
</tr>
<tr>
<td>1961</td>
<td>7 Bf 1x</td>
</tr>
<tr>
<td>1962</td>
<td>8 Bf 1x</td>
</tr>
<tr>
<td>1963</td>
<td>7 Bf 7x</td>
</tr>
<tr>
<td>1964</td>
<td>9 Bf 1x</td>
</tr>
<tr>
<td>1965</td>
<td>8 Bf 2x</td>
</tr>
<tr>
<td>1966</td>
<td>8 Bf 1x</td>
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<tr>
<td>1967</td>
<td>7 Bf 4x</td>
</tr>
<tr>
<td>1968</td>
<td>8 Bf 1x</td>
</tr>
<tr>
<td>1969</td>
<td>8 Bf 2x</td>
</tr>
<tr>
<td>1970</td>
<td>7 Bf 3x</td>
</tr>
<tr>
<td>1971</td>
<td>7 Bf 3x</td>
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<td>1972</td>
<td>8 Bf 1x</td>
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<tr>
<td>1973</td>
<td>7 Bf 4x</td>
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<td>1974</td>
<td>9 Bf 1x</td>
</tr>
<tr>
<td>1975</td>
<td>8 Bf 1x</td>
</tr>
<tr>
<td>1976</td>
<td>10 Bf 1x</td>
</tr>
<tr>
<td>1977</td>
<td>9 Bf 2x</td>
</tr>
<tr>
<td>1978</td>
<td>7 Bf 1x</td>
</tr>
<tr>
<td>1979</td>
<td>8 Bf 2x</td>
</tr>
<tr>
<td>1980</td>
<td>8 Bf 1x</td>
</tr>
</tbody>
</table>

Table 18. Recurrence number for the strongest, strong and stormy winds of south directions

The wind rose according the same source for the station of Rijeka, in period 1955 – ’69 (15 years) is shown in table 19, where it could be explicitly seen the appearance of winds also from the NE direction (445,9 o/oo), and SW direction (120 o/oo).

Finally, as data source could be cited the publication “RHMZ” (3), in which are elaborated winds for Adriatic area during the 20-years period (1957-1976). From those data could be defined, for area of Kvarner, the frequency of hour winds for single interesting direction and force, for all seasons, in (o/oo), as follows:
scheme of wind force

1 – 3 Bf 4 – 5 Bf 6 – 7 Bf = 8 Bf

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>NE</th>
<th>SE</th>
<th>S</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>spring</td>
<td>41,0</td>
<td>10,3</td>
<td>174,4</td>
<td>51,3</td>
<td>41,0</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>summer</td>
<td>131,4</td>
<td>- 138,7</td>
<td>29,2</td>
<td>58,4</td>
<td>14,6</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>autumn</td>
<td>96,8</td>
<td>8,1</td>
<td>137,1</td>
<td>121,0</td>
<td>104,8</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>24,2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>winter</td>
<td>148,2</td>
<td>18,5</td>
<td>111,1</td>
<td>64,8</td>
<td>37,0</td>
</tr>
<tr>
<td></td>
<td>18,5</td>
<td>9,3</td>
<td>27,8</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

This data should be applied critically, because a too low number of controlled data, received mainly from vessels and lighthouses, are giving too low values of stormy winds, especially jugo.

WIND ROSE

Station Rijeka
Period 1955 - '69
Table 19. Wind rose

The model of wind rose shows the frequency of winds: from direction n 17%, force 1 bof; from ne 35%, force 4 bof; from e 8%, force 3 bof; from se 28%, force 2 bof; from w 1%, force 5 bof, calm 12%.

EXPLANATION FOR USE OF WIND ROSE
To complete statistical data on wind appearance from various directions, at the end are shown data from (16) about wind roses per months for Rijeka, received in basis of measurements performed during the period 1949 – 1970. Based on roses shown in table 20, the data on explicitly prevailing of NE direction has been confirmed. Only little more than other directions appears the direction SW, while considerably stronger south winds are in November and December.
A.3.4.1.3. SELECTION OF PROJECT WIND CONDITIONS

Analyzing all presented data, we received possibility for establishment of project conditions of wind forces for terminal Brajdica location.

First of all it should be chosen the calculated risk $R$ (%) for exposure to project conditions within the life time of the object.

For the port of such importance as the Port of Rijeka, it should be applied the customary chosen life time of 100 years, on which time the port will be projected. The return period of project conditions $T_d$ depends on chosen calculated risk. The return period $T_d$ is the time period in which are expected appearance of adequate values with probabilities of exceed of the most once, calculated according to adequate method of long – term division, or in other words the return period is the average time interval between two manifested appearances of project conditions, in which they will be statistically reached or exceeded.

The relation between them is

$$R = 1 - \left(1 - \frac{1}{T_d}\right)^2$$

The project conditions return period was also chosen as $T_d = 100$ years, which means that it exists 63% of probability for reaching or exceeding of project conditions, during the duration (life time) period. Naturally, if chosen lower return period the probability would grow, and for the higher one it would be decreasing.

**Project conditions of wind for calculations of berths and movements of berthed vessels**

It could be concluded with very high degree of probability that the wind at location Brajdica will not exceed, in period of 100 years, the following values:

**TWO-MINUTES SQUALL**

- DIRECTION: NE Quadrant (NN – NE – NEE) $V_{max} = 54$ m/s (12 Bf)
- DIRECTION: SE Quadrant $V_{max} = 31$ m/s (11 Bf)
- DIRECTION: SW Quadrant $V_{max} = 45$ m/s (12 Bf)

**Project conditions for calculation of waves in Brajdica aquatorium:**

Presented directions.

- DIRECTION: SSE: 10 Bf, duration more than 2 h (26 m/s)
- DIRECTION: S: 10 Bf, duration 2 h (26 m/s)
DIRECTION: SSW: 10-11 Bf, duration up to 2 h (30 m/s)

Taking into consideration the aforesaid data and values, it is evident that in determined percent of the year the transhipment activities should be stopped because of land devices, respectively vessels berthing possibilities. Based on herein showed data, in the project this period should be analyzed more in detail.

**Project conditions of wind for calculations of waves in front of Brajdica terminal**

Based on above shown data and their analyzes, and taking also into consideration the values of wind squalls, there are chosen the hour parameters for waves prognoses in 100 years of return period, as follows:

<table>
<thead>
<tr>
<th>Critical directions</th>
<th>Wind speed Bf (m/s)</th>
<th>duration h</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE</td>
<td>10 (26)</td>
<td>&gt;2</td>
</tr>
<tr>
<td>S</td>
<td>10/11 (30)</td>
<td>&gt;2</td>
</tr>
<tr>
<td>SSW</td>
<td>10/11 (30)</td>
<td>2</td>
</tr>
<tr>
<td>SW</td>
<td>10/11 (30)</td>
<td>&lt;2</td>
</tr>
</tbody>
</table>

Here are presented the project conditions for constructions on the coast.

The port operationally project conditions could be also defined from the further shown data, but they depend on selection of transhipment constructions, size of vessels and criteria of their movements, which should be elaborated in separate hydraulic study within the project.

**A.3.4.1.2. DOMINANT WAVES ON TERMINAL BRAJDICA AREA**

**A.3.4.1.2.1. GROUND SWELL WIND WAVE**

The prognoses of wind waves as the most important long–term manifestation of sea dynamics could be determined directly from sufficiently measured data, with long–term division or indirectly from data on winds. We will here elaborate the prognoses with both of mentioned methods.

**A long–term prognoses of waves statistical characteristics by direct measurement**

For such a prognoses we have on disposal two sources. The first one is directly measurement of waves at jetty Brgudi in Rijeka, therefore very close to our investigate location, which was executed during 11–month period (VII/74 – V/75) (17). The measurement was performed co-operationally by equips of Hydro-technical laboratory of Civil engineering Faculty Zagreb and Institute “Rudjer Boskovic”. The second one is the Climate atlas of Adriatic sea, where was shown the mean and maximal registered wave height. Measurements at jetty Brgudi has been showed in tables 21 – 29.
Table 21. Wave appearance according to high, for measuring period 10th - 24th Sept. and 29th - 31st Dec. 1974

<table>
<thead>
<tr>
<th>H(cm)</th>
<th>česta</th>
<th>cena</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>do 10</td>
<td>12</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10 do 20</td>
<td>43</td>
<td>53,6</td>
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<tr>
<td>20 do 30</td>
<td>27</td>
<td>22,6</td>
<td></td>
</tr>
<tr>
<td>30 i preko 60</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Table 22. Registered maximal wave high in 96 measurement periods

<table>
<thead>
<tr>
<th>H(cm)</th>
<th>br. pojavov</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>do 10</td>
<td>127,5</td>
<td>16.04</td>
</tr>
<tr>
<td>10 do 20</td>
<td>18,41</td>
<td>2,08</td>
</tr>
<tr>
<td>20 do 30</td>
<td>10,41</td>
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<td>930 do 940</td>
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<td>960 do 970</td>
<td>1,23</td>
<td>0,15</td>
</tr>
<tr>
<td>970 do 980</td>
<td>1,23</td>
<td>0,15</td>
</tr>
<tr>
<td>980 do 990</td>
<td>1,23</td>
<td>0,15</td>
</tr>
<tr>
<td>990 do 1000</td>
<td>1,23</td>
<td>0,15</td>
</tr>
</tbody>
</table>
Table 23. Registered maximal wave high in 88 measurement periods

Table 24. Registered maximal wave high in 189 measurement periods
Table 25. Duration period for single sea conditions

Table 26. Relation between the significant and maximal wave high
Table 27.  Relation between the considerably wave high and the significant wave period

Table 28.  Relation between the wave high with speed and duration of the wind
Table 29. Relation of the wave period with speed and duration of the wind

Table 30. Relation of the wave period with duration of the various wind intensity
This waves are in fact characteristic for period of 1,5 year, so their return period could be considered in that period for Brajdica.
On such a manner we receive the values of wave high as follows:

Measuring at jetty Brgudi

Significant wave highs and periods of one-year wave

\[ H_{1/3}^{1.5} = 2.4 m \tau = 4.7 s \quad H_{\text{max}}^{1.5} = 5.0 m \]

The climate atlas for Adriatic Sea shows for Rijeka bay quadrant the wave rose per months.
In table 31 was shown the wave rose for the whole year as maximal, therefore this data can be used for 14 – years return period. The waves shown as maximal based on vessels registering, according to experience, should be taken as significant wave highs.

Table 31. Elaborated wave rose for the whole year

<table>
<thead>
<tr>
<th>DIRECTION</th>
<th>SE</th>
<th>( \bar{H} = 1.08 )</th>
<th>( H_{1/3}^{14} = 3.50 ) m</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIRECTION</td>
<td>S</td>
<td>( \bar{H} = 1.04 )</td>
<td>( H_{1/3}^{14} = 2.50 ) m</td>
</tr>
<tr>
<td>DIRECTION</td>
<td>SW</td>
<td>( \bar{H} = 1.35 )</td>
<td>( H_{1/3}^{14} = 3.50 ) m</td>
</tr>
</tbody>
</table>
Unfortunately, those data are not numerous and reliable for a wider area, so for final prognoses could be taken only as informative, but they show relative relations of single wave directions, respectively that the waves from Se direction are equal to one from SW direction, and that they are smaller from S direction.

Table 32. Sector of exposure for the critical waves on terminal Brajdica
A long – term prognoses of wave characteristics by data on wind

The wave prognosis from a long – term winds measurement has been one of the most used and reliable methods, as it was established their reciprocal connection. If the long – term appearance of the wind speed was properly defined, it could be defined also the characteristics of statistical wave parameters. The port of Rijeka is positioned in a very close aquatory of the Rijeka bay, with very jagged edges of islands and the coast, as visible from picture No. 3.12. Dimensions of windward side correspond to very small aquatories, so for wave prognoses cannot be used methods developed for oceans and open seas.

As in the previous chapter were in detail elaborated winds at port of Rijeka location, from which is visible, in 100 – years return period possible wind speeds per hour, responsible for development of waves, of directions as follows:

\[
\text{SSE} = \frac{9}{10} \text{ Bf} \ (25 \text{ m/s}), \quad S = \frac{10}{11} \text{ Bf} \ (28 \text{ m/s}), \quad SW = \frac{10}{11} \text{ Bf} \ (28 \text{ m/s})
\]

A very reliable and approved checked method for prognoses of wave characteristics for small windward sides into strong winds is the Groen – Dorrenstein diagram from which is possible to read out the wave highs, periods and minimally lasting winds for some windward side. By this diagram and correction of the windward side, we receive the result as follows:

<table>
<thead>
<tr>
<th>Direction</th>
<th>Windward side</th>
<th>Wind 100 g.p.p.</th>
<th>Waves H 1/3</th>
<th>Duration</th>
<th>Period T</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE</td>
<td>14 km</td>
<td>26 m/s</td>
<td>2,8 m</td>
<td>&lt; 2 h</td>
<td>4,4 s</td>
</tr>
<tr>
<td>S</td>
<td>24 km</td>
<td>30 m/s</td>
<td>3,9 m</td>
<td>&lt; 2 h</td>
<td>5,2 s</td>
</tr>
<tr>
<td>SSW</td>
<td>19 km</td>
<td>30 m/s</td>
<td>3,6 m</td>
<td>&lt; 2 h</td>
<td>5,0 s</td>
</tr>
<tr>
<td>SW</td>
<td>22 km</td>
<td>30 m/s</td>
<td>3,8 m</td>
<td>&lt; 2 h</td>
<td>5,1 s</td>
</tr>
</tbody>
</table>

The next source for wave prognoses was the study of waves at position of the Shipyard “3rd May”, a little bit more than 1 km west from the port, which in the year 1991 made professionals of the Civil engineering Faculty Zagreb (10). Based on winds registered at meteorological station Rijeka, they made a long – term prognoses, showed in tables as follows:

<table>
<thead>
<tr>
<th>Return period (year)</th>
<th>Hs (m)</th>
<th>TS (s)</th>
<th>( H ) ( 1/10 ) (m)</th>
<th>T ( 1/10 ) (s)</th>
<th>H ( 1/100 ) (m)</th>
<th>T ( 1/100 ) (s)</th>
<th>H ( 1/1000 ) (m)</th>
<th>T ( 1/1000 ) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11:10</td>
<td>2.2</td>
<td>3.8</td>
<td>2.8</td>
<td>4.2</td>
<td>3.7</td>
<td>4.9</td>
<td>4.4</td>
</tr>
<tr>
<td>2</td>
<td>1:10</td>
<td>2.7</td>
<td>4.2</td>
<td>3.4</td>
<td>4.5</td>
<td>4.5</td>
<td>5.4</td>
<td>5.1</td>
</tr>
<tr>
<td>10</td>
<td>1:10</td>
<td>3.4</td>
<td>5.7</td>
<td>4.2</td>
<td>6.5</td>
<td>5.7</td>
<td>7.4</td>
<td>6.8</td>
</tr>
<tr>
<td>10</td>
<td>1:10</td>
<td>3.4</td>
<td>5.7</td>
<td>4.2</td>
<td>6.5</td>
<td>5.7</td>
<td>7.4</td>
<td>6.8</td>
</tr>
<tr>
<td>50</td>
<td>1:10</td>
<td>3.9</td>
<td>5.0</td>
<td>5.0</td>
<td>6.5</td>
<td>6.5</td>
<td>7.4</td>
<td>7.8</td>
</tr>
<tr>
<td>50</td>
<td>1:10</td>
<td>3.9</td>
<td>6.1</td>
<td>5.0</td>
<td>7.0</td>
<td>6.8</td>
<td>7.9</td>
<td>8.7</td>
</tr>
<tr>
<td>100</td>
<td>1:10</td>
<td>4.1</td>
<td>5.1</td>
<td>5.2</td>
<td>6.8</td>
<td>6.8</td>
<td>8.2</td>
<td>8.2</td>
</tr>
<tr>
<td>100</td>
<td>1:15</td>
<td>4.1</td>
<td>6.3</td>
<td>5.2</td>
<td>7.1</td>
<td>6.8</td>
<td>8.1</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Table 33. Value of characteristic ground well south wave parameters steep 1 : 10 / 1 : 15 at location of the shipyard “3rd May” in Rijeka
The further prognoses sources are (Androcec, 4 (1986)) diagram of the long – term division of significant wave highs for closed Adriatic windward, from which we receive:

<table>
<thead>
<tr>
<th>Direction</th>
<th>Windward</th>
<th>$H_{1/3}^1$</th>
<th>$H_{1/3}^{20}$</th>
<th>$H_{1/3}^{100}$</th>
<th>$T_{1/3}^{100}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE</td>
<td>14 km</td>
<td>1.9 m</td>
<td>2.7 m</td>
<td>3.2 m</td>
<td>4.5 s</td>
</tr>
<tr>
<td>S</td>
<td>24 km</td>
<td>2.5 m</td>
<td>3.5 m</td>
<td>4.0 m</td>
<td>5.2 s</td>
</tr>
<tr>
<td>SSW</td>
<td>19 km</td>
<td>2.2 m</td>
<td>3.1 m</td>
<td>3.6 m</td>
<td>5.0 s</td>
</tr>
<tr>
<td>SW</td>
<td>22 km</td>
<td>2.4 m</td>
<td>3.3 m</td>
<td>3.7 m</td>
<td>5.1 s</td>
</tr>
</tbody>
</table>

And prognoses for the port of Rijeka Zagreb pier (18).

Summing all above results, as the final one was decided to take the prognoses of statistical wave parameters at deep water position in front of terminal Brajdica, as follows (Table 34.)

![Wave Prognoses Near Terminal Brajdica](image-url)

Table 34. Wave prognoses near terminal Brajdica
Table 35. Prognoses of the ground swell waves in front of Brajdica terminal from critical directions

It was also shown the wave highs of one tenth for the waves, which is the usual project parameter for such a type of construction. It was concluded that there are relatively high waves at such an opened coast, and in accordance with the same should be dimensioned terminal and defined the transshipment conditions as well as staying of the ship on berth.

Influence of waves at location of Brajdica terminal

The afore progessed waves are the ground swell ones, respectively it was supposed that they will not be subject to deformation or that it’ll be minimal because the sea depth at the same building location comes to cca 30 m and more, and they are steeply increasing.

The influence on wave deformation because of shallow waters, respectively influence of the seabed could be ignored, because they start to appear when depth smaller than half of the wavelength, which in this case doesn’t appear neither for the highest waves.

The influence of diffraction appears for the above described critical wave directions, and so at the ends of terminal, depending of wave direction. This deformation is some more important at the part of pier and radial performed coast, and which will super-pone with reflections from radial coast, therefore here will arise an area of short three-dimensional waves, which fact shouldn’t influence on the very same berthing of the ships.

More problematic has been the case with wave reflection from the vertical terminal wall, especially of those waves coming vertically on the same. Here will appear the standing waves which could have a double highness from the coming incidental ones.

This manifestation will have more importance than it has now at existing terminal, because the vertical wall will be double longer, so the lateral effect will not be so important.

A.3.4.1.2.2. SEA CURRENTS AT LUKA RIJEKA AREA

The Rijeka bay as part of Kvarner is a closed system which has three entrances – exits. At east “Tihi kanal” (Calm channel), at south “Srednja vrata” (Middle door) and on south-west “Vela vrata” (Big door).
The circulation of the sea within this area depends, besides on sea daily changes because of ebb and flow and on main Adriatic current, on many local factors as geometry, jagged coast, salinity, temperature changes, affluent fresh waters, and wind and similar. Consequently, it was established that currents in this area have a complicated and changeable three-dimensional flow. Measurements performed during the year 1976 and 1977 from the Center for sea research side (11), showed all complexity of sea motions within the Rijeka bay, especially comparing surface currents and undercurrents, which are at the same spot frequently of opposite direction, so it can be concluded that general stream goes through a series of water whirl pools, formed and arranged during the time.

The speed of the current is the highest at entrance–exit areas, while it decrease toward the Rijeka port, where it comes up to cca 0.2 Kn.

The summer and winter regimes are especially noted. At summer generally, the flow of streams in front of Rijeka are coming from NW towards SE direction, while on the contrary during the winter.

In paper (11) are shown measurements of sea currents speeds and directions characteristic for Rijeka port wider area.

Currents by ground swell layers in different directions (layering) appears in all situations, except in December when the movement of the water masses is homogeneous from surface to the bottom (regarding direction), and so in “Srednja” and “Velika vrata” (Middle and Big passage);

The resulting current’s speeds of the highest values are in February and December and they appear in all layers, which is especially noted in February;

Minimal resulting speed values under 0,1 Kn are the most frequent during the summer months.

Of similar behavior are mean values of current speeds, with difference of higher frequency in September;

Appearance of current’s speeds maximal values are similarly equally divided in February, September and December. In June and August the absolute values of maximal current’s speed are lower regarding other months;

The absolute maximal speed is 1,65 Kn and appears in February, while other value maximum of 1,63 Kn appears in September. Both maximums were measured in surface layer. Taking into consideration that registered maximums were measured during specific meteorological conditions (wind direction NE, speed 6,5 – 21,0 cm/sec) it could be expected that such maximums could appear during similar meteorological conditions without regard to season.

With smaller exceptions, it could be concluded that in most of cases the speed of current decreases with depth increasing,

The flow of the sea currents in Rijeka bay depends a lot on fact if the basin is “filled up” with water from “Kvarneric” over the “Srednja vrata” (Middle door), or with water from Kvarner over the “Velika vrata” (Big passage).
Measurements and analyses performed thus far, pointed into dominant entering flow of waters from Kvarneric through “Srednja vrata” during the autumn and winter period. As especially in December and February is already formed the flow of gradient currents in Adriatic, so in those months the flow of streams in the bay has characteristics of general gradient currents flow in this part of Adriatic. Considering the fact that in bay prevails, especially in winter months, the cyclone flow of current, so the speed of such a current at trajectory edges is higher than in the central part of the bay. In the whole bay is characteristic decreasing of the current’s speed from the bottom surface;

Measurements by “Drift” buoys showed that direction and speed of the surface current in Rijeka bay mostly depends on direction and force of the wind as well as on wind duration period. Dominant influence on surface current elements have N and NE winds. In the bay prevails a cyclonal flow of surface current. This is especially notable in months of December and February/March. During explicitly calm weather, from local influences could be pointed out the influence of river Rjecina at narrower part in front of terminal Brajdica. In mentioned situation can appear “division” of current’s flow in this part of the bay. Commonly, the configuration of coastal line influences on sea current’s direction.

Concerning preliminary design for Brajdica terminal expansion, it’s evident that the sea currents in wider and narrower building area practically will not change, and that it will be reached sufficient speed for self-cleaning of the same terminal aquatory, as until now.

Therefore, it’s considered that there are not necessary any separate modellings of works impact regarding the sea currents.

A.3.4.1.2.3. SEA TIDES AT TERMINAL BRAJDICA POSITION

Sea tides at Adriatic in general

The sea tides are defined as periodically oscillation of level under influence of periodical forces, arising because of gravity of the Moon and the Sun at Earth during Rotation. Therefore the sea tides are an determined movement of the sea water. If controlled during certain period of time at some area, it could be prognosticate with sufficient exactness for several years in advance.

The sea tides were started to be studied in oceanography, because the basic astronomical theory was known since the end of 17th century; the hydrodynamic theory was relatively good for applying also without modern issues on friction and turbulence; besides, it was of practical use in navigation. The sea tides appears as periodical vertical movements of the sea levels which accompany horizontal water progressing or withdrawing, e.g. currents of rising and falling tides.

The sea levels, even during the longest calm, constantly oscillate around defined medium condition. When the sea level descend to the lowest water level, for some short period of time stays on the same and than become slowly to rise. In the same time can be visible the horizontal flow from the open sea toward the coast. Rising of the sea level is slow in the beginning, and after (during transition of medium condition) faster, and at the end (closer to the highest water level) again more slowly. When reached the highest condition, the sea level again stays at the same level. The same happens during level descending: in the beginning it’s slow, near the medium water level faster, and near the end slow again.
Phases of the highest water level is called High water (French: Pleine mer, Deutsch: Hochwasser, Tal: Alta marea), and phase of the lowest water level Low water (French: Basse mer, Deutsch: Niedrigwasser, Tal: Bassa marea). Rising of the sea level, i.e. a period of time between Low water and the next High water is called Rising tide (French: Flux or montant, Deutsch: Flut, Tal: Flusso), and descending of level Falling tide (French: Reflux or perdant, Deutsch: Ebbe, Tal: Riflusso). The difference of high between the high and low water is called amplitude of the sea tides. Time between two successive high waters is called period, which at normal sea tides lasts on average 12 hours and 25 minutes (half of the moon day), but the rising and falling tide during that period aren’t mutually equal.

The sea tides are controlled by water-gauges and mareographs. The ordinates on mareographs are vertical components of sea surface vacillation. With longer controlling is defined the medium sea level which is the base for all controlling, for all calculations and for defining of high at the land. But all measurements of highs and depths could be referred only to the medium level of some point in determined area, because the medium level is only the conventional one, exactly defined only in one spot of the area, and has the value only for that very same spot. At Adriatic sea that spot is in pier Sartori in Triest (0 – general leveling).

The Adriatic sea tides are of mixed type, with very explicit daily high’s difference. They are not independent, which means that oscillating Adriatic masses are coming from the Ionic sea with periodical water circulation through the Otrant door, and not directly with gravitational acting of the Moon and the Sun.

**Sea level long-term prognoses at port of Rijeka position**

Within the port of Rijeka position doesn’t exist a mareograph which could register the sea levels. Therefore, for a long-term prognoses should be use measurements data from other stations. Based on measurements from meteorological stations Koper, Rovinj, Bakar, Split and Dubrovnik, Mr. Prsic (Magister paper 1983) elaborated a long-term prognoses of Adriatic sea levels. Based on those data, and especially by interpolation of data for mareographic stations Rovinj and Bakar, it was made a prognoses presented in table 36.

Consequently, medium level is for 15 cm higher than zero of general level GH, and hydrographic zero is 28 cm lower than zero GN.

The extreme values of one hundred year VR and NR are on distance of 2,25 m, which fact should be taken into consideration during projecting of the port coast.
In general, the characteristic of climate at port of Rijeka area is that it represents a mild Mediterranean type of climate, with warm but more humid summers and mostly mild and rainy winters. Based on climate characteristics from (14) in period 1949 – 1976 (27 years) presented by medium monthly values at table 3.17., we can conclude the following:

Temperatures are in range from minimum lower than (-12°C) to maximum higher than (+37°C).

The average monthly cloudy weather is between 50% and 60%, during summer months cca 40%, and during winter months cca 70%.

Average relative humidity is in narrow limits between 56% and 70%, while the atmospheric precipitations are considerably and on average cca 1400 mm yearly, which is double of continental Croatia average.
The number of cloudy days is cca 120 which represent one third of the year, while sunny are cca 80. The number of days with snow is on average 3, and with hail 2 yearly.

Regarding the mist which could jeopardize operating of the coast, statistic shows that it appears on average 5 days yearly, in which could be under question the coastal operations and port manoeuvres.

### Table 37. CLIMATE CHARACTERISTICS – medium monthly values of meteorological elements and appearances

<table>
<thead>
<tr>
<th></th>
<th>TEMPERATURE</th>
<th>B. Vl.</th>
<th>RADUVNE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MJ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sun day avg.</td>
<td>9.7</td>
<td>9.7</td>
<td>22.0</td>
</tr>
<tr>
<td>Sun day min.</td>
<td>6.4</td>
<td>8.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean temp.</td>
<td>12.1</td>
<td>8.4</td>
<td>5.0</td>
</tr>
<tr>
<td>Max temp.</td>
<td>15.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Min temp.</td>
<td>7.0</td>
<td>5.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

4.1. Data from two very close meteorological stations as well as other data, are giving a good base on wind characteristics at location of terminal. The strongest winds explicitly frequently are blowing from NE quadrant and reach stormy and hurricane speeds with squalls over 50 m/s. Those data are important for the project because all port devices and equipment should be dimensioned for such circumstances.

The same operating of the port here could be defined as a period in which the port devices are in function regarding the wind and the waves, because of different size of ship movements, which should be, according to adequate data, defined within a hydraulic study in frames of the same project.

The waves climate at location of Brajdica, regarding the surface waves, is expressed as direct influence of herein prognosticated deep-water waves from critical directions.

Calculated wave highs shows on possibility of high waves appearance (e.g. 100-years maximal wave was high cca 8m) according to which, by chosen criteria, should be dimensioned the construction of the coast, taking into consideration especially the wave reflections.
Because of all above mentioned reasons it’s necessary to analyze presently preliminary solution in sense of change of the new coastal route, and construction of the same coast as mentioned previously.

The sea currents which circulate around terminal are of enough speed to make changes of sea masses. As the construction of terminal’s second phase will not considerably change this picture neither in the close environment, there is no need to analyze such a condition with separate measurements and models, because their controlling will be defined within the project.

Sea changes described and defined herein will contribute to good changes of the sea in the very same terminal aquatorium, and defined sea levels are a good base for final decision on coastal wall high to assure the terminal functioning.

Changes of the sea nearby and on the same terminal will improve dynamic influence of river Rjecina waters, delta of which is situated near the same.

Experiences up today at constructed first phase of terminal Brajdica in sense of sea and wind dynamics influence on operating and security of such an opened type of terminal, shows that present level of functioning is satisfactory, and that there are not considerably often and bigger work stoppages. Anyway, with construction of this terminal, and by increasing of port capacities, the ship’s arrivals will be more frequent and it’ll surely appear the problem of berth safety and transshipment possibilities, especially during the winter. It could be defined in general that depending of ship’s size, terminal will not be in function because of the wind and the waves cca 6 – 10% yearly.

It’s obvious that such a terminal solution is acceptable from all aspects of the environmental protection regarding the sea dynamics, and if acceptable for investor also economically, notwithstanding the mentioned working limitations because of construction of the opened port coastal system, it could be accepted with aforementioned additional calculations and analyses which will be elaborated within the project.

A.3.4.2. PLANT AND ANIMAL WORLD IN THE SEA

A.3.4.2.1. INTRODUCTION

Structure and extension of life communities at seabed are indirect indicator of certain aquatory general characteristics, depending on geo-morphological, hydrographic and hydrodynamic particularities of the area. Degradation changes within the concrete communities points at long-term unfavorable influences of changed life environment. From the other side, communities living at seabed are because of their long life quite slow in response, and a consequences of disturbance can be visible during the longer period of time. Even in case of acute short-term but explicitly strong and not noticed disturbance, the consequences will be visible in composition and structure of impacted community. Therefore nowadays studying of concrete communities is considered as one of methods reliable for discovering of men’s acting on the sea environment.

A.3.4.2.2. AREA OF RESEARCHING
According to available data, the area under construction (port terminal Brajdica) was a subject of biocenological research within the project “Ecological Study on Rijeka bay” in period from the year 1976 – 1981.

Unfortunately, at only station in the area under construction (RI-40) were, in accordance with work program, performed controls only in communities of supra-, medium-, upper infralitoral, and vertical carting at bigger depths wasn’t performed. Therefore there aren’t historical data on condition of the coastal concrete’s communities at area under construction. However, it was made a conclusion based on data from other localities, as follows:

“… The coastal area of north and north-west part of the Rijeka bay between Urinj and Ika is constantly under influence of polluted surface waters which results with changed, respectively degraded and nitrofile aspect of communities in mediolitoral and upper infralitoral. At bigger depths were not noticed unfavorable influences of direct pollution with waste waters, except on area of the Rijeka port…”

A.3.4.2.3. METHOD OF WORK

As a rule, for evaluation of present conditions for life communities of the seabed are used the standard methods of work. During the terrene biocenological research along the transsects has been used a standard method of direct observing and sampling, with use of autonomic diving equipment (SCUBA), and on site notes are completed with photographs. A biological material is conserved in 70% alcohol or 4% neutralized formaldehyde. The average number of individuals is evaluated in degrees of abundance: R = rare specimens, + = species is frequent, C = species very frequent, CC = the species prevails with numerousness. Besides this marks, it’s also registered the number of single specimens in the certain sight field.

For purpose of biological evaluation for the environmental impact study regarding the constructing of objects at the coast, it has been performed a biocenological analyses of the seabed flora and fauna with goal of seabed communities valorization. The biocenological analyses of the seabed communities is performed on bases of fitocenologic method according to Braun-Blanquet (1921), and for their names is used a nomenclature Per?s and Picard (1964), Gamulin-Bride (1967), Per?s and Gamulin-Bride (1973), and Bellan-Santini and ass. (1994), generally accepted for similar researches in Mediterranean and Adriatic.

However, the area of construction is the prolongation of the port area. In the same time that is an area of constant filling with construction and every kind of other materials, and has the role of some kind of city dump. Therefore, because of reason which will be elaborated later on, it was made an inspection into results of batimetric measurements executed in the year 1994 and 2004 within the area under construction.

A.3.4.2.4. RESULTS OF DISCUSSIONS

Inspecting results of measurements of the sea depth at area under construction, performed in the year 1994, and comparing the same with results of measurements performed in the year 2004 (Attachments I, II), there are visible consequences of constant filling with materials and covering up of the seabed. Decrease of depth isn’t uniformly disposed at area under construction. The biggest change during the last ten years occurred at profiles 12, 5 and 2, where a depth was on some spots decreased for cca 30 meters! At transverse profile VI only at depth of 35 m aren’t any more visible traces of filling, which is for cca 120 meters on distance of the coastal line from the year 1994. In the same time the line Om was displaced for almost 20 meters into the
sea. At transverse profile IV a depth is on some spots decreased for 19 meters, and a coastal line was displaced for more than 20 meters.

At transversal profile X a depth was in some places increased up to 5.5 meters, which is quite surprising. The only logical explanation is that there were performed works on excavation of materials for reaching of needed working depth. However, after 33 meters of depth it’s visible a new layer of sediment, thickness of 1.5 meters.

Already with one term filling of materials comes to destroying of autochthonal seabed communities because of filling:

“...By construction works along the coast or filling of terrain comes, meanwhile, as a rule, to locally limited destroying of coastal communities...”

According to results of batimetric measurements and differences of measured depths during the ten-years period, it’s visible that the process of filling with materials was performed continually. Owing to that, it was physically stopped any process for recovering of the seabed communities, as the new materials were permanently deposited on. The area of influence isn’t limited only to a narrow litoral area, but it embraces quite larger zone, at least 120 meters from the coastal line from the year 1994. That influence was possible to measure applying the batimetry of the area.

Besides, by filling of materials, the inclination of the coast and a type of substrate was changed, which brought to aggravate recovering of the autochthonous communities. The recover of the community is a long lasting process, aggravated by non-consolidate base and a type of substrate of soil origin (Jaklin and Arko-Pijevac, 1977). Changed conditions of environment provides sometimes a development of new communities, very often and on long term in degrading aspect.

Besides destroying of the autochthonous community in the filled area, under influence of filled material dispersion was encumbered the wider area of the named aquatory. As a consequence of sedimentation of heavier particles it will be physically aggravated the condition at the bottom, and detaining of the finest fraction in suspension will decrease penetration of light through the water column. Decreased intensity of light near the bottom can considerably deteriorate the life conditions of autotrophic biocenose organisms of photophile algae. Even though that community, if it could be a word about community at all, has presently an explicitly degrading aspect, it still, up to some measure, increases the biologic diversity of the mentioned aquatory and represents the most productive and biologically the most valuable part of the infralitoral.

That part of influence, because of sedimentation of suspended filled materials fraction, wasn’t possible to measure by biometric method. It’s a question of substrate mudding and covering of organisms with layer of the finest particles, which has also negative influence for the living seabed world (Jaklin and Arko-Pijevac, 1994). Nevertheless, based on experience, it’s possible to evaluate that it is expanding on considerably wider area and probably comprehends an area of several square kilometres of the sediment seabed.

A.3.4.2.5. CONCLUSIONS

Autochthonal communities were destroyed by covering because of continually filling with materials.
Under the aggravated conditions within the port, and because of constant sedimentation of the new materials of soil provenience, it was rendered impossible even the initial grade of the concrete communities recuperation.

The influence of material filling wasn’t limited only to a coastal edge, because it is extending at considerably wider area of the aquatory in subject.

Picture 38. Synoptic situation of Brajdica
LEGEND:
- Red: SEA DEPTHS MEASURED IN THE YEAR 1994
- Blue: SEA DEPTHS MEASURED IN THE YEAR 2004
A.3.4.3. GEO-TECHNICAL EVALUATION OF THE LOCATION

A.3.4.3.1. GEOLOGICAL STRUCTURE

The basic rocks at elaborated area are the sediment rocks of carbonate type, from upper calcareous to paleogen age. The upper calcareous rocks are: dolomites and lime-stones in exchange ("cenoman-turon") and mineral calcarees ("turon-senon"). The paleogen rocks are foraminifer lime-stones (lower-middle Eocene). On calcareous and paleogen carbonate rocks can be sporadically found the not eroded remains of sediment rocks of paleogen age, but of classical type: calcareous 2brece" (Eocene – Oligocene).
The elaborated location is positioned at junction of tectonic units Ilirska Bistrica – Rijeka – Vinodol – Omisalj and tectonic unit Podgrad – Kastav. The main structure direction is dinaric: NW – SE. Because of accentuated tangential movements during the paleogenic tectonic age, it came to contraction of the rock’s masses. The consequence of such deformation was wrinkling of the calcareous and paleogenic rocks and creation of reverse structures and layers. After changed direction of regional stress from SW-NE at almost all N-S in younger, neotectonic age, were disturbed the previously created structures. The rock’s mass was in whole deformed, cracked and chipped several meters under it’s surface.

The geologic structure, as also the engineering – geological and geo-technical characteristics of the container terminal location were defined by the morphological evolution of the Rijeka bay. Presently, the appearance of the landscape regarding the coast and the seabed, is the consequence of overflowing of the land because of sea level increasing, than because of filling the estuary with sediments brought by river Rijecina, and finally, because of filling of the submarine area during the construction of the port and expansion of the city. During the last glacial age (140,000 to 10,000 years a.c) the level of Adriatic sea was considerably lower and expressively oscillating between –40 and –120 m. Owing to that, the flow of the river Riječina in that period was deeply cut into carbonate rock mass at area of today’s delta. In those times the river delta was positioned at south – west from nowadays coast. With sudden arise of the sea level, the sea overflowed Rijeka bay as well as the existing valley, forming estuary. During the last millennium, because of slowing down of the sea level, started intensive sedimentation of materials brought by river Rijecina. Sediments were brought in form of pulled and suspended levels, and they arose by erosion of paleogenic fisch layers and quart masses at upstream part of the river Rijecina valley.

A.3.4.3.2. GEO-TECHNICAL CHARACTERISTICS

A basic rock in the submarine area is completely covered with flooded materials (gravel and sand), marine sediments (fine, partially dusty sand) and filled materials (mostly big stones). Being the fossil bed of the river Rijecina deeply cut into carbonate rock mass, a total thickness of natural sediments and fillings comes at some places up to 60 m at the south end of nowadays coast.

At location of already constructed and for expansion planned container terminal, the sediments above the basic rock are made of poorly consolidated sandy-dusty flooded materials and marine sediments. They are almost completely non-coherent and loosen to weekly compacted. They are of considerably week geo-technical characteristics in regard to the rock mass at the base. During formatting of the big rock fill, the material was segregate according to size, and a rock blocks penetrate into small grained sediments. The hydro-dynamic acting of waves increased mixing of those two, second the granulation essentially different materials. The analyses of geo-technical characteristics and sagging of the plateau south of the Old city in Rijeka, which was also created by filling of the seabed, showed that the primary consolidation lasted cca 80 years. Consolidation of rock’s dam is mainly finished, and it’s difficult to distinguish the influence of consolidation of marine sediments and it’s saturation with dam. Therefore even presently lasts the secondary consolidation.

A.3.4.3.3. HYDRO-GEOLOGICAL DATA

Examined area belongs to water – spring basin between delta of Rječina and Martinscica bay. According to surface, it’s a small basin limited at the north-east by fisch hydro-geological barrier, extending along the
central part of Susacka draga valley. The basin area is made of carbonate rocks, as described in previous chapter. Because of explicit cracked and chipped structure, the carbonate rock mass is considered in whole, of medium up to good non-watertight. Porosity is of fissure – cavern type. That is in the same time the water carrier of the karst type. The sources are of small abundance and mostly salted. The most of underground waters diffusely flows into the sea. The coastal area of Brajdica is positioned out of sanitary zones of drinking water sources.

A.3.4.3.4. SEISMIC CHARACTERISTICS

Wider area of Rijeka is seismically active. The same is visible from thickness of earthquake epicentres, their frequency as well as the size of seismic impacts magnitudes. The cause of increased seismic activity is passing of the Adriatic plate under the Dinarides. The highest seismic-tectonic activity is in the zone 30 km of average width, which is extending from Klana over Rijeka and Vinodol, and comprehends the north-east part of island Krk. The basic seismic characteristic makes appearance of considerably number of relatively weeker earthquakes in seismic active periods. The hypocentre, respectively earthquake’s epicentres are positioned at depth of 2 to 30 km, which is relatively shallow. Therefore the earthquakes are local, and they don’t embrace wider area. The epicentre areas are in Klana, the same Rijeka, east of Omisalj and between Bribir and Grizane in Vinodol valley.

Thus far the strongest earthquake at Kvarner area happened in the year 1916, in zone Bribir – Grizane. It had magnitude $M=5.8$ and intensity 7-8° MSC. According to new informations, the strongest earthquake at Rijeka area could reach the force of $M=6.1$. Seismic waves can come to area of Rijeka from two neighbouring areas: Furlania’s and Lubiana’s, where the earthquakes of higher magnitudes could be expected. According to seismic micro-territory from the year 1974, the basic seismic degree is of 8 MCS scale, and seismic coefficient $K_c = 0.06$. This values are referring to etalon soil: cracked and chipped carbonate rocks. Of similar characteristics are also the rock masses found at area of Brajdica at bases of planned construction. On flooded materials and marine sediments, where is also the high level of submarine water, the seismic grade is 8*, and seismic coefficient $K_c = 0.08$.

According to other data in force, the basic seismic intensity at coastal area of Rijeka, has been 7° of the MCS scale. The expected intensity, with appearance probability of 63% are: 6° MSK-64 for return period of 50 years, 7° MSK-64 for return period of 100 years and 8° MSK-64 for return period of 200 and 500 years.

The special characteristic of the small grained sediments saturated with water, is a danger of liquefact appearance, during earthquake of higher intensity. In that case, sediments in moment of seismic waves passage, completely loose their strength, therefore are possible extremely high sagging and damaging of constructions based on such sediments. The small grained marine sediments at area of Brajdica can be also counted into liquefable type.
A.3.5. EVALUATION OF EXISTING LOCATION LOADS

A.3.5.1. AIR

At the port area of Rijeka–Susak basin, aren’t biggest stationed, pointed sources of air pollution. In some smaller boiler rooms, intended to heating of business premises, is used gas or special light liquid fuel, and quantities of polluting materials which are emitted in the air are insignificant.

The transhipment devices belong to diffuse sources of area pollution, i.e. there is not existing the certain exhaust where the values of polluted materials emission could be controlled. Respectively, the whole transhipment devices are the opened source of air pollution, and there are not exact data on measurements of emitted particles from container terminal Brajdica area into Susak basin within the port of Rijeka.

Regulations on emission values limits for polluted materials into air (Official Gazzette 140/97) prescribes limits of values only for stationed sources, and diffuse sources and transport means are not included.

A.3.5.2. SEA – QUALITY

A.3.5.2.1. DESCRIPTION OF THE PLANNED CONSTRUCTIONS WIDER AREA

The container terminal Brajdica is positioned within the port basin Susak situated at the north side of the Rijeka bay. The Rijeka bay is a closed bay with surface of 450 km², of average depth 60 m and water mass volume 27 km³. Through the “Vela Vrata” (Big Door), it’s connected with Kvarner, through the “Srednja Vrata” (Middle door) with Kvarneric, and through “Tihi Kanal” (Calm channel) with Vinodol channel.

The first systematic oceanographic researches of Rijeka bay aquatory were performed in period from the year 1976 to 1981 (with intervals) in frame of “Ecological study on Rijeka bay aquatory” on which were working together the Centre for sea research, Rovinj - Zagreb, Institute “Rudjer Boskovic” Zagreb, Institute for oceanography and fishing Split and Dubrovnik, and Hydrographic institute Split. The Croatian national program for monitoring of the pollution conditions of Adriatic, which comprehended also the Rijeka bay, started in the year 1983, and it was interrupted in the year 1993. In frame of National project for monitoring of ecological conditions of Croatian part of Adriatic “Adriatic”, which started in the year 1998, the research was performed at four stations in the Rijeka bay. The basic oceanographic characteristics of the bay, and it’s ecological condition were shown based on those researching.

The water within the Rijeka bay is in the mostly part of the water column originating from central Adriatic, of good transparency, very transparent (15-35m, usually about 20m) and marked with salinity of at least 38, with minimal concentration of rich salts and planktons. Those are characteristics typical for oligotrophic condition, i.e. minimal production of organic substances. This water has been mixing at surface with fresh waters from local sources, which are positioned in the north part of the bay: under seabed sources nearby Opatija riviera and in Bakar bay, river Rjecina, and in considerably smaller size with the waste waters. The influence of fresh waters into surface salinity is very changeable, depending on atmospheric precipitations which are as a rule more abundant during the spring and autumn, and that’s very considerable for the whole bay, but with essentially different intensity. For example, in the western part of the Bakar bay, the surface
salinity varies from 20-35, and in the northern coastal line between 35 and 38 (but it can decrease on cca 30). In central and southern parts values are mainly more than 37, but lower are also possible 35-36. Nevertheless, the influence of nutrient salts brought by fresh waters has been limited on north-western part (coastal line from Opatija to Rijeka), in which periodically appear moderately blooming of fitoplanktons, with considerable decreasing of water transparency (<10m). That's probably conditioned also with slower exchange of water in relation to the major part of the Rijeka bay.

Namely, time of bay exchange, calculated from measuring of the stream in the sea in “Vela” and “Srednja vrata”, varies from one to two weeks at winter and about three times longer value at summer, with maximum of ten weeks during transitive periods between those seasons. Data on stream speeds points that this evaluations are valuable for the most part of the bay, except for the north-western part. In this part the exchange of water is surely longer, but there are no data for quantitative evaluation.

Within the seabed layers of the central part of the Rijeka bay, in the middle of the autumn comes to considerably decreasing of share saturated with oxygen (almost on 50%), which is probably on the first place caused with prolonged detaining of water under exceptional meteorological and oceanographic conditions. Namely, in the other parts of the bay, including the eutrofnic ones (north-western part, Bakar bay), the airness of the seabed layer is very good.

The temperature of the sea is considerably lower within the Rijeka bay than in the central Adriatic, because of influence of the cold air. On average, it’s lower in March in the whole water column (cca 11°C), and the highest on surface in August (cca 23°C). In this month the water near the bottom is still cold (cca 13°C), and only in autumn, by mixing in the water column, but parallel with cooling of the sea, reaches 15°C.

During the most part of the year, the water column of the Rijeka bay is layered because of vertical difference of temperature and salinity. During the spring and summer, in central and southern parts of the bay the most important fact is temperature, in the northern equally temperature and salinity, and in the Bakar bay the salinity. Layering is biggest in areas where the influence of fresh waters is more expressive. For example, difference in density between the surface and the seabed in the Bakar bay can reach in spring up to 20 kg m⁻³, in the northern part of the Rijeka bay up to 10 kg m⁻³, and in other areas up to 5 kg m⁻³.

Rijeka bay is an area where comes to expressively collision of urban, industrial and tourist’s activities and recreation zones. The impaired area is the north-eastern side of the bay, where exists the highest concentration of industrial and urban contents. Besides the city waste waters, the biggest industrial polluters of the bay is the oil refinery Urinj and Mlaka, shipbuilding industry, petrochemical industry and potentially dangerous oil terminal in Omisalj bay. In the Rijeka bay has always intensive maritime traffic along with the adequate port activities.

In relation to sources of pollution within the Rijeka aquatory (urban waste waters, oil refinery, petrochemical industry, maritime traffic), it could be stated with considerable certainly that pollution with rich salts and organic materials has the primary importance. The confluence of rich salts into eutot layer of the sea from natural external sources (confluence by non-polluted rivers) and under influence of the men (mainly urban waste waters), can cause increasing of biological sea productivity, which could have detrimental consequences for the sea eco-system. It has been evaluated that by direct release of waste waters into Rijeka bay comes yearly cca 1.200 t of nitrogen in total and 150 t of phosphorus. Currently, by river Rjecina
brought values are 265 t/a and 6.5 t/a for of total nitrogen, respectively phosphorus. Cca 82 % of total affluence into Rijeka bay, happens at the north-eastern side of the bay.

The affluence of some specific organic materials into sea, which because of their chemical composition have detrimental effects on many biological processes, could cause ecological disturbances not only of local, but also of wider proportions.

Because of presence of big refinery capacities and incident polluting in connection with maritime traffic and port activities, the oil and oil derivatives (hydrocarbons) are probably the most usual polluters of the Rijeka bay. Examinations on concentration of hydrocarbons at sediments of the Rijeka bay shows that sediments within areas near the polluting sources at north-eastern part of the bay, are much more encumbered than sediments in other parts of the bay (table 1).

<table>
<thead>
<tr>
<th>Station of examination</th>
<th>Sea depth, m</th>
<th>Total hydrocarbons mg/kg wet weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kantrida</td>
<td>55</td>
<td>69</td>
</tr>
<tr>
<td>In front of the Rijeka port</td>
<td>47</td>
<td>162</td>
</tr>
<tr>
<td>In front of oil refinery Urinj</td>
<td>20</td>
<td>211</td>
</tr>
<tr>
<td>Central Rijeka bay</td>
<td>63</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 1. Concentration of hydrocarbons in the surface sediment layer in the Rijeka bay

Because of their poor melting in the water, the polycyclic aromatic hydrocarbons are accumulated in sea sediments and organisms. Therefore, the content of that dangerous materials in sediments and sea organisms, represent the reflection of the long – term releasing into the sea environment. Examination of concentration of polycyclic aromatic hydrocarbons in sediments of the Rijeka bay were performed in frame of monitoring for the environmental impact of the Shipyard “Viktor Lenac” positioned at Martinscica bay, and oil refinery in Urinj. The results of those examinations warns on problem of accumulation of this dangerous compounds in single critical coastal zones (table 2).

<table>
<thead>
<tr>
<th>Station of examination</th>
<th>Sea depth, m</th>
<th>Concentration of PAU μ/kg dry substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance into Martinscica bay</td>
<td>42</td>
<td>16.6</td>
</tr>
<tr>
<td>Svezanj bay</td>
<td>31</td>
<td>3.13</td>
</tr>
<tr>
<td>In front of oil refinery Urinj (in front of a central device for waste water processing)</td>
<td>28</td>
<td>41</td>
</tr>
<tr>
<td>Bakar bay (in front of decantator for acceptance of oily waters from ships)</td>
<td>22</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 2. Concentration of polycyclic aromatic hydrocarbons (PAU) in sediments within the Rijeka bay coastal area
A.3.5.2.2. NARROWER AREA OF THE PLANNED WORKS

Planned works foreseen extension of the container terminal Brajdica, which is positioned in the Rijeka port, Susak basin. By filling of the sea, at the eastern side of terminal will be created new working and manipulation area.

From the west side of the container terminal Brajdica is positioned the delta of river Rijecina, and at eastern side is extended the Susak bathing zone. The first beaches are on 300m of distance from terminal. It should be mentioned that in last few years, citizens make bath even at eastern coast of terminal, on the coast arose with filling of this part of the sea.

There were no examinations of sea quality at the same location of the planned works. The sanitary quality of the sea is systematically examined from hotel “Jadran” to “Grecevo”, at six stations: bathing place of hotel “Jadran”, beach Sablicevo, bathing place of hotel “Park”, beaches Glavanovo, Ruzicevo and Grecevo (table 3.). Examinations are performed by Institute for public health of County Primorsko-Goranska, in accordanc with Regulations on standard sea qualities at sea beaches (“Official Gazette” No.: 33/1996). They shows that for several years the sea at bathing place “Jadran” and beaches Sablicevo and Glavanovo don’t correspond to prescribed standards, i.e. that it’s present the micro-biological pollution of fecal provenience, of stronger intensity. At bathing place “hotel Park” and beaches Ruzicevo and Grecevo the sea is adequate for bathing.

Table 3. Stations for sea examinations at Susak beaches

Rjecina is the most important water current of this area. It as a torrent character and it’s natural water regime has been under influence of the hydro-energetic plant HE Rijeka, as well as use of water for the water supply. Examinations of water current Rjecina quality at the spot of it’s confluence into sea, are performed in frame of National program for examination of surface waters quality. In table 4. is shown the water quality of this water current in the year 2002. At spot of examination, the waters of Rjecina are under influence of the sea. Chemical characteristics points at water of good quality, without considerably antropogenic influence. The micro-biological pollution strongly varies and points to temporary influence of fecal waste waters.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of examinations</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical-chemical characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature, °C</td>
<td>12</td>
<td>7,8</td>
<td>12,3</td>
<td>9,19</td>
</tr>
<tr>
<td>pH</td>
<td>12</td>
<td>7,90</td>
<td>8,22</td>
<td></td>
</tr>
<tr>
<td>Salinity, ‰</td>
<td>12</td>
<td>0,005</td>
<td>6,42</td>
<td>1,73</td>
</tr>
<tr>
<td><strong>Oxygen regime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solved oxygen, mg/L</td>
<td>12</td>
<td>8,80</td>
<td>12,9</td>
<td>11,6</td>
</tr>
<tr>
<td>Saturation with oxygen,%</td>
<td>12</td>
<td>74,5</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>BPK 5</td>
<td>12</td>
<td>0,70</td>
<td>3,70</td>
<td>2,14</td>
</tr>
<tr>
<td><strong>Reach salt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia, mg N/L</td>
<td>12</td>
<td>&lt;0,01</td>
<td>0,25</td>
<td>0,026</td>
</tr>
<tr>
<td>Nitrites, mg N/L</td>
<td>12</td>
<td>&lt;0,001</td>
<td>0,039</td>
<td>0,004</td>
</tr>
<tr>
<td>Nitrates, mg N/L</td>
<td>12</td>
<td>0,59</td>
<td>1,22</td>
<td>0,83</td>
</tr>
<tr>
<td>Total nitrogen, mg N/L</td>
<td>12</td>
<td>0,79</td>
<td>1,41</td>
<td>0,98</td>
</tr>
<tr>
<td>Phosphates, mg P/L</td>
<td>12</td>
<td>&lt;0,001</td>
<td>0,009</td>
<td>0,004</td>
</tr>
<tr>
<td>Total phosphorous, mg P/L</td>
<td>12</td>
<td>0,005</td>
<td>0,054</td>
<td>0,016</td>
</tr>
<tr>
<td><strong>Bacteriological characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total coliforms/100 mL</td>
<td>12</td>
<td>180</td>
<td>40 000</td>
<td>3 800</td>
</tr>
<tr>
<td>Fecal coliforms/100 mL</td>
<td>12</td>
<td>58</td>
<td>40 000</td>
<td>3 670</td>
</tr>
<tr>
<td><strong>Organic materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral oils, mg/L</td>
<td>12</td>
<td>&lt;0,01</td>
<td>0,022</td>
<td>0,011</td>
</tr>
<tr>
<td>Fenols, mg/L</td>
<td>12</td>
<td>&lt;0,001</td>
<td>0,006</td>
<td>0,0017</td>
</tr>
<tr>
<td>Anion detergents, mg/L</td>
<td>10</td>
<td>&lt;0,01</td>
<td>0,05</td>
<td>0,02</td>
</tr>
<tr>
<td>Polyclor bifenils, ng/L</td>
<td>9</td>
<td>&lt;0,01</td>
<td>0,01</td>
<td>&lt;0,01</td>
</tr>
<tr>
<td><strong>Heavy metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper, ,µg/L</td>
<td>12</td>
<td>&lt;1</td>
<td>14</td>
<td>2,6</td>
</tr>
<tr>
<td>Zinc, µg/L</td>
<td>12</td>
<td>&lt;10</td>
<td>13</td>
<td>3,9</td>
</tr>
<tr>
<td>Cadmium, µg/L</td>
<td>12</td>
<td>&lt;0,1</td>
<td>1,4</td>
<td>0,22</td>
</tr>
<tr>
<td>Chromium, µg/L</td>
<td>12</td>
<td>&lt;1</td>
<td>1</td>
<td>0,8</td>
</tr>
<tr>
<td>Lead, µg/L</td>
<td>12</td>
<td>&lt;1</td>
<td>10</td>
<td>1,7</td>
</tr>
<tr>
<td>Mercury, µg/L</td>
<td>12</td>
<td>&lt;0,01</td>
<td>0,02</td>
<td>0,001</td>
</tr>
</tbody>
</table>

Table 4. Rjecina water quality at confluence to the sea in the year 2002

On Delta, at River Rjecina right side, has been positioned the central device for purification of the Rijeka city waste waters. After partly primary purification, waste waters are released into sea by submarine exhaust length of 500 m, on depth of 40 m. According to examinations performed during the year 2002, waste waters (average daily quantity 32 000 m³) had at exit from device the average composition as follows: pH 7.19 – 8.59, suspended material 112 mg/L, chemical expense of oxygen 420 mg O₂/L, BPK5 142 mg O₂/L, total nitrogen 44 mg N/L, total phosphorus 4.48 mg P/L, total greases 17.7 mg/L and anion
detergents 0.69 mg/L. Loads with organic dangerous substances (organochlorine pesticides and polichlorine bifens) as well as with heavy metals, was low.

A.3.5.2.2.1. Examinations of sea water quality at narrower area of planned works

For necessities of this study, it was performed the examination of sea water quality for area of planned works. The examination stations are shown at Picture 5.

Picture 5. The examination stations of sea water quality, at area of planned works in April 2004
Examination of sea water quality

The examination of the sea water quality was performed at 4 stations:
Station P1 is positioned at eastern side of container terminal, under the entrance into tunnel of the road GMC 105, on distance from the coast of cca 25m.
Station P2 is positioned in center of container terminal east side, on distance from the coast of cca 50m. The sea depth at this spot comes to 40 m.
Station P3 is positioned in front of “Kostrensko pristanište” southern side, on distance from the coast of cca 50m. The sea depth at this spot comes to 50 m.
Station P4 is positioned at confluence of river Rjecina into the sea, i.e. on the west side of “Kostrensko pristanište”.

At stations P1 and P4 for analyses were taken only samples of the sea water from the surface (30 cm of depth). At stations P2 and P3 were taken samples from the surface (30 cm of depth) and from the seabed (30 cm from the bottom).

Examination of the sea water quality included defining of the basic physical-chemical characteristics: temperature, salinity, melted oxygen, ammonia, nitrite and ortophosphate. The bacteriological analyses was performed only on samples taken from the surface. It were defined the bacteriological indicators of fecal pollution, as follows: total coliform bacteria, fecal coliform bacteria and fecal streptococcus. The water transparency was measured at stations P2 and P3.

Solved oxygen was defined by Winkler method (ISO 5814). The sea transparency was measured with white Secchi table. The pH of the water was defined with electrochemical method ISO 10 523. Salinity was defined with titration of AgNO3 method according to Mohr – Knudsen. Ammonia was defined with spectrofotometric fenat method – Standard methods 20th Edition 4500 – NH3F. Nitrites were defined with spectrofotometric method – Standard methods 20th Edition 4500. The analyses of ortophosphates was made by spectrofotometric method – Standard methods 20th Edition 4500. Bacteriological analyses were made by method of membrane filtration. For evidence of total coliforms, it was used the LES ENDO AGAR (35 - 37°C), for fecal coliforms m- FAECAL COLIFORM agar (44,5°C) and for fecal streptococcus SLANETZ BARTLEY AGAR (35-37°C).

With the County Primorsko-Goranska Physical Plan (“Official Gazzette”,14/2000), the sea at area of container terminal Brajdica was listed in the second category of waters. According to Regulation on water classification (NN 77/98) and Regulation on dangerous materials in waters (NN 78/98), for examined items the limit values for the second category of the sea, were given as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency, meters</td>
<td>2</td>
</tr>
<tr>
<td>Visible waster materials and oils</td>
<td>without</td>
</tr>
<tr>
<td>pH</td>
<td>8.1 +/- 0.3</td>
</tr>
<tr>
<td>Solved oxygen, % saturation</td>
<td>70 – 120</td>
</tr>
<tr>
<td>Ammonia, mg/LN</td>
<td>0.1</td>
</tr>
<tr>
<td>Nitrites, mg/LN</td>
<td>-</td>
</tr>
<tr>
<td>Ortophosphatus, mgP/L</td>
<td>-</td>
</tr>
<tr>
<td>Total coliforms bacteries/100 mL</td>
<td>500</td>
</tr>
<tr>
<td>Fecal coliform bacteria/100 mL</td>
<td>100</td>
</tr>
<tr>
<td>Fecal streptococcus/10mL</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 6. Table of limit values for the second category of the sea