Sustainable Navigation in Ukraine

Alternatives in and around the Ukrainian Danube Delta

Report

WWF

September 2009
Final

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1 INTRODUCTION

1.1 Project Background

As mentioned in the Terms of Reference (ToR) drafted by the WWF, the (Ukrainian) Danube Delta is struggling to find a balance between the need for economic development of the region and the responsibility of the natural preservation of this same area for future generations. The Delta lies at the mouth of the Danube, one of the most important rivers of the pan-European navigational network and designated as Transport Corridor VII under the TEN-T programme (Trans-European Transport Networks). In potential, it forms a connection between the Black Sea all the way to the industrial Ruhr Area in Germany and ultimately the main Port of Rotterdam in the Netherlands. At the same time, the Danube and the Danube Delta are areas of natural beauty and important ecological havens for a wide variety of (endangered) plants, animals and fish.

Lessons learnt from previous developments of similar Transport Corridors such as the Rhine-Meuse, indicate that a purely navigational development leads to a reduction in the natural potential of the river especially in ecologically and morphologically sensitive areas. Restoration costs and efforts far exceed the costs that would have been made if the natural function of the river and deltaic areas were taken into account at the start of the development.

WWF has been working on a Vision on the Danube Delta and the Lower Danube over the past several years, and has run projects and model / pilot sites in the area such as

- Restoration of the natural floodplain by removing of dykes;
- The introduction of natural grazing.

and in the Romanian part of the Delta and the Lower Danube:

- Removal of embankments along former agricultural polders;
- Restoration of floodplains;
- Natural grazing;
- Ecotourism;
- And the restoration of the Black Sea Coast.

This study on the Development of Sustainable Navigation and Ports in the Ukrainian Danube Delta is situated in the context of these projects.

In addition to the degradation of the water habitats in the natural river and delta system, the experts in the project expressed their concern about the ability of the entire Danube Delta to follow the expected sea level rise due to climate change in the future. Under natural circumstances, sedimentation of silt and sand carried by floodwaters flowing into the floodplains from the lower Danube River and peat formation via the growth of the reed beds easily allows the Delta to keep up with the 1-2 cm/year sea level rise. However, if the floodwaters from the Danube cannot reach over new embankments and flood the surrounding plains during high water levels, no sediment can be deposited and the reed beds will dry up. This ensures that the land in the delta will drop relative to the sea and (ecological) problems can occur when habitats disappear.

1.2 Aim of the report

Although there is an existing route to the inland ports of Ukraine through the Sulina Channel in Romania, the Ukraine would like to have an own access route to the Danube and thus is working on the construction of the Bystroe Channel.

This report will give an overview of the Bystroe channel and other alternatives for a Ukrainian navigation route connecting the Black Sea to the River Danube and related potential locations of new or existing ports. The alternatives will be described based on their navigational aspects and will be compared on the basis of their impacts on various criteria including navigability, ecology, (coastal) morphology, economy, social and environment during construction and operation.

1.3 Sources of Information

Most of the information used in the project was collected from different sources including:

- WWF archives;
- Personal archives of the Dutch, Ukrainian and Romanian experts;
- Various public Internet sites;
- Interviews with Port Authorities and other stakeholders met during the site visit.

This information formed the basis for the discussions held throughout our site visit and the technical content of this report. Where relevant, sources will be named.

1.4 Project team

The project was carried out by a Consortium of experts from DHV (lead), ECORYS and Wildernis Consultancy strengthened by several renowned Ukrainian and Romanian experts.

The project team consisted of the following Dutch experts:

- Team Leader and Waterway & Ports Expert: Wim Klomp DHV
- Transport Economics Expert: Johan Gille ECORYS
- Morphological and Ecological Expert: Willem Overmars Wildernis Consultancy
- Environmental Waterway Expert: Daan Rijks DHV

strengthened with the following key Ukrainian and Romanian experts:

- Coastal and Morphological Expert Prof. Dr. Nicolae Panin
- Nautical Expert Cpt. Konstatin Sizov
- Nautical and Economics Expert Dr. Yakov Shpigelman
- Danube Delta Expert Dr. Oleksandr Voloshkevych

The project was carried out in the context of the WWF International Danube-Carpathian Programme ("WWF DCP") sub-project “Danube Delta – A Natural Gateway to Europe – Module C - Navigation”. It is part of the Work Programme as described in the Operating Grant Agreement No 070307/2007/SI2.480483/SUB/A1 between the European Commission and WWF-DCP.

1.5 Acknowledgements

This project was initiated and carried out thanks to the inexhaustible efforts of WWF and in particular Misha Nesterenko who brought together the two teams of experts from Netherlands and Ukraine / Romania and made sure everything was organised perfectly in the Ukraine for our visit.

We would like to thank the experts who participated in this project and made time available for an intensive visit to the Ukrainian Delta and later also for their valuable input for this report.

We would also like to thank Captain Sizov for his great efforts in organizing the field trip to the Danube Delta Area by boat and making it possible for us to visit the river ports along the Kiliya Branch.

Figure 1-1: Project team (missing on picture Dr. Shpigelman and the author Mr. Rijks)

2 PROJECT APPROACH AND METHODOLOGY

The approach and methodology consists of the following steps:

1. Description of the situation
2. Determination of alternatives
3. Field visit along the locations of the alternatives
4. Technical meetings with international experts
5. Quick scan alternatives with list of themes and criteria
6. Reporting

The steps are described in more detail below.

2.1 Description of the Situation

Europe's Corridor VII stretches along the Danube and Rhine Rivers from Rotterdam to Constanza and back. The mouth of the Danube River at the Black Sea offers opportunities for development of trade between the sea and the large hinterland along the Danube River system. Three countries border the Danube Delta: Romania, Ukraine and Moldava. Each of the countries has an ambition to develop the opportunities that the river and the sea offer them. The question is: how to develop harbours, industries and shipping routes without damaging the morphology and ecosystem of the Danube Delta?

Since the Prorva Canal became silted in 1997 (see Figure 2-2), Ukraine no longer has its own permanent deepwater connection between the Danube and the Black Sea. Part of the ships that sail to the Ukrainian port cities of Kiliya, Izmail and Reni pass through the Bystroe and the Ust-Dunaysk branches, while the greatest part of the shipping has to travel through the Sulina Channel in Romania. Ships have to pay to use this canal. Since 1997 the payment is 1.51 USD per ton cargo or 0.83 USD per ton ballast.

Figure 2-1: Entrance Bystroe Channel with breakwater & Entrance to Sulina Channel

After the silting up of the Prorva Canal, the Government of Ukraine adopted a resolution to build its own navigation canal through the Bystroe branch in the Ukrainian Danube Delta in 2003. Phase I of the deepening of the Bystroe branch and sea access route is being finalized (see chapter 2.2.2 for a description of Phase 1).

The construction of this new canal was based on three main reasons:

1. To revitalize the Ukraine Delta port cities of Kiliya, Izmail and Reni ports that closed or downsized in the 80s and 90s. These small ports can expand when sea cargo traffic increases due to a better sea connection;
2. To relieve the expense of having to use the 70 km long Sulina Channel in Romania as access route to sea;
3. To generate own revenue from foreign ships.

However, the Bystroe branch lies in the middle of the Ukrainian part of the Danube Delta Biosphere and runs directly through the Biosphere Reserve. This means that construction and operation of the canal will directly affect the Delta and the near-shore coastal zone at the mouth of the Bystroe Furthermore, transboundary effects can be caused by changing erosion and sedimentation patterns due to the breakwaters.

Objective

This study will look at potential alternatives to the Bystroe Channel and/or a new location of a harbour and related industry that take the delicate nature and ecology of the Delta in relation to air, water- and noise pollution into account. If possible, it should be situated outside of the ecological heart of the Delta.

2.2 Determination of Alternatives

There are several alternatives to the Bystroe Channel. In this study we used alternatives found in a quick scan literature study. Although the experts discussed potential additional alternatives, it was decided that none needed to be added to those found in the study as these were deemed to be complete and cover all viable options. The alternatives found are summarized in the table below. All alternatives eventually connect to the Kiliya branch of the Danube River that has depths of 15-20 meters up to the city of Reni and the Moldavan part of the River. The Romanian branches, with the exception of Sulina Channel, are less deep but have already been canalized for shipping.

Table 2-1: Alternatives obtained from the literature study (North to South)

Waterway route (H=historical, C=Current)		Author	Year
H1	Solomonov Arm – Zhebriyanskaya Bay	Eng. P. Chehovich	1904
H2	Arm Polunochnoye (Ochakovskoye Arm – Zhebriyanskaya Bay)	Eng. V. Rummel	1900
H3	Potapovskiy channel (Estuary part of the Ochakovskoye Arm)	Admiral Potapov	1918
C1	Solomonov Arm – Lake Sasyk – Black Sea	Rechtransproekt	2003
C2	Solomonov Arm – Bazarchukskiy Backwater–Zhebriyanskaya Bay	Proectgidrostroy	1998 - 2008
C3	Ochakovskoye Arm – port Ust-Dunaysk (Zhebriyanskaya Bay)	Chernomorniiproekt	1990
C4	Connecting channel port Ust-Dunaysk (Arm Prorva- Zhebriyanskaya Bay)	Chernomorniiproekt	1979
C5	Channel Prorva (Arm Prorva – Black Sea)	Chernomorniiproekt	1957
C6	Bystroe Arm (Novostambulskoye Arm – Black Sea))	Rechtransproekt	2003–2006
C7	Tsyhanka Arm (Starostambulskoye Arm – Black Sea)	Rechtransproekt	2003
C8	Starostambulskoye Arm (Kiliyskoye Arm – Black Sea)	Rechtransproekt	2003

The alternatives vary in water depth, and thus in size of vessels that can be accommodated and also in sailing length from main shipping routes to the Danube ports. However, they can be divided into two main sets: those lying in the Delta consisting of revitalisation and deepening of existing branches and those lying outside the Delta consisting of new channels or widening and deepening of existing drainage channels.

The picture below shows the locations of the alternatives in and outside the Danube Biosphere Reserve, Ukraine. The Kiliya branch of the Danube Delta forms the border between Ukraine and Romania.

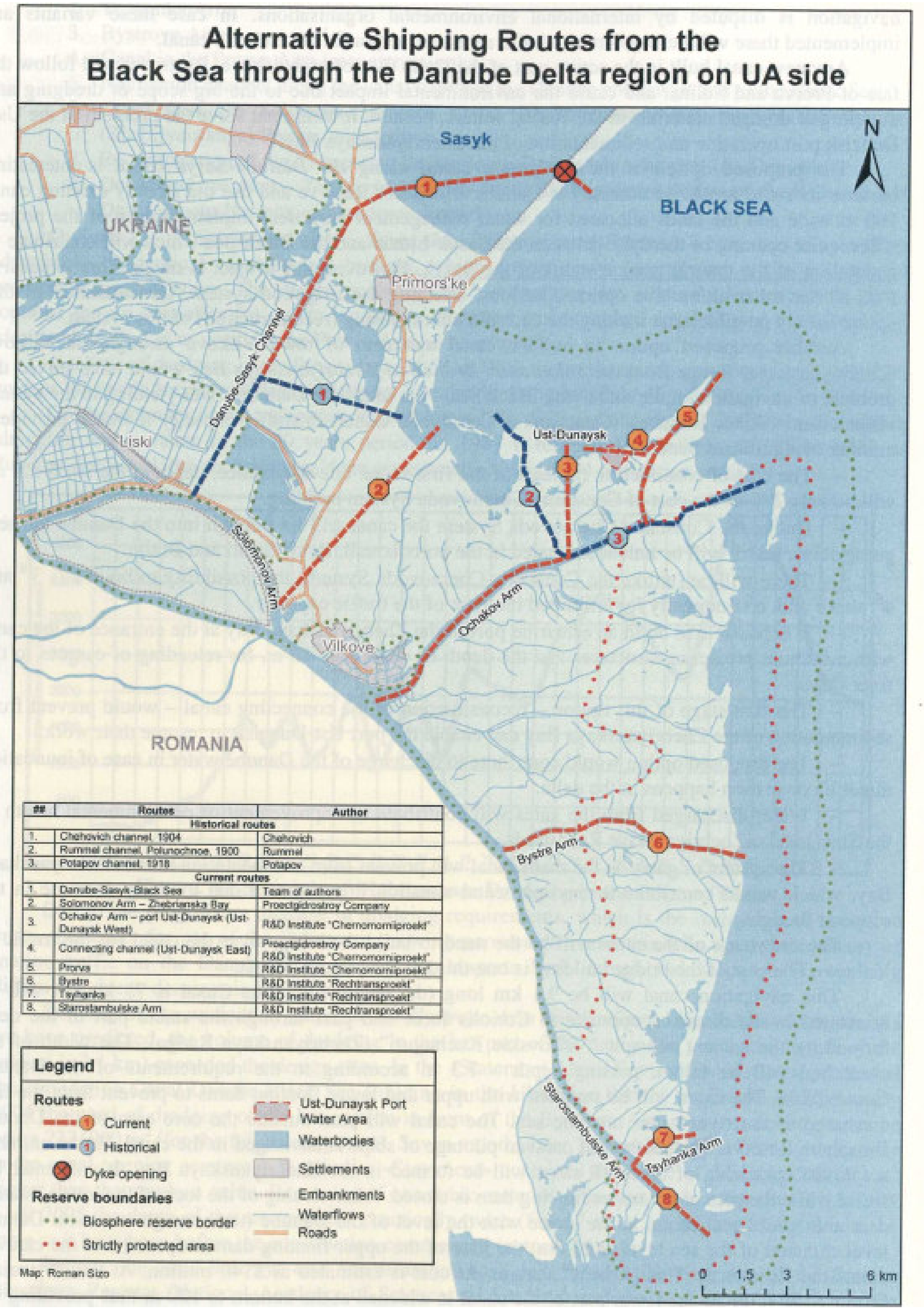


Figure 2-2: Map showing the locations of the alternatives (Source: WWF Germany)

During the first expert meeting, the alternatives found in our literature study were discussed and categorized for use in the determination process. The following final list was made and used in the project:

0. Base Alternative: no access channel in Ukraine, all ships pass through Sulina Channel
1. Sulina + Bystroe First Phase (C6 in previous table): Situation as it is now
2. Sulina + Bystroe Second Phase (C6 in previous table): Situation with deeper channel and completed breakwaters
3. Sulina + Starostambulsky Channel (C8 in previous table)
4. Sulina + Tsyhanka Channel (C7 in previous table)
5. Sulina + Ust-Dunaysk Channel (C3 in previous table)
6. Sulina + Solomonov Channel, new channel (C2 in previous table)
7. Sulina + Danube-Sasyk Channel, current drainage channel (C1 in previous table)

Each of the nominated alternatives is described in more detail in the following chapters.

The waiting or anchor areas shown indicated in the rough sketches of the alternatives in the paragraphs below have been included by the experts and are only meant to give a general idea of the location of such an area.

<u>Base Alternative</u>

Although the current navigation situation in the region includes the availability of the Sulina Channel and a part of the works for the Bystroe Channel Phase 1 i.e. the deepening of the channel and part of the breakwater at sea, we will consider the Base Alternative to be only the Sulina Channel. The reason for this is that the works on the Bystroe Channel are still under discussion in a UN International Court and thus it is uncertain if they will be completed (Letter from United Nations Economic Commission for Europe to Ukrainian Deputy Prime Minister, d.d. 30 October 2008, Ref: ECE/EHLM/239/2008/L).

<u>Sulina Channel</u>

We have included the presence of the Sulina Channel in each of the alternatives described below. We have done this on the assumption that the Sulina Channel will continue to be operated by Romania even when an additional access channel is created in the Ukraine. In all cases, the Sulina will offer an alternative passage for ships to reach the Danube if the Ukrainian channel is closed for a variety of reasons including maintenance works, natural circumstances (e.g. ice), stranding and accidents of ships etc. Furthermore, because of the guaranteed water depth of 7.3m in the Sulina, very large ships can pass through the Sulina most of the year. This fact can be used when considering a lower channel depth in the Ukrainian Danube access channel – a lower depth means less construction costs, less maintenance dredging and thus in both cases less effects on the environment.

2.2.1 Alternative 0: Base Alternative

This alternative is the current (or recent) situation in which all ships for the Ukrainian river ports of Kiliya, Izmail and Reni pass of the through the Sulina Channel in Romania to reach their destination. In this alternative there are no deepwater navigation routes for large-scale shipping in or near the Ukrainian Danube Delta.

The Ukrainian Danube Delta environment and coastal zone will not be affected by construction-, maintenance- and navigational operation works.

Figure 2-3: Sulina Channel embankments and oceangoing tug constructed in the Romanian Danube shipyards

2.2.2 Alternative 1: Sulina + Bystroe First Phase

This alternative is the choice alternative of the Ukrainian government to revitalise shipping in the Ukrainian Danube. Although it is being debated in UN Court, it is currently under construction – shallow zones in the channel are being dredged and a breakwater is being constructed in sea in front of the entrance to the channel. It is unclear if or when these works will be completed.

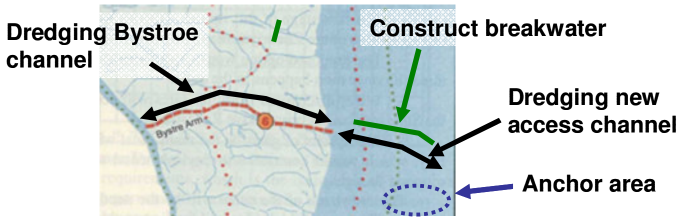


Figure 2-4: Schematic overview of works needed to construct the alternative

The Bystroe Channel is a natural, straight deepwater canal with a sandbank in the coastal zone of the Black Sea. It takes ca. 40% of the Kiliya arm discharge. Its orientation is favourable for incoming ships. If dredging works are completed, the channel can accommodate one-way traffic of ships with a 5,85m draft. Ships take approximately 1 hour to pass the 8km from the Kiliya Branch to the Black Sea at a maximum speed of 8 knots. The sea access channel at the channel mouth is partly dredged and about 3km in length, orientated toward southeast. The breakwater now under construction is 1,2km long and meant protect the access channel from the littoral drift of sediments. A waiting area will be created at the beginning of the sea access channel where ships can wait for their turn to pass through the canal. Since 2004 there have been 2200 registered ship passages. The channel is managed from Vilkove by the Delta Pilot.

Figure 2-5: Bystroe Channel L: looking at breakwater in sea, R: looking towards Kiliya Branch

2.2.3 Alternative 2: Sulina + Bystroe Second Phase

This alternative is the proposed second phase of the construction of the Bystroe Channel and concerns the deepening of the channel to accommodate ships with a draft of 7,2m and the extension of the breakwaters in sea. In addition, the Kiliya Branch will de dredged in 12 locations to guarantee a longer period of time per year for deepwater navigable circumstances. It is unclear if and when the proposed works of this phase will be started.

2.2.4 Alternative 3: Sulina + Starostambulsky Channel

This branch is the southern most channel in the Ukrainian Delta and is the final stretch of the Kiliya Branch. The shallow, but very wide channel enters a semi-lagoon created by the growth of a natural sandy spit from the mainland along the coast to the south, effectively closing the bay and direct access to the Black Sea. The lagoon area is a valuable area for (migratory) birds. A long sea access channel must be dredged through the shallow lagoon area and the spit to reach the Black Sea. Finally, a breakwater similar to that of the Bystroe Channel must be constructed to protect the ships from waves and to keep the access channel deep enough.

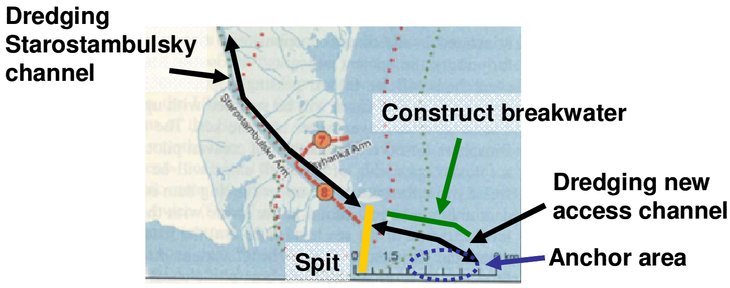


Figure 2-6: Schematic overview of works needed to construct the alternative

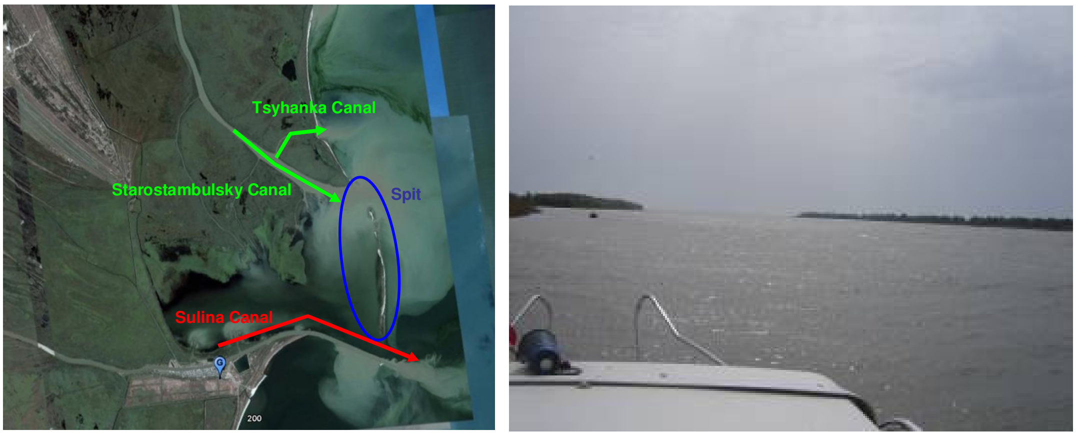


Figure 2-7: Location of Starotambulsky Channel Goolge Earth and photo looking towards the spit

2.2.5 Alternative 4: Sulina + Tsyhanka Channel

This is a side branch of the Starostambulsky Channel that reaches directly to the sea without passing through the lagoon, saving a lot of dredging and maintenance works. Like the Bystroe alternative, breakwaters are needed to protect the approach channel. The first part of the alternative is the same as the Starostambulsky alternative, but the second part is a narrow winding channel.

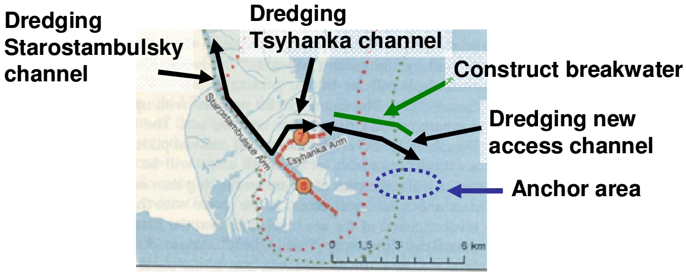


Figure 2-8: Schematic overview of works needed to construct the alternative

Figure 2-9: The Tyshanka Channel. Left looking towards Kiliya and Right looking towards the Black Sea

2.2.6 Alternative 5: Sulina + Ust-Dunaysk Channel

This is the original navigational channel used before the independence of Ukraine. During operation, there was a relatively large (floating) transhipment port at the mouth of the channel with the Black Sea. During that time, 2-3 dredgers worked almost permanently to keep the route open for shipping. After 1950s, the maintenance dredging was temporarily stopped and the canal silted up and was not accessible for deep sea shipping. The Port of Ust Dunaysk also stopped operating. The channels need to be dredged and maintained to meet required water depths. Dredging works were started again in 1970s to ca. 1994 when they were stopped again. In this period the port was in operation. The old port can be revived, although new connecting roads (and railway) need to be built to be able to reach the port with heavy cargos.

Figure 2-10: Schematic overview of works needed to construct the alternative

Figure 2-11: Left Ust-Dunaysk Channel, Right the (floating) port

2.2.7 Alternative 6: Sulina + Solomonov Channel (new channel)

This alternative lies just outside of the Danube Delta. It connects the Kiliya branch to the shallow Zhebriyanskaya bay in the Black Sea. It lies along the edge of the natural paleo coastline now a raised ridge in the landscape. There is no channel there now, so a new one needs to be dredged. It needs a lock and sluice complex at the connection with the Kiliya Branch of the Danube. Because of the shallow bay, a long access channel needs to be dredged and maintained.

A (movable) bridge must be constructed over the channel to connect the urban areas in the Delta with the Ukrainian hinterland.

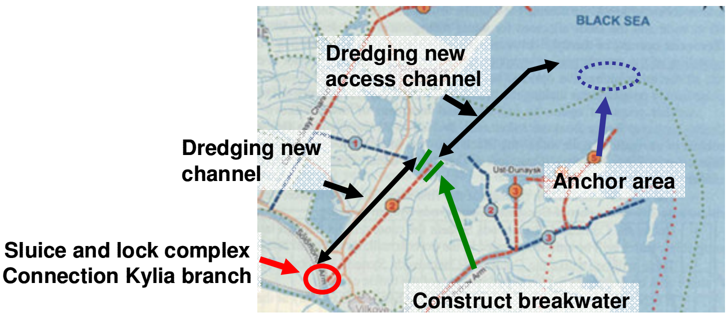


Figure 2-12: Schematic overview of works needed to construct the alternative

Figure 2-13: Left location of Solomonov Canal in relation to paleo sand ridge, Right location of channel

2.2.8 Alternative 7: Sulina + Danube-Sasyk Channel (current drainage channel)

Basically, this alternative can be split up into the following parts:

1. Adaptation of the existing drainage channel: This alternative makes use of the existing drainage / water management channel connecting the Danube and the Sasyk Lake. This is a former marine estuary that was converted into a freshwater reservoir to provide water for agriculture. Unfortunately the water remained salty and could not be used. At the moment, the drainage channel is hydraulically isolated from the surroundings. There is a sluice complex at the connection with the Danube River that is opened when there are high waters in the Danube to allow fresh water to enter the Sasyk Lake. Water levels can vary up to 1m during seasonal fluctuations and much more during high floodwaters in the Danube. The sluices are opened to allow Danube water to enter the lake in an effort to turn it into a fresh water irrigation lake. The channel itself is narrow and needs to be widened and deepened and the dikes on both sides of the channel need to be heightened and spaced more apart. A more environmentally friendly option would be to bring the channel into 'contact' again with the surroundings by removing the dikes on both sides and effectively allowing natural flooding to occur again. This will ensure that natural marshland is restored in the region;
2. Channel through Sasyk Lake: The channel must be dredged into the existing lake bed and clearly marked with buoys. A waiting area can be built alongside the channel where ships can wait for their turn to pass through the channel and lock towards the Kiliya Branch;
3. New connection between Sasyk Lake and the Black Sea: The new connection must be dredged through the old spit so that the Lake and the Black Sea are connected;
4. A relatively short sea access channel that is aligned in such a way that large ships need only minimal turning and no additional use of tugboats.

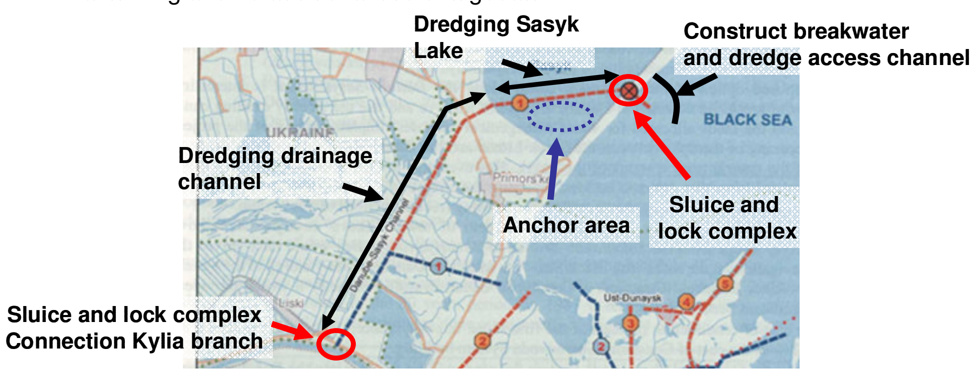


Figure 2-14: Schematic overview of works needed to construct the alternative

In addition to the dredging works, three main civil engineering works are needed:

1. A new low but movable or very high, fixed bridge would be needed over the channel to connect the villages of Primorske and Vilkove and the other smaller populated areas with the Ukrainian hinterland (alternative is a ferry);
2. A lock complex must be constructed next to the sluice complex at the connection between the drainage channel and the Danube River;
3. A new sluice and lock complex needs to be constructed at the connection between the Sasyk Lake and Black Sea.

Figure 2-15: Left Sluice complex at connection with Danube, Right bridge crossing drainage channel

2.3 Site visit

The site visit was carried out in three stages:

1. Site visit to the alternatives lying in the Ukrainian Danube Delta (boat);
2. Site visit to the alternatives lying outside of the Delta (car);
3. Site visit to the river ports of Vilkove, Kiliya and Izmail lying along the Kiliya branch (car).

Each of the locations of the alternatives was visited by the team. The alternatives using existing branches of the Kiliya were visited by boat and the alternatives that need to be dredged through land were visited by car. The river ports were visited in order for the team to obtain data on cargo throughput and -type and available area for expansion.

Figure 2-16: Boat used for site visit

The site visit went from Vilkove through the Ochakov Arm [3] to the Prorva channel [5] then to the Ust Dunaysk (mouth of Danube) [4] and old port facilities i.e. floating mooring points. There we saw two empty inland ships flying Moldavian / Romanian flags going to load sand. After having visited the port, we passed through the Bystroe Channel [6] to the sea. Unfortunately strong winds and high sea waves stopped us from reaching the coastal breakwater (now under construction). At the end of the Bystroe Channel, the visit stopped briefly at the local Biosphere field office. Next we passed through the Starostambulske Canal [8] and the Tsyhanka Arm [7] and into the lagoon protected by the spit from the sea.

During the site visit, we were fortunate enough to be able to visit the TSHD Prorvina, a state-owned dredging vessel, and spoke to the captain about the ongoing dredging operations. The Trailer Suction Hopper Dredger (TSHD) was waiting for the high sea waves to pass so that it could resume its dredging works of the sea access channel. At the moment, the water depth is (only) 6 m and the draft of boat is 5m – this means that during high waves the ship hits the bottom. The Prorvina dredges up to 500.000m^3/year to keep the access channel deep enough for ships to pass.

In addition to dredging the sea access channel and deepening the Bystroe Channel, the Prorvina also dredges parts of the Kiliya Branch (2004) to guarantee a 5m draft in the river.


Figure 2-17: TSHD Prorvina and Captain Roman kindly showing us the ship

2.4 Technical meetings

Technical meetings were held before and during the site visit. After the expert team verified that no new alternatives needed to be determined or existing alternatives combined, each alternative was discussed based on expert judgement and a predefined list of themes and criteria. The results of these meetings have been used in this report.

The following aspects were taken into account:
- Different types of ports and harbours, both sea and inland;
- Current industrial activities in the Ukrainian maritime Danube ports and their dependency on maritime shipping;
- General shipping costs for various routes to/from these ports;
- Analysis about potential future development of markets and related expected transport volumes, types of goods and involved sectors;
- Land infrastructure network to and from alternative port locations in the Ukraine (road and rail);
- Ship types/sizes of maritime ships currently visiting the Ukrainian ports;
- Trends in ship types and cargo segments on the maritime Danube;
- Waterway profile exigencies;
- Effect of reduced cargo volumes to minimize shipping draught;
- Sediment flow in the Danube Delta;
- Water and sediment distribution in the Delta;
- Dynamics of currents and sediment flows in the coastal area (morphology);
- Sustainable constructions with as little impact on the natural and ecological system as possible;
- Locations of fragile ecological systems;
- Socio-economic aspects.

2.5 Assessment Method

To be able to determine which of the alternatives described in Chapter 2 are favourable in certain conditions and for certain aspects, they were compared using a list of predefined aspects (criteria) related to several different themes. The alternatives were compared to the Base Alternative 0 Sulina Channel in which there are no connecting channels in/around the Ukrainian Danube Delta area. The comparisons were made based on the extensive knowledge of the team (expert opinion) and the findings of the site visit, no simulations or model computations were performed. The geographical extent to which presumed effects were examined is the Ukrainian Danube Delta.

The themes and criteria are shown in the table below. They were used solely as a basis for the discussion making sure that the experts did not omit effects or issues from the final determination. Where necessary, criteria were added to the list or changed and in some cases joined to make a new criterion. The presented analysis should therefore be seen as a first assessment. The resulting favourable alternatives need further study.

As an additional exercise, the different criteria were given a score by the experts based on expert judgement. The results of this exercise are shown in the Appendix Report. Please note that the final choice for the alternatives was based on expert judgement.

Table 2-2: Themes and criteria used in the discussions

Theme	Criteria
Construction	Hinder for existing navigation
	Hinder for ecology
	Hinder for social
	Volume of civil works (breakwater, lock, bridge etc)
	Volume of material to be dredged (incl access channel)
	Construction time
	Volume of resources available after dredging
Operation	Hinder for navigation (maintenance dredging, locks)
Navigation	Accessibility of approach channel (entrance to channel)
	Nautical safety in channel
	Potential traffic intensity
	Hinder from infrastructure (sluices, locks, bridges etc)
Port	Chances for hinterland connection (road / rail)
	Available space for expansion of existing port (land use)
	Available space for construction of new port (land use)
	Available workforce
Economy	Investment costs
	Maintenance and operation costs
	Economical benefits
Ecology	Habitat & biodiversity coastal zone: benthos / fish / seabirds
	Habitat & biodiversity channel: benthos / fish / birds
	Habitat & biodiversity land: flora / fauna
	Red list species
	Protected areas (changes and loss)
Landscape & Morphology	Change in land and water use
	Visual appreciation
	Coastal morphology (beaches / foreshore)
	Paleo-morphological value

Theme	Criteria
Social	Public opinion
	External safety (effects of accidents)
	Protection against flooding (sea / channel)
	Chances for tourism & recreation
	(Political) support of international authorities / politics / NGO’s
	(Political) support of national authorities
	(Political) support of local and international NGO's
Environment	Water quality
	Hydraulics
	Suspended solids and turbidity in channels
	Air quality
	Noise
	Shipping waste (bilge water, general waste etc)
	Soil and groundwater

3 ECOLOGICAL AND MORPHOLOGICAL DEVELOPMENT OF THE DANUBE DELTA

This chapter will give an impression of the complex ecological and morphological development of the Delta and the many aspects that need to be taken into account when determining the effects of the various navigational alternatives. A more extensive description of the development of the Ukrainian Danube Delta are given in Appendices 3, 4 and 5.

3.1 Introduction Ukrainian Danube Delta

The Danube River is Europe's second largest river extending 2,800km from its source in Germany to the Delta at the Black Sea. It drains water from 817.000 km^2 within 17 European countries. The head of the Danube Delta lies at the bifurcation point at Izmailskiy Chatal where the river is divided in two arms: Kiliya and Tulchea Branches. The latter flows into Romania and divides again after 17 km into the Sf. Gheorghe and Sulina branches. The 116km Kiliya branch lies in South- West Ukraine and discharges 52-54% of the water. For the most part it forms the border with Romania. Downstream of Vilkove, the Kiliya branch flows into the outer delta and divides (from north to south) in the Ochakov, Bystroe and Starostambulsky branches. The latter is the main branch although it appears to be silting up making Bystroe more important as discharge channel.

The Ukrainian Danube Delta represents one of the most recent deltaic subsystems of the whole Danube Delta, having a surface of about 945 km^2, and representing about 21% of the whole Danube Delta. The real surface of the whole Danube Delta is 4,455 km^2, out of which the greatest part is situated on the Romanian territory, respectively 3,510 km^2 (79%), (Gastescu P., 2005). The surface of the ancient Halmyris Bay on which the lacustrine complex Razim-Sinoie is grafted is about 1,145 km^2, and together, the two geographical entities represent 5,600 km^2.

The deltaic space differentiation, from the first bifurcation towards the sea shores (Izmail Chatal), and from the main arms to the interior, it is the result of time evolution which had determined the formation of the various ecosystems (river banks, marine levees, lakes, streamlets, wetlands, etc.). Danube Delta is a unique area hosting more than 5,500 species of flora and fauna, including 315 species of birds, 97 species of fish, 39 species of mammals, etc.

The Romanian part of the Danube Delta is the main and the biggest component of the Danube Delta Biosphere Reserve, declared in 1990, with a total surface of 5,800 km^2. Danube Delta Biosphere Reserve is included in the network of MAB Program UNESCO, recognised as well as Ramsar Site (1991), and World Heritage Site (1991). From 2000 it was awarded the European Diploma.

The Ukrainian part of the Danube Delta is the main component of the Danube Biosphere Reserve, declared in 1998, with a total surface of 464.03 km^2, being recognised as Ramsar site as well. In 1999, the both biosphere reserves were recognised as the Transboundary Danube Delta Biosphere Reserve, Romania/Ukraine.

The survival of the Danube Delta on the (very) long term depends on whether enough sediment can be kept in the system to compensate for the combined effects of the rising sea with 1.5 - 4 mm/year (2.6 mm/yr. at Selariu 1972; 3.7 mm/yr. at Sulina and 2.7 mm/yr. at Constanța - Bondar, 1989) and a sinking land (1.5-1.8 mm/yr subsidence). Together these effects amount to about 1m subsidence / century. Sediment influx in both the coastal area and the inner delta can prevent the drowning and erosion of the delta. If enough sediment is available the delta is perfectly able to maintain itself through natural processes of siltation and sedimentation as it has done for the last centuries. To be able to grow with the sea, in the first place the natural processes must be able to function without constraints such as dykes and dams. In the second place the amount of sediment brought to the delta by the river must be maintained within the system, or even better, the sediment that has been taken out of the system through unnatural processes (e.g. dredging) should be restored.

Kiliya Delta

The 116 km long Kiliya arm of the Danube River originates at the Izmailsky Chatal point and is the most northern and abounding in water out of three main arms of the Danube estuary emptying into the Black Sea. The Kiliya arm formed three deltas during its historical/geological evolution: between Pardina – km 75 and Kiliya – km 46 (1st), between Kiliya – km 46 (2nd) and Vilkove – km 20, and between Vilkove – km 20 and Black Sea (3rd). The third delta 'Kiliya arm delta' branches as follows: first the Belgorodsky arm separates, then the Ochakovsky and Ankundinovo arms followed by the Starostambulsky arm which is the biggest in the Kiliya delta. The Ochakovsky and Starostambulsky arms have their own secondary arms.

Although in the 19th century there were several plans to construct a canal through the Kiliya Delta, or from Zhebriyanskaya Bay to the river Danube, these plans all were abandoned or stopped after a period (e.g. Ust Dunaysk). This is the reason why the Kiliya Delta still is in a very natural state.

3.2 Ecological and Morphological Aspects influencing Navigation in the Delta

The navigation potential of channels depends largely on the natural circumstances. Channels lying in areas of high dynamics and/or sedimentation need much (expensive) maintenance dredging and are thus not preferable. Shallow river and channel mouths such as in the Delta area have well developed mouth bars that also need to be dredged to allow passage of ships between the sea and river.

The hydraulics and sediment transport system in the Delta is the basis of the present shape and water distribution system. By changing one or even a part of one of them e.g. by introducing a barrier in the shape of a breakwater, will ensure a chain reaction that affects a much larger part of the Delta than just the project area. That is why we look at the entire system and not just the locations of the alternatives.

Hydraulics in the Danube Delta

In the past years, the main water discharge distribution has changed from the Starostambulsky Channel to the Bystroe Channel that now drains more water. This is a natural process as the first channel is silting up and water cannot pass through it any more. The two discharges are almost equal now.

Sediment in the Danube Delta

The amount of sediments transported to the Danube Delta increased sharply in the 19th and early 20th century as a result of the massive opening of the Romanian soils for grain production. The average annual suspended sediment discharge before the Iron Gate I and II dams were built was 2,140 Kg/s (67,5 millions t/yr), out of which sandy alluvia ca. 10% (Almazov et al., 1963; Stançik et al., 1988). In 1970, after the building of the Iron Gates I dam (Km.942,95 from the Black Sea) and Iron Gates II (Ostrovul Mare) dam (Km.864) in 1983, the sediment discharge decreased catastrophically. At present, the Danube total average sediment discharge is estimated to be not larger than 35 - 40 million t/yr., out of which less than 4 million t/yr. is sandy material (Panin, 1996). This is the amount of sandy sediments that contributes to the yearly littoral zone sedimentary budget which became strongly uncompensated since 1970. It is also obvious that the present day coarse sediment load (bed load) of the Danube originates mainly in the sediments eroded from the river bottom.

The distribution of sediments at the peak of the Delta to each main branch is approximately 20% Sulina, 30% Sf. Gheorge and 50% Kiliya.

Sand bars in the Near Shore Zone
Sand bars are formed in the channel near the river mouth and in the near shore zone in front of the mouth of the river. These zones form shallow areas that need to be dredged periodically to allow shipping to pass safely and for longer periods per year.

The river channel sand bars occur due to the deposition of the sedimentary load of the water at the landward reach of the salt-water wedge. The bed load of the river will stop at the upper limit of the salt wedge or very close to this limit. The wedge migrates in or out of the river mouth depending of the river water discharge and the relationship with the energy of the sea.

The formation of coastal sand bars at the mouth of the river depends on the waves and littoral currents. The waves keep the sedimentary load in movement (suspension or bed-load) facilitating the redistribution of the sediments along the shore by the littoral currents. In case the water discharge of the river becomes too small, sedimentation will dominate and the coastal bar will close the opening of the river branch.

Hydraulic Characteristics of the Near Shore Delta Zone of the Black Sea
Most wind-waves come from a NE direction (40-50%) corresponding to the prevailing wind direction, whilst swell waves come from the east. The mean and maximum heights of wind- and swell waves are higher for the eastern direction as the wind fetch is the longest; 7.8m at Constanța and ca. 11.0m at the Sulina jetties.

Prevailing winds exceeding 2 m/s are recorded for 80-90% of a year, winds exceeding 6 m/s for 30-55% and those exceeding 11 m/s for 4-15%. The frequency and duration of storms from the northern sector are clearly predominant (more than 55%).

The general water circulation in the Black Sea in front of the Danube Delta is characterised by a circular or 'Rim' current occupying a zone of about 50 km wide that coincides with the continental slope. The current has two layers separated by the pycnocline at 100 – 200 m depth: the upper layer is characterised by average velocity of ca. 50 cm/s, and the lower one with ca. 20 cm/s.

The near shore seawater surface current is not linked to the Rim current. In the north-western and western areas of the sea, this current flows southwards towards the Bosporus at a mean speed of 20-30 cm/s. Within the Danube Delta coastal area, there is generally a southward current of 5-50 cm/s velocity depending on water supply of rivers and the Coriolis force. In addition to this current, varying winds generate a complex current system roughly corresponding to the wind direction and influencing the direction and spread of the river jet-like wedge.

Along the Danube Delta, the net longshore sediment drift system in sea is directed towards the south. Its intensity is high enough to transport the coarse-grained discharge of the Danube many tens of km south along the shore. This current is influenced by local anthropogenic structures such as the Sulina jetties that create large eddy circulations.

3.3 Anthropological Influence in the Delta

The anthropological influence in the Delta can be summarised as follows:

- The Danube European Commission that was established in 1856 after the Crimean War carried out the Sulina meander belt cut-off programme during 1858-1902 period in order to improve the navigation along this tributary. The Channel was defined as a shipping canal between the Danube and Black Sea. The programme shortened the branch by about 25% (83.8 Km before the cut-offs and only 71 Km today). These works caused the increase of the water free slope and current velocity and, consequently, of the water discharge of the Sulina tributary from about 7% of total Danube discharge around 1860 to ~ 15% in 1928 and about 20% today;
- The British engineer Sir Charles Hartley advised to use Sf. Gheorghe' s branch for shipping. Contrary to this advice, the Commission ordered Sir Charles to build bilateral jetties at the Sulina tributary mouth to wash out the mouth bar deposits and protect the navigable channel from the Kiliya-born sediments, drifted southward by the littoral current along the shore. The jetties went on building since 1858. In 1861 the length of jetties was 1,412 m, in 1939 - 4,150 m, in 1956 - 5,773 m, today - about 8 Km. The jetties create changes in the littoral water and sediment dynamics and influences the development of the shoreline in the area. At the same time the channel was straightened out, cutting of several meanders;
- In 1984-1988 a similar cut-off programme was carried out on the Sf.Georghe tributary course. These works lead to a shortening of the tributary by about 31 km and, consequently, to an increase of the free water surface slope and of the water velocity. As result the Sf.Georghe tributary water and sediment discharges are also slowly increasing by re-distribution of the Danube discharge among the main Delta tributaries;
- Construction of the Iron Gates I (1970) and II (1983) dams upstream of the Delta influenced the natural water and sediment flows of the Lower Danube River and Delta. Sediment volumes dropped 40% after construction and the waters of the Danube eroded the embankments downstream of the dam to ‘recharge’ themselves with sediment;
- Dredging of riverbeds for navigational purposes i.e. removal of shallow zones in sedimentation areas and as a source of raw materials (sand). The dredged material was used to raise or reclaim land, deposited in natural deep areas in the river or if within reach of the sea it was deposited in the open sea (deep water).

4 CURRENT NAVIGATION SYSTEM

The navigation system should be considered as an integral system consisting of navigation routes, ports and hinterland connections. In this chapter, each of these systems will be described.

4.1 Navigational Routes

The Danube is the most important transport waterway in Central and Western Europe. Apart from internal basin traffic, it contains important routes such as Danube-Main-Rhine-North Sea and Danube-Oder-Elbe routes. The lower Danube can connect these routes to countries in the east such as Russia, Kazakhstan, Azerbaijan, Uzbekistan, Iran, etc. via the Black Sea, Kerch-Enykalsky Strait, Azov Sea, Volga-Don Navigational Channel, the Volga and Caspian Sea (Transport Corridor Europe-Caucasus-Asia). It has the potential to turn into a very important cargo route connecting east and west and has accordingly obtained the status of International Transport Corridor (ITC) Nr. 7. However, the route crosses the ecologically important and fragile Danube Delta and, if developed, it needs to be done with great care and consideration of the natural environment.

At the moment, two main routes are used by shipping through the Lower Danube Delta to reach Ukraine and Romania; via the Sulina Channel (big ships) and through the Bystroe Channel / Kiliya Branch.

Main problems
The development of the Lower Danube River for navigation purposes is a process that has been going on for more than 150 years. The main problems encountered are related to:

- Shallow sand bars along the coast and natural sedimentation in the rivers ensuring the need of continuous maintenance dredging and construction of long breakwaters. Both these aspects are time consuming and expensive;
- Creation of straightened and deepened channels influences the balance of the natural water system and thus the natural environment in the surrounding floodplains. In turn this causes changes in ecological habitats;
- The route crosses several countries, and ships passing through must prepare for the related administrative and customs procedures. Furthermore, the countries must agree on a political and regional level on navigational waterway dimensions i.e. width and depth, and allow transboundary traffic. Finally, the countries bordering the river and ships passing through must take international legislation into account for the Danube (e.g. Belgrade Convention).

4.1.1 Sulina Channel

The Sulina Channel of the Danube River was chosen as the main entrance for ships travelling up the Danube from the sea in the past. This has been the case from the period when merchant and navy ships were powered by man or sail up to the modern age internal combustion engines. The authorities preferred that ships proceeding from the Bosporus to the Danube used the Sulina Channel because:

- Less maintenance works were needed at the entrance compared to the other options and the channel was relatively stable;
- It was less winding (less curves) compared to the Sf Georghe arm;
- It had a low water current speed;
- It had permanent depths on bars of 2.5 m and;
- It had a low, dry right bank where, at the time preceding modern engines, people and horses could move freely and pull barges upstream in the absence of fair wind.

In the 19th century, Western Europe needed vast amounts of grain for the expanding populations. A new passage to the Lower Danube and plains of Romania was needed. A harbour was constructed in the third largest branch of the Danube Delta, i.e. the Sulina branch, to accommodate see-going ships to the harbour of Braila (located along Danube River just before division in final two branches), where the grain of the plains was brought by river vessels.

The construction of the straightened channel started in 1854 and lasted 24 years. Its initial length was 83.8 km and was shortened considerably to 63km. The canal has a width of 130-250 m and a depth of 7.3 m. The current Sulina Channel is 73 km long and includes:

- The Sulina Arm with a length of 63 km, between NM 34 (4 nautical miles downstream of Tulcea) and NM 0 at Sulina;
- The Mouth to the Black Sea with a length of about 5.5 nautical miles, located between two guiding dams of some 7.7 km.

Nowadays, the Sulina Channel is a class VII waterway (European classification of internal waterways) and ensures maritime ship traffic between the Black Sea and the Danube maritime ports of Tulcea, Galati and Braila in Romania, and Reni and Izmail in Ukraine. The Sulina Channel lies in the Romanian Delta Biosphere Reserve and falls under the jurisdiction of the Danube Commission.

The Romanian River Administration of the Lower Danube R.A. (AFDJ) is entrusted with the arrangement and maintenance of the Lower Danube in line with the recommendation of the Danube Convention, the requirements of the EU, and the responsibilities of the Biosphere protection. AFDJ should facilitate safe navigation through the Channel for 25,000 DWT (Dead Weight Tons) partly loaded vessels with a max. draught of 7 meters.

4.1.2 Bystroe Channel

The Bystroe Channel has effectively replaced the Prorva Channel and Ust-Dunaysk port system (see next chapter) again after having been abandoned in 1958. It was opened again in 2004 and since then 2200 ship passages were registered. Navigation is controlled with a Vessel Tracking System (VTS) to minimize risk of accidents.

The Bystroe Channel is a natural, straight deepwater canal with a sandbank in the coastal zone in front of the mouth to the Black Sea. The channel is naturally deep to accommodate the increase in water discharge that occurs due to the sedimentation of the Starostambulsky channel and the related inability of this channel to keep discharging large volumes of water.

The orientation of the channel is favourable for incoming ships. The 100m wide canal accommodates one-way traffic and ships take approximately 1 hour to pass the 8km from the Kiliya Branch to the Black Sea at a maximum speed of 8 knots. The sea access channel is about 3km in length and is orientated toward southeast. A waiting area is created at the beginning of the sea access channel where ships can wait for their turn to pass through the canal.

The breakwater extends to sea up to the 10m water depth contour. After this, the seabed drops fairly rapidly to a water depth of 20m.

4.2 Ships and Ship Sizes

In addition to the inland barges, the following ships can sail in the Sulina channel or Bystroe Channel:

- Sea-river vessels;
- Seagoing vessels;
- Container feeder vessel;
- Ro-Ro vessel;
- TSHD Seagoing hopper.

Sea-river vessels (see also paragraph below):
The ships have dimensions that fit both coastal sea routes and inland waterways. Special attention is given to the vessels water draught, air draught and beam, to fit the dimensions of inland waterways. The ship was developed to meet the increased cargo volume on specific routes, to minimize cargo transfer operations (and congestion in seaports) and to comply with increased demand for just-in-time delivery.

Seagoing vessels:
Tankers or bulk carriers of limited length and DWT, which serve smaller ports for import or exports of goods. Ships call mostly one specific destination and are loaded based on the available water depth on the route.

Container feeder vessel:
Container feeders are smaller container ships sailing on specific destinations between large container hub ports and regional import/export ports. The sizes of vessels vary with the cargo flows. For the Danube ports in future feeders to 400 TEU are envisaged mainly to/from Mediterranean or Black Sea hub Ports.

Ro-Ro vessel:
Roll on Roll off vessels are designed to load and transport rolling cargo, especially trucks. As the trucks can use a ramp to board and leave the ship, loading is very fast. The total principle of Ro-Ro ships is based on short port time and fast sailing. These ships are presently not deployed on Sulina Channel or in the Danube delta.

TSHD Seagoing hopper:
A seagoing hopper is a vessel that can dredge sand from the seabed and store the sands in its hopper. It can discharge the sand from its bottom doors (normally for dumping at sea) or be unloaded via pumps and pipelines to land terminals. A seagoing hopper is especially suited for dredging sand from the seabed and transport the sand over longer distances (for instance dredging of Danube River).

Table 4-1: Ship types and dimensions

	Length [m]	Draught [m]	Width [m]	Capacity
Container vessels				**[TEU]**
Feeder vessel (max)	140	21	7.5	800
Feeder vessel (average)	110	16	6.1	400
Sea-river vessel (max)	135	16	4.5	250
Sea-river vessel (average)	85	12.5	4.0	160
Tanker – bulk carriers:				**[Tons]**
Seagoing Hopper (max)	125	22	8.0	7,500
Seagoing Hopper (average)	80	14	5.0	4,000
Sea-river vessel (max)	135	16	4.5	2,250
Sea-river vessel (average)	85	12.5	4.0	1,000
Seagoing vessel (max)	180	23	9.8	10,000
Seagoing vessel (average)	86	15	7.5	1,800
Car Carrier:				**[Cars]**
Car carrier	140	22	6.5	1,000

Sea-River Vessels

Last decade a new transport system has developed: combined sea-river transport. This was driven by the increased cargo volume on specific routes, to minimize transhipment (an congestion is seaports) and the increased request of so-called just in time transport (cargo is delivered in a short fixed timeslot).

This Sea-River vessel type is mainly used in Europe and the Community of Independent States (CIS). The ships have dimensions and shape that fits both the coastal routes and the inland waterways. Special attention is given to vessel draught, air draught and beam, to fit in the inland waterways. In Europe and CIS mostly the ship was designed according to the existing waterway characteristics.

PIANC (Permanent Navigation Association) has assigned a Working Group on the features of River-Sea navigation and conducted an extensive survey into the existing fleet. The conclusions for the European Sea-river fleet are summarized below:

- About 80% has a length ≤ 90 m;
- 87% have a beam ≤ 13.5 m (distinct category: 12.5 - 13 m);
- 50% have a beam ≤ 11.5 m (distinct category: 11 - 11.5 m).

For the 11-11.5 m beam Class:

- Almost all ships have a vessel draught ≤ 4.7 m;
- The majority has a vessel draught of 3.5 - 4.5 m;
- Over 50% of the vessels have an air draught ≤ 7.0 m;
- Almost all have an air draught ≤ 11.0 m (River Rhine control height).

For the 12.5-13 m beam Class:

- Almost all ships has a vessel draught ≤ 5.0 m;
- The majority has a vessel draught of 4.5 m;
- Over 50% of the vessels have an air draught ≤ 9.0 m;
- 20% have an air draught ≥ 11.0 m.

In general, Sea-River vessels in Europe have a maximum capacity of 3,000 DWT, vessel draught limit of 5.0 m and an air draught limit of 9.0 m.

The conclusions for the Russian Sea-River fleet are summarized below:

- Three categories:
  11-12 m beam, with dimensions (AD = Air draught, WD = draught)
  LxBxWDxAD = 82 x 11.9 x 3.1 x 9.0 or 82.4 x 11.4 x 4.0 x 8.3 m
  ˜ 13-13.5 m beam, with dimensions
  LxBxWDxAD = 114 x 13.2 x 3.7 x 13.7 or 116 x 13.4 x 4.0 x 13.2 m
  ˜ 15.5-17 m beam, with dimensions
  LxBxWDxAD = 139 x 16.6 x 4.3 x 13.2
- The fleet has a high degree of standardization; the stated dimensions are almost always met by the vessels in the Class.

Sea-river vessels face some constraints because of the operational and dimensional requirements to the vessels. Because of the restrictions for their dimensions, the vessels will be more expensive in construction costs than seagoing vessels of the same cargo capacity. The running costs for sea-river vessels are also higher than for IWT barges, because of the added complexity of the ship structure. Furthermore the crew is also more expensive because of their higher qualifications (both river and sea navigation).

Sea-river vessels, because of the abovementioned reasons, mainly carry bulk loads such as coal, grain, raw building materials (sand, cement) and fertilizer. Moreover neo-bulk loads such as steel, steel products, scrap, sawed timber and paper transported by sea-river vessels and in certain cases the vessels are being employed for container transportation purposes as well.

Figure 4-1: Sea-river container vessel, 160 TEU, 85x12.5x4 m

PIANC, as a result of the sea-river vessel survey and market potential, has defined a sea-river classification for the European waterways. Three classes have been discriminated, based on the existing dominating sea-river vessel dimensions and with a vision for future development of sea-river transport:

Table 4-2: PIANC Classification of Sea-River waterways

R/S Class	Maximum permissible dimensions of vessels			Air clearance (m)
	length (m)	beam (m)	draught (m)	
1	90	13	3.5 or 4.5	7 or 9.1
2	135	16	3.5 or 4.5	≥ 9.1
3	135	22.8	4.5	≥ 9.1

4.3 Current ship traffic in Sulina

When looking at the (potential) shipping traffic in the region, we can use the data for the Sulina Channel as a general reference. These can and do travel to Ukrainian territory.

The average ship using Sulina Channel has changed since 1978. Figure shows that while in the early 1980s the average ship had a size of over 5,000 GRT (Gross Tonnage) and carried cargo volumes in the order of 2,500 tons, these levels have reduced to around 2,500 GRT and 1,500 cargo tons on average during the 1990s and 2000s. This trend will also be related to the coming up of the sea port of Constanta and as a consequence the use of Sulina Channel only for smaller ships or special cargo deliveries.

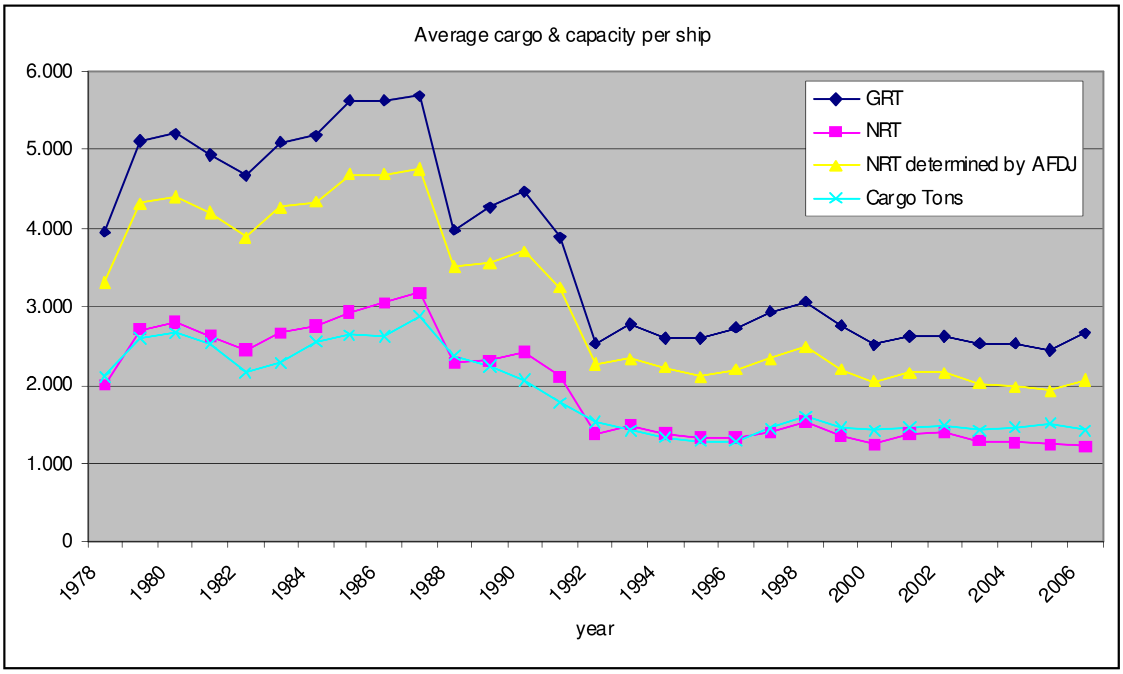


Figure 4-2: Average ship size development (Source: AFDJ, calculations ECORYS)

On these historical data, no spread of ship sizes is available. For the shorter past (1999-2006) such an analysis could however be made, see the next section.

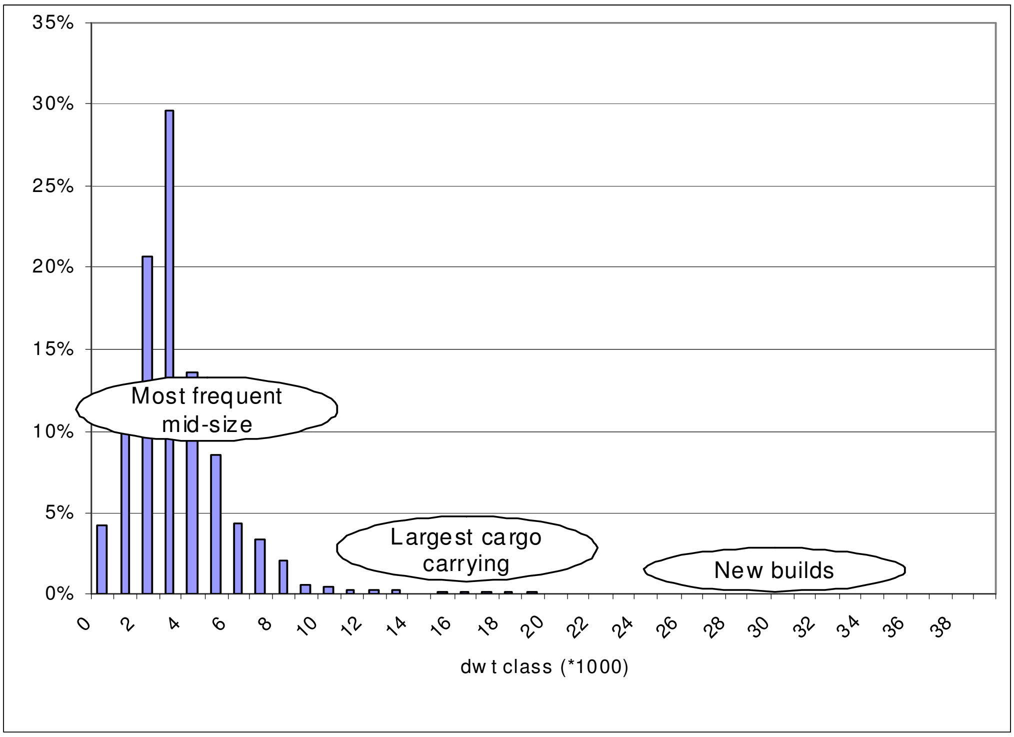


Figure 4-3: Typical vessel size

The figure above indicates the share of ship size classes using Sulina Channel between 1999 and 2006. It clearly shows that the largest part, almost 30% concerns vessels between 3,000 and 4,000 DWT. It also shows that 95% of all vessels has a size smaller than 10,000 dwt. Incidentally, larger vessels up to 29,000 DWT enter the channel, while new built vessels of up to 38,000 DWT also use the Channel. However since 2004 the largest vessel was 20,000 DWT at most (LOA around 150m, beam 23m, draft max 9m, thus usually not fully loaded when entering Sulina Channel).

Table 4-3: Typical ship size per DWT category – some examples

Dead Weight Tons DWT	GRT	NRT	LOA (m)	Beam (m)	Max. draft (m)
3,000	1,800	1,100	80	14	5.3
4,500	3,300	1,900	110	15	6.0
10,000	5,500	3,300	135	19	7.9
20,000	11,500	6,000	160	22.5	9.5
38,000	21,000	11,500	200+	24	10-11

Source: Lloyds world shipping database, aggregation estimates ECORYS
Note that there is no linear relation between DWT, GRT, NRT and dimensions. This also depends on engine type and vessel characteristics.

Although a 'typical vessel' cannot be defined, it is possible to define some typical categories:

- Small vessels, below 3,000 DWT
- Mid-size vessels, ranging from 3,000 to 4,000 DWT
- Larger-sized vessels, ranging from 4,000 to 10,000 DWT
- Incidental large vessels and new-builds, of size above 10,000 DWT.

4.4 Sea and River Ports

There are two types of ports that should be taken into account: those situated along the Black Sea Coast and capable of receiving large sea- and ocean going ships and those situated inland capable of receiving small ocean going ships, Sea-River vessels and IWT ships and barges. A cooperation between these ports means that a network can be created that has access to the very large Danube River Hinterland and major international sea routes.

4.4.1 Black Sea Ports

There are several major ports along the Ukraine and Romanian Black Sea Coast that can influence the navigation and cargo transport in the Danube Delta region. From North to South these are: Odessa and Illichivs'k ports in Ukraine and Constanta Port in Romania.

These ports lie relatively close to the Ukrainian Danube Delta and are of interest for transhipment of cargo from sea-going vessels to sea-river vessels and larger IWT vessels that can navigate up the Danube River via the inland ports. At the moment, ore is transported from Illichivs'k Port to Reni by train. This could also be done by IWT, but due to the relatively high Sulina Channel tariffs, the costs per train are the same.

Odessa Port

Odessa Port is a fully functional port that lies in the centre of town. It is one of the most important ports in the region but is desperately in need of a new port area because of limited capacity at the current site. At the moment, there is a discussion on the expansion of the Odessa Port. The Port needs to expand urgently but is not allowed to do so because of the heightened impacts on the city (noise, air, safety etc). In the mean time, cargo is diverted to Illichivs'k.

The Port includes an oil harbour, container handling facility, a passenger area and 7 facilities for handling dry - cargoes. It can handle up to 14 mln tons of dry-cargo and about 24 mln tons of oil products. The passenger terminal can receive up to 4 mln passengers per year. Cargo is transported by railway or road.

Figure 4-4: Odessa Port and Marina

Illichivs'k Port

Illichivs'k Port is situated to the west of Odessa in the deep water estuary Sukhoy Liman, connected to the sea by an approach channel and creating a natural protection of port water area from waves and currents. The port handles a wide range of cargoes from all over the world and has the facilities to handle up to 28,5 million tonnes of cargo annually. It can receive vessels with any length and draught up to 13,0 m.

Besides multipurpose berths, ferry and ro-ro terminals, the port has berths for containers, grain, oil products, vegetable oils, fertilizers in bulk and sulfur and liquefied gas. Cargo can be transported by railway and road.

Figure 4-5: Illichivs'k Port showing the different cargos that are being transshipped at the port

Constanta Port

Constanța Port is located in Romania and is both a maritime and a river port with a depth of 18.5m. It has a handling capacity of 100 million tons per year and 156 berths. The Port is connected to the Danube River through the Danube-Black Sea Canal.

The Port can handle the following goods: liquid bulk, dry bulk, ore, coal, coke, chemical products and fertilizers, agribulk, cement and construction materials and containers. Furthermore, it has RoRo berths and Ferry terminals.

4.4.2 Inland Ports

Along the Danube River there are a multitude of important commercial-, distribution- and transport centres situated in and next to many large cities. The Danube offers opportunities to transport cargo all the way up to Vienna (Austria), Budapest (Hungary), Bratislava (Slovakia) and Belgrade (Serbia and Montenegro). On the tributaries of the Danube there are more large cities; Zagreb (Croatia) and Ljubljana (Slovenia) along the Sava, Sofia (Bulgaria) along the Istra and in extreme case Munich (Germany). Along the Ukrainian stretch of the Danube there are the towns of Reni (23.000 inhabitants), Izmail (90.000), Kiliya (25.000) and Vilkove (11.000).

At the beginning of 1950s the ports of Izmail, Reni and Ust-Dunaysk were (re)constructed to increase the cargo throughput. In addition, shipbuilding and ship repair yards were built in Izmail and Kiliya and transport routes were created connecting the ports to the hinterland and increasing their reach.

At the same time, a navigational route was made by deepening the Ochakov branch and dredging the artificial Prorva channel connecting the then important Ust-Dunaysk Port with the inland ports along the Kiliya branch. The choice for this route was a political one without taking into account morphological and hydrological factors.

However, intensive sedimentation processes in the Prorva channel meant that the water depth decreased rapidly and large-scale maintenance dredging was needed. In the 1950s dredging was temporarily stopped and water depth decreased. In the 1970s dredging started again to finally stop in 1994. After that big-tonnage shipping on the Ukrainian reach of the Danube delta could not take place any more through this channel. A short-lived revival of dredging activities in 1997-98 pushed by economic needs did not last and now it is not in use anymore. The channel was in use from 1957-1994, including a period when only smaller ships could pass.

Currently, the Ust-Dunaysk port is not really in use because the access routes are not suitable for sea-going ships (too shallow and too many sharp bends). The degradation of this port also caused social and economic problems for the inhabitants in the region. Exact data on the extent of these problems is unknown.

Reni

Reni Port was founded as the biggest grain trading place in the region. Its intensive development started after World War II. In the 1960–80s, it became necessary to enlarge the port and new berths, warehouses and civic infrastructure was constructed. The port's throughput handling exceeded 10 million tons of cargo per year; its record turnover was 13.7 million tons of cargo in 1989. The total area of covered warehouses is 25,200 sq. m, and that of open warehouses is 246,200 sq. m (www.ukrport.org.ua/p-reni-e.htm).

Port Reni consists of 3 cargo areas and a ferry complex. The length of the berthing line is 3,900 m, and the territory covers 175 ha. Cargo areas Nos. 1 and 2 are specialized in throughput handling of general cargoes. Area No. 3 specializes in bulk cargo handling; and has a complex for throughput handling of motor trucks.

There are 37 port berths for general, bulk liquid, bulk, foodstuffs, heavy lifts and packaged cargo, as well as containers and wheeled motor cars. Two specialized berths operate in the port: a berth for heavy lifts, equipped with a bridge crane (cap. 250 tons); the berth's length is 120m; and water depth at the wall is 3.6 m; a berth for handling RO-RO vessels, 85 m in length with 3.6 m depth.

The port has an oil terminal that can accommodate seagoing and river oil-carriers of up to 10,000 t. Terminal can handle 500,000 tons of petroleum products a year.

Izmail

Since the city of Izmail was established in 1810, foreign merchant vessels began calling at it. Nowadays, the enterprises of Izmail are generally connected with the shipping business. The most important development period for Port Izmail was between 1968-1992, when handling complexes for general cargoes, bulk cargoes and containers were built (www.ukrport.org.ua/p-reni-e.htm).

The port can accommodate vessels that meet the following specifications:

- Sea-going cargo ships with: deadweight up to 10,000–15,000 tons; draft in full load up to 7.2 m; and length up to 150 m. max. 30 m width;
- River cargo ships with: deadweight of up to 5,000 tons; draft in full load up to 2.7–3.5 m; and length up to 150 m.

The port has equipment, loading devices, and machinery for handling all kinds of incoming cargoes, such as: bulk, dry-bulk, packaged, and containers and is designed to handle up to 7.7 Mtons of cargo per year.

The territory of the port comprises 23 berths which extend for 2,500 m; the depth at the berths is from 3.5 m to 7.5 m. The port is divided into three cargo handling complexes, as follows:

- Complex No.1 (berths Nos.1–8) handles mostly packaged cargoes in bags, equipment, agricultural equipment, metals, packed cargoes, and grain with a total capacity of 1.2 Mtons per year.

- Complex No.2 (berths Nos.19–22) is intended for handling bulk cargoes: ore, coal, coke, concentrates, iron ore, pellets, metal products, and grain with a total capacity of 5.4 Mtons per year. Complex No.2 also includes a specialized container terminal (berths Nos.12–14), where ships with draft up to 6.5 m can be handled. The total length of the three container berths is 250 m., and there are nine gantry cranes with lifting capacity of 40 tns. 2,200 containers can be stored there, simultaneously. The cargo capacity of this container terminal is 660,000 tons cargoes per year.
- Complex No.3 (berths Nos.16–18, 23–26) handles bulk and general cargoes: equipment, coal, metal, ore, and grain.

The port has at its disposal 8 sheltered warehouses whose total area is 24,300 sq. m. The open cargo storage area is 162,800 sq. m.

Figure 4-6: Pictures of Izmail Port

Kiliya

Kiliya is a port-station i.e. organization department of the Port of Ust-Dunaysk Port with a total area of 43,500 m², a quay length of 150 m and berth depths of 2,8m (5m from the berth the depth is 4,4m). There are 2 berths and a road connection to the hinterland.

Figure 4-7: Pictures of Kiliya Port

Vilkove

This is a small river port now focussed on inland shipping / barge transport. It has a poor hinterland road connection, no rail connection and no large scale industrial activity. It has a relatively large protected basin in which inland ships and barges wait in the wintertime. In the basin there are several floating docks for repairs.

This port will not be considered in the rest of the project.

Figure 4-8: Left Tugboats lying at Vilkove, Right barges lying in the basin and floating docks

4.5 Connections to the Hinterland from Project Area (Ukrainian Danube Delta)

There is no railway and only a two lane road connection to the Danube Delta area. In some cases the only transport mode to the smaller settlements is over water. Any port development in the area will require an investment in a new railway or road improvement including possible bridges over the river branches.

The larger inland ports of Reni and Izmail are connected by road and railway, in the case of Kiliya only by road. These transport routes may need improvement or expansion if cargo volumes increase.

Figure 4-9: Road- (red line) and rail connections (black line)

5 CARGO AND SHIPPING FORECAST

5.1 Introduction

Ukraine has four cargo ports along the Danube River:

- Ust Dunaysk: along the coast at the mouth of the Prorva arm handles fluctuating volumes of cargo. Mostly it concerns sands that are loaded there and shipped upstream by IWT (1 mln tons in 2004, but only 75,000 tons in 2007 after stopping of the maintenance dredging works);
- Kiliya: a very small port handling some 100,000 tons of cargo, mainly grain;
- Izmail: the biggest Danube port of Ukraine, handling some 7 mln tons of cargo;
- Reni: the second biggest port handles some 3 mln tons of cargo.

Figure 5-1: IWT through Ochakov Channel to Ust Dunaysk and loading sand at Usk Dunaysk

Together, these ports account for a throughput of 10.5 million tons (2005 data). Three product groups accounting for 78% of all cargoes handled in terms of volume are:

- Solid fuels (3.1 mln tons)
- Iron ore and scrap (3.9 mln tons)
- Semi-manufactured products (1.1 mln tons)

Izmail and Reni both handle solid fuels and iron ore/scrap. Izmail also handles the third largest commodity (semi-manufactures), while Reni exports grains and fertilizers as well. Kiliya and Ust Dunaysk in 2005 were relatively in balance having similar volumes of loading and unloading. For both ports sands and grains are the most important commodity.

Izmail was the second largest Danube port in terms of throughput, after Galati in Romania that handled almost 10 mln ton in 2005. Reni ranked fifth, just after Belgrade.

Reni and Izmail are mainly exporting ports, as can be seen from the graph below. Over 80% of cargoes handled in Reni are exported, for Izmail this is over 95%. Most of these exports are transported into Europe along the Danube by IWT and are therefore not relevant for the Ukrainian sea access considerations. Cargoes are brought to the ports from the hinterland mainly by rail and some by road. In the case of Izmail, ores and coal are transported by rail from central and north-eastern Ukraine and Russia. For these cargoes, a sea access in the current logistics system will not be of added value.

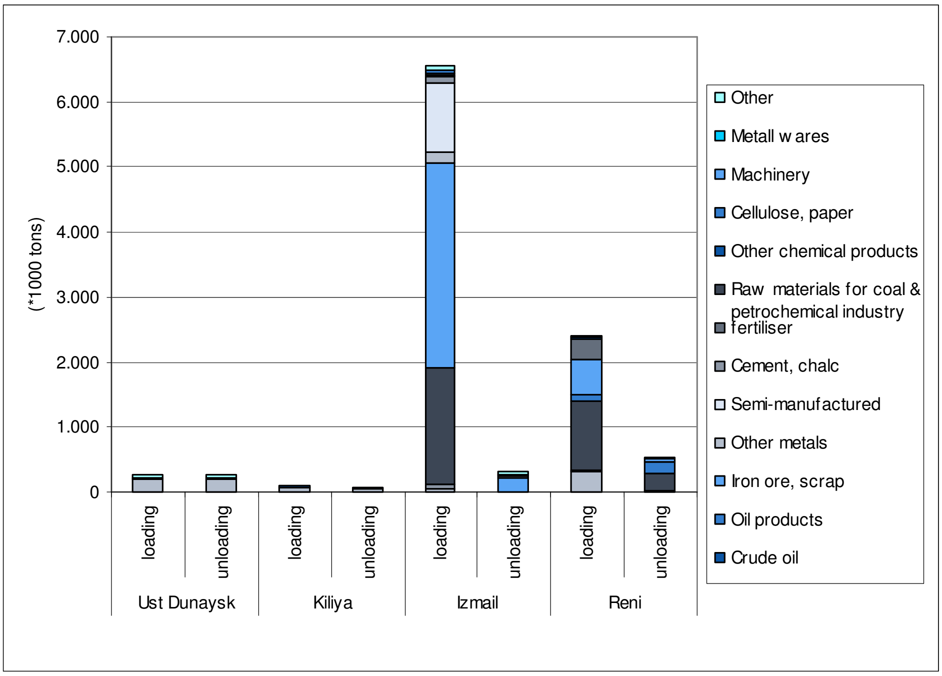


Figure 5-2: Cargo handled by commodity and by port, loading and unloading [Source: Danube Commission, 2007 Statistical Yearbook (data on 2005)]

Detailed statistics on the share of maritime cargoes handled in the various ports are not provided by the Danube Commission or the individual ports and therefore have to be constructed within this project.

5.1.1 Historical Data on Maritime Trade and Traffic

Available statistics on maritime trade and traffic to the Danube river ports go back as far as the 1950s. In this period, the Ukrainian arms of the Danube were used by maritime traffic even though the Sulina Channel was also available (since 1856). In the 1970s, the Prorva channel was dredged (again) and the Ust Dunaysk Port was revitalised. In those days, large maritime vessels were lightered using IWT vessels of Europa-2 size (length 76.5m, beam 11.4m, draft 3.5m, capacity 1,450 ton).

Past data show that for example in the 1950s, the Bystroe arm accounted for almost 40% of incoming and outgoing volumes.

Table 5-1: Cargo through Sulina and Bystroe during the 1950s (*1000 tons)

Year	Sulina Channel *	Bystroe Channel **
1950	216	160
1951	338	351
1952	351	199
1953	561	197
1954	767	516
1955	1,280	851
1956	1,201	819
1957	1,409	991
Average share	**61%**	**39%**

Source: *Statistical Reference Book of Danube Commission for the period of 1950 to 1974
** Statistical Data of SDSS for the period of 1945 to 1966.

5.1.2 Current Maritime Trade and Traffic to Ukrainian Danube Ports

Based on interview reports, the total throughput of maritime cargo in 2006 for all four ports was estimated to amount to some 1.4 mln tons. Half of this volume is said to have passed through Reni and virtually all of the remainder through Izmail. Kiliya and Ust Dunaysk play no role of importance for maritime trade and traffic.

An analysis was made of detailed data of ships passing through Sulina Channel and through Bystroe Channel over the last years. The main conclusions on Sulina Channel are:

- In recent years, 20-30% of all vessels passing Sulina Channel had a Ukrainian port as its destination. Reni receives the largest share (357 vessels in 2006), Izmail a lower amount (101 in 2006) and Kiliya only marginal numbers (11 in 2006);
- Average size of vessels that pass the Sulina Channel currently is 3,500 DWT, carrying 1,500 tons of cargo (full and empty taken together). For Reni and Izmail average cargo carried tends to be slightly higher than the overall average, in the order of 1,650 tons per vessel (again full and empty). Kiliya has insufficient data to give reliable averages;
- Average draft of vessels visiting Ukrainian ports over the period 2002-2006 was 4.5m (5.1m for laden vessels and 3.8m for empty ships).

Figure 5-3: Shipping along Kiliya Branch

Commodities shipped through Sulina Channel to and from the Ukrainian ports are mainly (based on AFDJ, Romania data):

- Cereals to/from Kiliya, in vessels of 3,000 to 5,000 dwt (carrying 3,000 to 4,000 tons, and a draft of 3 to 4 m);
- A variety of cargoes to/from Izmail (general cargo, steel, laminates, utilities, kaolin, etc). The average vessel is smaller than the ones visiting Kiliya, ranging between 2,000 and 4,500 dwt and an average of 2,400, draft of 3m on average;
- A variety of cargoes to/from Reni, including liquid bulks (fuels, chemicals), in vessels of similar size as and occasionally even bigger than those calling at Kiliya;
- It is noted that about three quarters of all maritime cargoes through Sulina concern exports from Ukrainian Danube ports to foreign destinations.

It is noted that data on Sulina Channel concern the period until mid 2006. This means that the developments caused by the Phase 1 deepening of Bystroe Channel cannot be traced back in the Sulina analysis. Additional analysis of traffic data on Bystroe Channel can provide insight in the most recent trends.

Data from the period August 2004-March 2006 show that after an initial steep increase in the number of ships' passages through the Bystroe Channel, the share in total traffic declined again. This is however not followed by an increase of Sulina routed traffic but apparently by a general reduction in maritime traffic in general during 2005. Low water levels in this dry year may be at the cause of this.

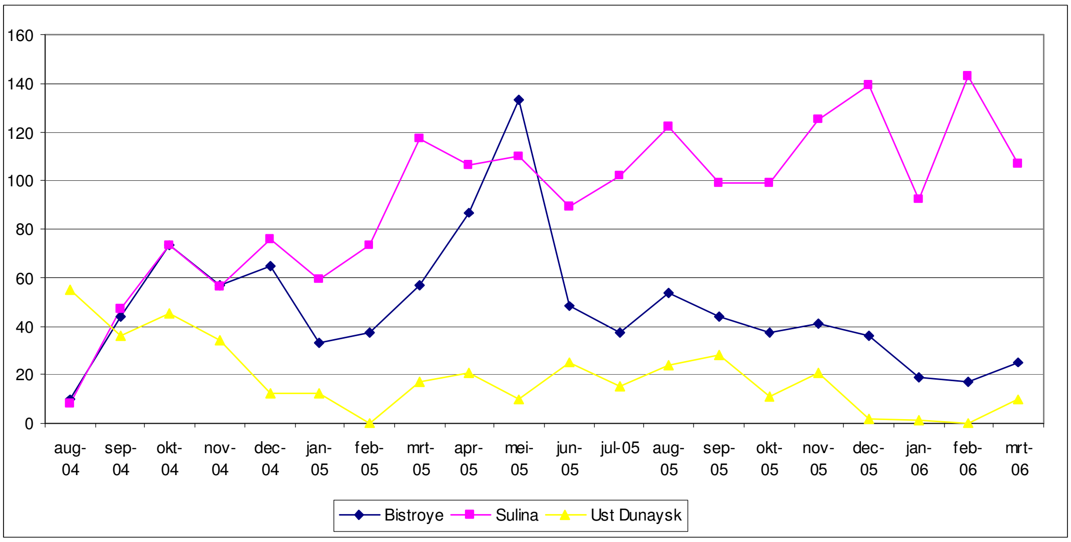


Figure 5-4: Number of ships per month and per route (Aug 2004 to March 2006)

Source: Delta Pilot (Mr. K. Sizov)

A detailed analysis for Bystroe routed traffic was made based on traffic data for the period from April 2007 to April 2008. The following is concluded based on this analysis:

- Over 1,100 ships have passed Bystroe channel in the reported period. Some 22% had Izmail as destination or origin, 18% Reni and 18% Vilkove. Remarkably, 28% was destined for the Romanian port of Galati, even though the sailing route through Sulina is much shorter than through Bystroe (this also holds for Reni). Although not certain, it seems that the reason could be the higher tariffs of the Sulina Channel;
- Average vessel size was around 2,200 GT (ca. 3,000 DWT), which is much smaller than the vessels going through Sulina Channel (3,100 GT or up to 4,500 DWT for Ukrainian bound vessels). Logically this is caused by the lower available water depth in Bystroe Channel. This is also confirmed by the average draft, which is about 2.9m, compared to 4.0m for ships through the Sulina Channel. Also the average cargo volume carried is lower: 1,033 tons on average, versus almost 1,500 tons through Sulina;
- The assumption that empty vessels enter or exit through Bystroe, while loaded vessels sail through Sulina, was not confirmed by the data analysis. On average the share of empty vessels through Bystroe is 53%, which is about the same as for Sulina Channel (50%);
- In total, during the reported period (approximately 1 year), over 1.1 mln ton was shipped through Bystroe Channel. Compared to the 2.7mln tons that were shipped through Sulina Channel in 2006, this is a substantial share, which must have negatively affected the Sulina routed traffic.

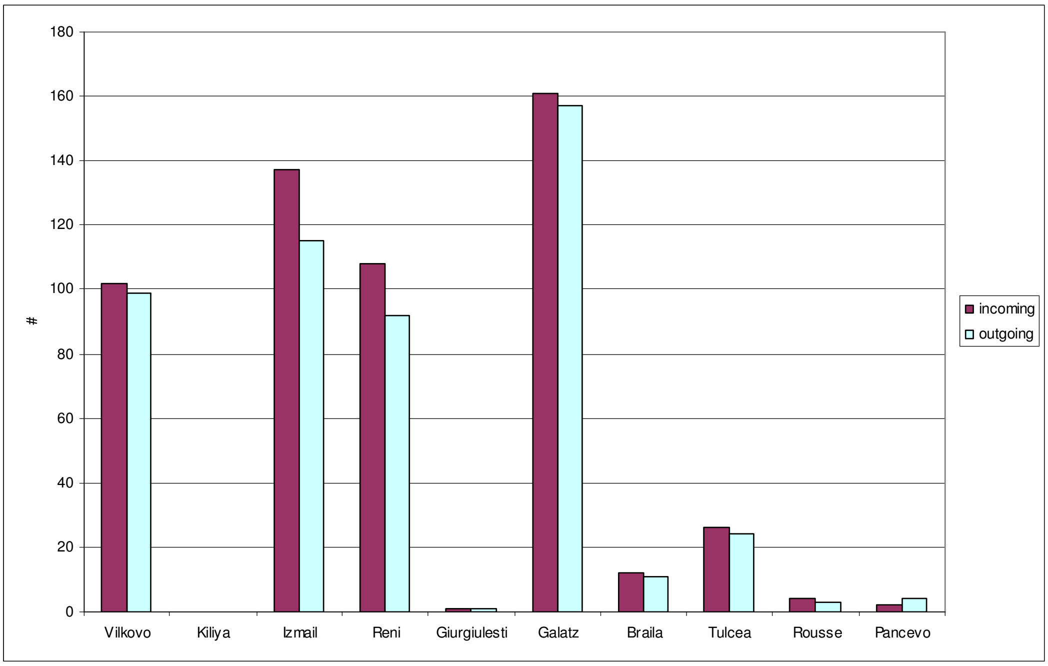


Figure 5-5: Number of ships through Bystroe by port of origin/destination

Source: Bystroe traffic data; calculations ECORYS

5.2 Cargo Forecast

An important starting point for the economic analysis is the trade forecast: the volumes and segments of cargo. The trade forecast is developed based on:

- Recent work done related to the Sulina Channel study conducted by DHV and ECORYS. This took into account economic growth of Romania, Moldova and Ukraine, as well as the position of specific industries (main shippers) and the planned investments in the region;
- Existing port throughput of Ukrainian ports;
- Possible future changes in the shipping demand of major industries in the region (e.g. investments in new plants, decisions to move production to elsewhere, etc.);
- Port development plans, such as intentions to invest in port capacity or industrial sites in or near the port area.

The growth of commodities/destinations is taken to follow the expected GDP growth of Romania and Ukraine/Moldova for the coming years (EC DG TREN estimates), assuming a correlation between economic growth and port throughput and applying elasticises to assess the trade growth that follows from this. Based on available information the following forecast for the total throughput of all maritime Danube ports (in mln ton throughput) is made. It is clearly visible that in the low scenario, the trade volumes will even decline after 2020.

Table 5-2: Maritime trade forecast Danube ports (mln tons)

Scenario	2006	2010	2015	2020	2030
Low	3.6	4.0	4.5	5.2	4.8
High	3.6	4.8	6.3	8.6	9.8

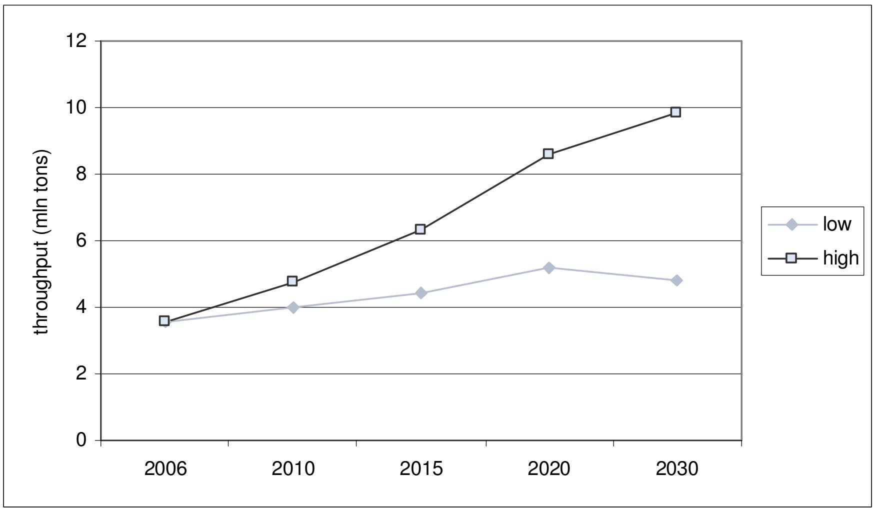


Figure 5-6: Maritime trade forecast Danube ports

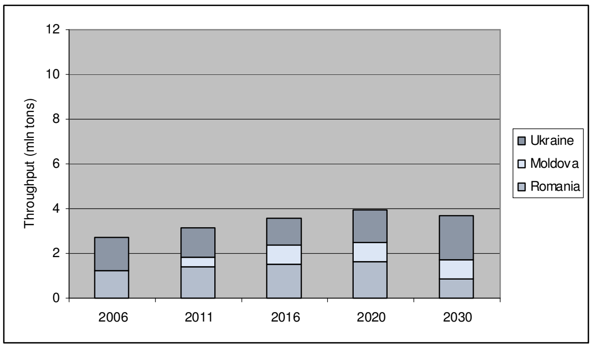
The above trade forecast does not only take into account the Ukrainian river ports, but also those of Moldova and Romania, as the Ukrainian sea access may also be used by ships bound for Moldovan or Romanian ports. It is, however, noted that benefits of using the Ukrainian sea route to these ports do not add value to the Ukrainian economy, but to that of Moldova or Romania.

The high scenario as presented above takes into account economic growth in the Ukraine as well as surrounding trade partners, but does not take into account specific developments in the Ukrainian Danube region. In the interviews held during the fact-finding mission to Ukraine, as well as in previous interviews held during the Sulina Channel project, it was concluded that no specific investments in regional industries are planned that will affect the volumes through the Ukrainian Danube ports, other than normal economic growth and trades caused by that. Therefore, the high scenario does not need to be adjusted upward.

The low scenario is based on available knowledge of investments in Moldova and Romania that, if not implemented, will lower the growth expectations for the region. This includes amongst others:

- Decline of the steel industry in Galati
- No maritime container handling development in the Danube ports
- Slow growth of the new port in Moldova

The forecasted allocation of throughput over the three countries in both scenarios is given in below graph.



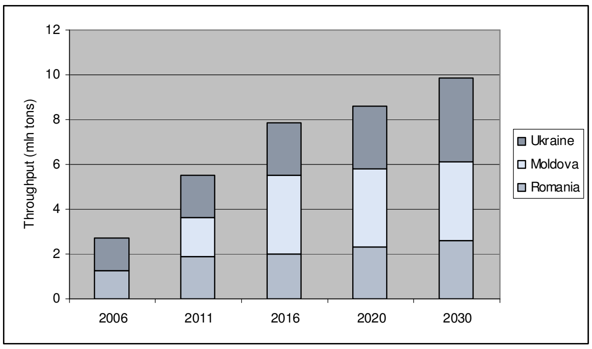


Figure 5-7: Forecasted throughput in three Danube countries (left: low forecast; right: high forecast)

Port capacity
One of the considerations of the Ukrainian authorities is to increase port capacity in order to facilitate the trade growth that the new sea access may enhance. Above graphs show that the throughput handled in Ukrainian Danube ports, currently at around 1.4 million tons, will in the low scenario grow to around 1.9 mln tons, and in the high scenario to twice this volume, 3.7 mln tons. It can be questioned whether the ports have sufficient capacity to handle these volumes. During the visits to Izmail and Kiliya, it was observed that there is some spare capacity available. From historical statistics it is known that much larger volumes of cargo have been handled in Reni and Izmail than are currently handled (Reni handled 12.3 mln tons in 1986; Izmail handled 10.1 mln tons in the same year), although a large share of this has always been IWT related cargoes.

Consultants did not conduct a detailed analysis on the existing port infrastructure, capacities or water depth/quays available. It might be that future growth on certain commodity segments may require some investments in handling equipment or storage facilities. These would then concern private investments to be made by port operators. On a general level port capacity is considered to be sufficient.

Bottlenecks are however identified with regard to hinterland infrastructure. Especially the railway line from Izmail to the Ukrainian hinterland was said to be used to its full capacity already, while the two lane road is of good quality, but also limited in capacity. For this analysis it is however assumed that hinterland infrastructure does not limit the growth of the ports.

5.3 Shipping Forecast

The next step is to translate the trade forecast to a shipping traffic forecast: how many ships will be required to ship the expected volumes. In order to assess this, the following assumptions have been made:

- The future maximum maritime ship size that can access the Danube river ports will be restricted by water depth available in either Sulina or the Ukrainian sea access. For most Ukrainian alternatives a maximum draft of 7.2m is assumed, similar to the Sulina Channel. Therefore, the same restrictions will apply to both routes;
- Current average size of ships sailing the Bystroe channel is smaller than the average of ships sailing Sulina Channel (around 2,200 GT versus 2,600 GT; average cargo carried ca. 1,000 tons versus 1,500 tons). It will be assumed that if the Ukrainian sea access has the same depth as Sulina Channel, the average ship will be of the same size on both routes;
- It is assumed that both in the low and high scenario, vessel types used for shipping to the maritime Danube ports will increase in size. For the high scenario it will be assumed that by 2030, average size will have increased to 4,000 GT, and average cargo carried to 2,250 tons. For the low scenario we assume a slightly lower growth of ship size, to 3,500 GT and average cargo carried to 1,900 tons.

As a consequence, in the high scenario the total number of ships required to ship the then expected cargo volume, will increase from the current ca. 2,800 per year (Sulina and Bystroe channels together) to almost 4,400 ships in 2030. In the low scenario, the number will slightly increase until 2020 and then decline again to some 2,500 in 2030, because of the withdrawal of several major cargo owners from the region. Below table gives figures for several intermediate years.

Table 5-3: Maximum ship size 4000GT

Length overall	Breadth	Full Load Draft
92-107	15-17	5.5-6.4

Table 5-4: Development of average number and size of maritime ships to/from Danube ports

	Current *)	2010	2015	2020	2030
Number of ships					
Low scenario	2,786	2,950	3,000	3,200	2,500
High scenario	2,786	3,400	3,900	4,700	4,400
Average GT					
Low scenario	2,503	2,600	2,800	3,000	3,500
High scenario	2,503	2,650	3,000	3,300	4,000
Average cargo carried					
Low scenario	1,304	1,350	1,500	1,650	1,900
High scenario	1,304	1,400	1,600	1,800	2,250

*) Current data are a mix of 2006 Sulina Channel data and 2008 Bystroe data and should therefore be read indicatively

The largest part of these vessels concern dry and liquid bulk vessels. In the high scenario a small share of container vessels will appear.

It is remarked again that the above number of ships concerns all ships that sail to/from Ukrainian, Moldovan and Romanian ports, irrespective of the route chosen. In the next chapter an assessment of the various routes will be made.

6 ECONOMIC ASSESSMENT OF ALTERNATIVES (CBA)

For a study into alternative investment options, and especially for an economic feasibility analysis, it is of utmost importance to have a clear project definition as a starting point for data collection and impact assessment. The project here was defined as:

1. The creation of a sea access to the Danube on Ukrainian territory, and
2. The necessity (if any) for an extension of port capacity, either through construction of new sea port along the Danube or along the new sea access, or through the extension of existing ports.

The alternatives vary in water depth (and thus in size of vessels that can be accommodated) and also in sailing length from main shipping routes to the Danube ports.

For the second project component, the extension of port capacity, no alternatives have been defined. However notions are given concerning:

- Extending terminal capacity in existing ports (Izmail, Kiliya) and invest in additional facilities for new activities (industries, new commodities)
- New port downstream of Kiliya near the entrance of, or even along, the new sea access channel. In the past some investments have been done in this respect.

Based on the visual inspections of the ports and interviews with port authorities, it was assessed that for the near future no additional port capacity is needed. Only if new logistical concepts will become in use, investments may be required.

6.1 Estimated Costs of Alternatives (Construction and Maintenance)

In the base case, with which the project alternatives will be compared, the sea access to Ukrainian Danube ports will be through the Sulina Channel and no new Ukrainian sea access will be developed.

No comparable data was found for construction and maintenance costs of the different alternatives. Any data found was mostly based on expert opinion and had no underlying breakdown of costs, making it difficult to determine which aspects of the alternative had been taken into account.

To be able to carry out the Cost Benefit Analysis we made an own estimation of the construction and maintenance costs. These are again based on expert opinion and should be used with caution.

Table 6-1: Estimation of construction and maintenance costs of the alternatives (expert judgment)

	Construction							Maintenance (per year)			
	Dredging		Breakwater		Lock		Total	Dredging	Lock	Br.water	Total
Alternative	Volume (Mm^3)	Costs (€ m^3)	Length (km)	Costs (€ m)	No.	Costs (€M)	Costs (€M)	Volume (Mm^3)	% of costs	% of costs	Costs (M EUR)
0. Sulina Channel											4
1. Bystroe Channel Phase 1								0.8	1.5	2.5	5
2. Bystroe Channel Phase 2	5	5	3	15.000			60-90	1	1.5	2.5	6
3. Starostambulsky Channel	7	5	3	15.000			75-100	1.5	1.5	2.5	8.5
4. Tsyhanka Arm Channel	9	5	3	15.000			75-100	1	1.5	2.5	6
5. Ust Dunaysk Channel	4	5	0.5	15.000			20-30	0.8	1.5	2.5	4
6. Solomonov Channel	16	5	0.5	15.000	1	75	150-175	0.5	1.5	2.5	4
7. Danube - Sasyk Channel	8	5	2	15.000	2	150	350-400	0.2	1.5	2.5	6.5

The maintenance costs are aimed at dredging works and civil structures, no costs have been taken into account for buoys, markings, lighthouses, bridges etc.

Of the alternatives presented in above table, 0 (Sulina Channel) and 1 (Bystroe phase 1) have already been realised. Therefore investment costs of these alternatives to take into account are zero (so-called ‘sunk costs’). Maintenance costs (dredging and other) however need to be taken into account when comparing with other alternatives.

Additional (very) long-term maintenance costs that are needed if the breakwaters do not function any more and need to be lengthened have not been taken into account (e.g. development of Sulina Channel). This includes the increase in maintenance dredging when a new sand bar is created in front of the breakwaters.

6.2 Impacts of the New Access Channel on Shipping

Vessels to/from maritime Danube ports can currently choose between Sulina Channel and Bystroe Channel. The latter route is currently not feasible for the largest ships, or only if they are empty. In the future, if a new Ukrainian sea access is created, either by deepening Bystroe or through another route, it is assumed that all ships can choose both routes and will do so based on cost and time considerations. However some alternatives will have less water depth than Sulina and thus only allow for smaller sized vessels.

For shipping, a new access channel can have the following impacts:

- Add capacity and reduce congestion
- Increase availability and reduce downtime
- Contribute to the creation of employment
- Reduce costs of shipping
- Allow growth of the river ports
- Increase costs for Ukraine waterway authorities
- Transfer of income from Romanian waterway authorities (AFDJ Sulina Channel charges revenues) to the Ukraine (through charges to be levied for the new sea access).

The impacts on environment cannot be quantified, but will be taken into account qualitatively in the economic feasibility assessment

Capacity
The current route, Sulina channel, is not congested and has sufficient capacity to allow substantial growth. Therefore, a new access route will not add relevant capacity or reduce congestion.

Availability
Having two routes instead of one may be beneficial for traffic, as it will reduce the risk of downtime. E.g. if one route is blocked, the alternative can still be used. Currently, the Sulina Channel route has a limited downtime due to ice and maintenance works. The norms of 94% ENR are easily met. The downtime by ice will not be reduced due to the project, as the alternative route in the same climatic area will be iced as well. Regarding maintenance however, during maintenance works on one route, shipping can choose the other route and thus prevent waiting costs. If maintenance planning of the two routes is planned efficiently (and not parallel) there is always one route available. For calculation reasons, we assume 1% less downtime if both routes have the same water depth, and 0.5% if the Ukrainian sea access has less water depth.

Savings that occur are based on reduced waiting time and average charter costs of the vessels concerned, assuming on average 1 day delay due to downtime.

In principle, this impact does not distinguish between the alternatives, as all of them will bring the number of routes to two. However technically more complex alternatives that include locks or other civil works (e.g. the Solomonov and Danube-Sasyk channel alternatives can be more vulnerable to downtime. For the sake of this analysis, such uncertain aspects have been kept outside the analysis.

Shipping costs
The shipping costs may be changed due to a new route in two ways:

- Sailing costs: the distance and travel time may change due to the new route: e.g. it may have a different length, and different rules with regard to shipping speed allowed. This impact will be different for each alternative due to its different length and different navigation restrictions, but also depend on the port of call. For all Ukrainian access routes identified, this new route will be shorter for ships bound for Vilkove, Kiliya and Izmail. For Reni as well as for ports in Moldova and Romania, the route via Sulina will remain the shortest.
- Channel charges to be paid: if tariffs differ between the two routes, the cheapest route can be considered. Currently the charges for use of Bystroe Channel are 90% lower than those for Sulina Channel, so evidently vessels can save substantial costs. This saving is similar for all alternatives, assuming that tariffs will also be kept the same. Notably, this benefit for ships will also apply to ships sailing to Romanian ports. This means that on the one hand, Ukraine may earn more from revenues than only from vessels sailing to Ukrainian ports, but on the other hand the savings of transport costs will accrue to Romania or elsewhere instead of to Ukraine.
- In one alternative, the Starostambulsky branch, two ways traffic will be possible for all vessels. This will reduce waiting time for larger ships if vessels are encountering each other. A 2 hour time saving is assumed.

For this analysis, we assume that time and costs are equally important to ships. Therefore, the generalised cost approach is applied:

GC = time * Value of Time + out of pocket costs

Where:

- Time refers to the sailing time of each route to reach the port of destination
- Value of time is taken to be the daily charter costs, which take account of operating costs of the ship per day (including fuel, etc.)
- Out of pocket costs in this analysis only concern the channel charges to be paid, as we assume other costs such pilotage and port dues to be the same irrespective of route.

Sailing time needs to be calculated based on distance and average sailing speed. On part of the current route through Bystroe Channel, speed limit regulations are in place. For the other routes, that do not exist yet, no information is available on speed limits that may be applied. Therefore, in this analysis no distinction will be made for speed between the alternatives considered.

It is calculated that:

- For the ports of Vilkove, Kiliya and Izmail, the sailing route through the Ukrainian sea access will be shorter, and the charges to be paid will also be lower.

- For the port of Reni as well as the Moldovan and Romanian ports, sailing time will be 2 to 5 hours longer, but potential savings assuming the current 90% lower charges, are sufficient to cover an extra sailing time of 11 to 13 hours.

Recently, the Romanian authorities have adjusted the Sulina Channel charges in order to gain back some of the traffic that shifted to the Bystroe Channel route. If this trend continues, finally tariffs on both routes will be similar and competition will only be based on route length and water depth.
Finally, only if the water depth of the Ukrainian sea access is the same as for Sulina Channel, the Ukrainian route offers an alternative for all vessels. We assume that:

- In all cases, 5% of the ships will keep using Sulina Channel because of the navigation advantages. This will be done by for example the large vessels that are built in the shipyards of Galati or Braila;
- In the Canal options (alternatives 5, 6 and 7), with limited width, part of the large ships will also keep using Sulina Channel. We assume this to be 10%;
- In the Bystroe phase 1 situation, with 5.85m water depth, we assume that 60% of the ships will keep using Sulina Channel, equal to the current situation.

Employment benefits
The project may contribute to the creation of additional employment. Some reports state that this might be up to 4,000 additional jobs due to the creation of the sea access. This seems very high. For this analysis we assume:

- Direct employment related to the operation and maintenance of the channel to be between 75 and 350, depending on the level of maintenance that is required
- Indirect employment to be depending on the number of ships. The relative contribution will be limited as the traffic volume will also be realised in the reference case.

The value of a job is assumed to be the average GDP per capita of the Ukraine. Regionally this may be lower. Given the relatively high unemployment in the Delta area, the economic value of a job may be lower, but the contribution of an additional job to the local economy will have higher than average impact. Therefore this average is taken to be a good proxy.

Operating costs of the fairway
Having an access channel will cause the Ukrainian waterway authorities to spend more on the fairway than without this access channel. The costs differ between the alternatives. For this analysis, we have taken into account for each section the investment costs plus the maintenance costs required for a period of 30 years (time horizon in conformity with EU CBA guidelines). See Table 6-1 above.

Port developments
Based on the trade forecast developed earlier and the existing port facilities in Izmail and Reni, it is concluded that no port investments are needed to accommodate the growth in throughput volumes. Only if specific segments of cargo will appear (e.g. containers), some additional (private) investments may be needed.

Logistics concept
In the current market organisation, most cargoes are brought from central and eastern Ukraine by rail to the Danube river ports Reni or Izmail, and from there shipped further by IWT. A future concept that is worth considering is that instead of rail, cargoes are delivered by larger ships coming from e.g. the Sea of Azov to the Ukrainian Danube ports from where cargoes are shipped onwards by IWT. This would imply the

same cargo handling in one of the Danube ports, but instead of rail <-> IWT transhipment it would now be sea vessel / IWT transhipment.

If this logistics concept is desired in combination with an increase in scale, the sea access can be a bottleneck assuming a max water depth of 7.2m. By returning to the concept of a sea port at the mouth of the Danube, similar to the Ust Dunaysk port in the 1970s and 80s, could solve this. However:

- The expected ship size increase on the markets served via the Danube is expected to be limited, and the water depth provided by Sulina Channel or one of the new Ukrainian sea access routes will not be a bottleneck for most ships for the next 15 years;
- Constructing a new port at a shallow location such as Ust Dunaysk will be expensive. The site itself will require port equipment, hinterland infrastructure will need to be constructed, and operating costs will be relatively high due to staff having to commute to/from far away residential areas.

Given the limited volumes concerned (in the highest scenario, throughput in Ukrainian ports will have increased from the current 1.4 mln tons to a level of 3.7 mln tons), investment in a new port will likely not be feasible. We will therefore not analyse this further.

Safety benefits

The natural channels have no locks, are straight and have a relatively smooth connection with the Kiliya Branch, as compared to the Sulina Channel route where ships have to pass the sharp bend at Tulcea. The Tsyhanka and Ust Dunaysk alternatives have many bends making navigation difficult. Solomonov and Sasyk have locks and sharp bends into the Kiliya branch.

For all alternatives, the opening of a second route to the Danube causes a distribution of traffic and results in lower traffic intensities on Sulina Channel. This may contribute to an overall reduction of accidents. The total number of accidents is however very low and mainly concerns groundings and offshore accidents, which will not be prevented by traffic intensity reduction. Therefore safety benefits are not quantified.

Environmental impacts

The impact on the environmental situation in the Danube Delta is difficult to quantify. The results of the discussions with the experts during the mission to Ukraine, provides detail on the relative impact of each alternative on the environment. The main conclusion from the experts is that:

- Sulina channel is already there and its negative impacts cannot be taken away anymore (except when the Sulina breakwaters are being removed, which is not considered a realistic option)
- All new routes will have negative impacts due to water quality, noise and emissions of vessels, which in fact is a redistribution of impacts currently located in Romania.
- Alternatives outside the Delta area can be positive to ecology as the Delta area will then not be disturbed by shipping (waves, turbidity) or construction/maintenance works.

For a detailed description of environmental impacts, we refer to section 7.2.

Distribution of impacts

It is concluded that:

- The expected cargo forecast will not increase due to the new sea access, as the existing route does not limit capacity;
- The project will however introduce competition between fairways in two different countries.

Due to this, distribution effects will occur between Ukraine and Romania (and Moldova to a small extent).

Table 6-2: General distribution of impacts

Impact	For Ukraine	For Romania	Total
Investment	Negative (Ukraine needs to pay the investment costs of the project)	Zero (Sulina Channel has already been constructed long ago	Negative
Maintenance costs	Negative (Ukraine will have to pay for annual maintenance of the new sea access	Zero (the maintenance costs for Sulina Channel will not change)	Negative
Income from charges	Positive (charges will be paid by ships using the Ukrainian route)	Negative (less ships will use Sulina)	Negative (due to higher losses Romania than gains Ukraine)
Transport costs for ships	Positive (reduced due to lower transit charges)	Positive (reduced due to lower transit charges; Romanian bound ships can also use the Ukrainian route). It is noted that more ships are bound for Romanian ports than for Ukrainian ports	Positive
Costs for end users	Positive (part of the gains of ships will be passed on to their clients)	Positive (part of the gains of ships will be passed on to their clients)	Positive
Capacity gain	Zero (fairway capacity is a problem)	Zero (fairway capacity is not a problem)	Zero
Downtime	Positive (less downtime with two routes instead of one)	Positive (less downtime with two routes instead of one)	Positive
Employment	Positive (especially due to job creation to maintain the channel)	Zero/Negative	Positive
Environment	Negative (changes in the morphological structure of the Delta area will negatively affect environment, except for the alternatives located outside the Delta)	Positive (reduction of traffic through the Romanian Delta)	Negative?
Safety	Negative (More shipping traffic through Ukraine may cause more accidents)	Positive (less traffic results in less risks)	Positive

In the next section, the results of the calculation of these impacts will be presented. The level of distribution will vary between the alternatives.

Other assumptions

For the economic analysis, further the following assumptions need to be made:

- Time horizon: we propose to set this at 30 years
- Residual value at the end of the time horizon for the investments made of 30%
- Discount rate of 5%, in accordance with EU guidelines on CBA for water infrastructure

The project takes place in Ukraine close to the border of Romania, and will affect the Romanian shipping sector. This might cause a redistribution of benefits or costs. The cost benefit analysis conducted in this study will firstly present the overall results of the project and then describe the results from the Ukrainian point of view and the consequences for Romania, as they can be relevant in the political decision making process.

6.3 Economic Assessment CBA

A Cost Benefit Analysis (CBA) model has been applied to assess the economic feasibility of each of the sea access alternatives defined. The CBA takes into account the impacts described in the previous section. The results are presented in three indicators:

- NPV or economic Net Present Value, which is the balance of costs and benefits in each year of the project, discounted to the present year using the discount rate and summed up for all years included in the time horizon.
- eIRR or economic Internal Rate of Return, which is the percentage to which the costs and benefits should be discounted to result in an NPV value of zero. This eIRR should be higher than the discount rate to consider the project economically feasible.
- B/C or economic Benefit over Cost ratio, which is the ratio of the sum of all discounted benefits over the sum of all discounted costs.

The results for each of the 7 alternatives are presented in the below table.` First we present the results for each impact, after which the overall figures are given.

Table 6-3: Impacts of the alternatives

No	Short name	Costs			Benefits					
		Invest-ments	Mainte-nance	Total costs	Downtime reduction	Route savings	Employ-ment	Safety	Environ ment	Total benefits
1	Bystroe 1	0	-	-	+	++	+	+	-	+
2	Bystroe 2	-	-	-	+	++	+	+	--	++
3	Starostambulsky	-	--	--	+	++	++	+	--	++
4	Tsyhanka	-	-	-	+	++	+	--	-	+
5	Ust-Dunaysk	-	0	-	+	++	+	--	-	+
6	Solomonov	--	0	--	+	++	+	-	0	+
7	Sasyk	--	-	--	+	++	++	-	+	++

Table 6-4: CBA results

No.	Short name	NPV	eIRR	B/C	Environmental impacts *)
1	Bystroe 1	159	n.a.	8.7	-
2	Bystroe 2	153	14%	2.2	--
3	Starostambulsky	142	12%	1.7	--
4	Tsyhanka	106	10%	1.7	-
5	Ust-Dunaysk	214	31%	6.9	-
6	Solomonov	-1	5%	1.0	0
7	Sasyk	-292	0%	0.5	+

*) Based on Chapter 7

The table shows that for the first five alternatives, the net present value is positive, which means that the economic benefits to society are higher than the investment and operating costs of the new sea access. This is confirmed by the economic IRR, which is above the cut-off rate of 5% for those alternatives. The Benefit/Cost ratio, which should be higher than 1, is sufficient for those alternatives as well. It is remarked however that the non-quantified environmental impacts for all these alternatives are negative.

The results of Bystroe 1 are high because investment costs have already been incurred and only operating costs (maintenance dredging) have been taken into account.

The NPV of alternative 6, Solomonov, is around zero, as costs of investment and maintenance are balanced by benefits for shipping.

Alternative 7 has a negative NPV. Although this section is favoured from the point of view of environmental impacts, its costs are the highest and are not balanced by economic benefits for shipping and indirect benefits.

The robustness has been tested using sensitivity analysis on the largest and most uncertain components of the CBA (see also table below):

- Costs: the impact of higher investment and operating costs is tested
- Trade scenario: two scenarios have been drafted in chapter 1, a low and a high scenario. Both will be included.
- Tariff level of the Ukrainian sea access versus Sulina Channel. In the base case it was assumed that Ukrainian charges are set at 10% of the Sulina Channel rate. If Romania will reduce its rate, the relative attractiveness of the Ukrainian route will change.

Table 6-5: Results of the sensitivity analysis (eIRR)

Assumption			1	2	3	4	5	6	7
	Base case	Alternative assumption	Bystroe 1	Bystroe 2	Starostambu lsky	Tsyhanka	Ust-Dunaysk	Solomonov	Sasyk
Investment costs		+50%	n.a.	9%	8%	7%	22%	3%	-1%
Operating costs		Doubled	n.a.	12%	8%	8%	31%	5%	0%
Trade scenario	high	low	n.a.	9%	7%	5%	23%	2%	-2%
Tariff ratio *)	10%		n.a.	6%	5%	3%	16%	Neg.	-2%

**) Ukrainian charge level as % of Sulina Channel tariff*

The sensitivity analysis shows that:

- If investment costs will be much higher, the conclusions on the alternatives will remain the same;
- Higher operating costs also do not affect the conclusions on the preferred alternatives;
- With lower trade growth, the eIRR will come below the 5% threshold for several alternatives;
- Changes in the tariff policy will have the highest impact on the economic feasibility of the project. It was tested that if Romania would set its tariffs equal to Ukraine, the eIRR would be negative for ALL alternatives.

This brings us to the conclusion that:

- While shipping benefits are similar for all alternatives, the eIRR is highest for those alternatives that have the lowest investment costs;
- Environmental benefits could not be quantified but may play a very important role in decision-making, as alternatives with higher investment costs appear to offer much better environmental performance;
- The result is highly sensitive to the tariff policy of Ukraine versus Romania and thus vulnerable to future policy changes in this respect.

6.4 Wider approach CBA

In the previous section, the costs and benefits of a new sea access have been analysed on an international level. Part of the benefits however will accrue to Romania instead of Ukraine. Ships passing the Ukrainian sea access will of course pay the charges to Ukrainian authorities, but their savings will accrue to the Romanian economy (lower shipping prices, resulting in lower costs to end users of the commodities shipped) or to other economies receiving the goods involved.

If we assume that only savings related to traffic bound for Ukrainian ports can be attributed to the project, the CBA can be calculated again. For simplicity we assume that the share of the Ukrainian pots in total traffic (around 37%) remains constant, and all growth is distributed evenly over the ports, the new results are as follows.

Table 6-6: CBA results for Ukraine only

No.	Short name	NPV (mln USD)	eIRR
1	Bystroe 1	1	13%
2	Bystroe 2	-99	-4%
3	Starostambulsky	-163	-11%
4	Tsyhanka	-125	-4%
5	Ust-Dunaysk	-2	5%
6	Solomonov	-183	-2%
7	Sasyk	-507	-4%

The result shows that for the Ukraine only, the net present value is negative. This is caused by the fact that Ukraine has to carry all investment and operating costs, while part of the (shipping) benefits accrue to ships sailing to and from Romanian ports.

In addition to the results for Ukraine, the income losses to Romania from less Sulina traffic charges have been estimated. Below table gives the result. For most alternatives these are clearly larger than the net costs for the Ukraine given in above table. This may provide an opportunity to negotiate with Romania on better terms for the usage of the Sulina Channel.

Table 6-7: Estimated income loss Romania

No.	Short name	NPV (mln USD)
1	Bystroe 1	217
2	Bystroe 2	343
3	Starostambulsky	343
4	Tsyhanka	343
5	Ust-Dunaysk	343
6	Solomonov	307
7	Sasyk	307

As a comparable situation one can look at the Westerschelde on Netherlands territory, which is the main (only) access to the Belgian sea port Antwerp. In the past, the Dutch have even closed off the Westerschelde (1585) as to stop the progressive growth of Antwerp port and to help Amsterdam gain importance. Nowadays, the two countries friendly negotiate on the terms of usage of the river, preventing the need for the Belgians to create a new access of their own, which would be by far more costly than agreeing on a Belgian contribution to Dutch dredging costs, and on pilotage and other aspects.

A similar solution appears most economical for Ukraine and Romania as well. The costs for both countries (Ukraine to invest in a new access and Romania to cover its maintenance costs from lower charge revenues) are higher than the optimal solution.

7 ASSESSMENT OF ALTERNATIVES

The advantages and disadvantages of the alternatives were discussed with the experts per criteria and theme and compared to the Base Alternative i.e. the situation without any connecting channel in the Ukrainian Delta and only use of the Sulina Channel. The core of the assessment lies in the search for a navigation alternative and thus on economics and navigation.

The economic assessment was given in the previous chapter. The chapters below describe the results of the discussions per alternative and per theme.

7.1 Results of the Assessment of the Alternatives

During the discussion, it became apparent that the alternatives could be divided into three main groups;

A. Reference (Base) Alternative
B. Alternatives lying in the Delta area and;
C. Alternatives lying outside of the Delta

7.1.1 Reference (Base) Alternative

The Base Alternative with the operation of the Sulina Channel scored best on all aspects except for two:

- Effect of the breakwaters on the coastal zone
- The absence of a connecting channel in Ukraine

This alternative already exists and so no additional construction works are needed, only maintenance. It lies outside of the Ukrainian Delta and therefore does not affect the natural environment of the Delta in the Ukraine (although it does in Romania). It ensures that no ships (including navigational works) need to pass through the Ukrainian Delta and in the coastal zone in front of the Ukrainian Delta.

However, this alternative has several negative aspects especially concerning the effect of the long breakwaters and volume of maintenance dredging. Concerning the latter, the spit north of Sulina is moving south and can cause a sharp increase in maintenance dredging works at the mouth of the Sulina Channel. This will probably be paid for by an increase in tariffs for passing ships. However, as this report concerns the Ukrainian Danube Delta, we will not discuss these problems in more detail.

Conclusion: This is the best solution to protect the Ukrainian Danube Delta and the cheapest solution for the Ukrainian Government, although maintenance costs and thus tariffs may increase sharply in the future. However it does not give the Ukraine an own access channel between the Black Sea and Danube.

7.1.2 Alternatives in the Danube Delta

All alternatives in this category will affect the natural environment of the Danube Delta, be it directly through construction, deepening of the riverbed and indirectly via ship emissions (air, noise and water pollution), water circulation patterns along the riverbed and risk of accidents.

1. Bystroe Channel Phase 1

This alternative is a good solution for navigation as it is naturally deep, straight and has good orientation for incoming ships.

The main impact of this alternative is around the breakwater that is being built to protect the access channel from sedimentation and ships from waves. Even with the breakwater, it is estimated that 500,000 m^3 of material needs to be dredged per year to keep the Bystroe channel and access channel open and at the predetermined depth. Most of this maintenance dredging will be in the sea access channel as historical data shows that the Bystroe channel stayed naturally deep because of the large volumes of water and needed almost no dredging. This means that there is less hindrance for navigation.

Conclusion: Good alternative for navigation, but great negative impacts on coastal zone due to the breakwaters stopping the littoral currents.

2. Bystroe Channel Phase 2

The second phase of the Bystroe Channel concerns the lengthening of the breakwater and deepening of the channel to accommodate larger ships (deeper draught) for a longer period per year. This is positive for navigation but increases the pressure on the natural Delta environment (ecology and morphology). The deepening of the channel beyond its present, naturally deep profile will ensure an increase in maintenance dredging as the channel tries to return to its original depth and a potential higher discharge volume. This higher volume means a change in the water discharge patterns in the other branches with negative consequences for the entire Delta and its floodplains and reed beds.

Conclusion: Best alternative for year round navigation for all ships including the larger ones. In addition to negative effects mentioned in Bystroe Phase 1, great negative impact on the Delta as a whole due to probable changes in water discharge patterns in all other branches.

3. Starostambulsky Channel

The Starostambulsky Channel alternative is the least viable of all the alternatives. Due to its shallow waters and the long access channel through the shallow lagoon and spit, it needs a large amount of dredging. Furthermore, and most importantly, this alternative passes through an internationally protected bird habitat area.

The breakwaters needed to protect the sea access channel are expensive and will probably be so long that they will reach into Romanian territory. Just as the Bystroe and Starostambulsky alternatives, the breakwater passes through the shallow coastal zone. This breakwater will stop or deflect littoral currents and severely influence the coastal zones around the mouth of the channel and further downstream.

One positive aspect of the Starostambulsky branch is the width of the channel; it is wide enough for two-way traffic. The downside of this is width is that when the obstacles now stopping the water from flowing into the Black Sea are removed (shallow lagoon and spit), the waters from the Kiliya Branch will flow freely and possibly act as a drain for the waters in the Delta.

Finally, the alternative lies far away from any urban settlements and can only be reached by boat. In case of accidents or vessel traffic control, the location cannot be reached quickly and can be a problem.

Conclusion: Least viable alternative due to its passage through protected habitat and potential access channel and breakwaters in Romanian territory. No easy access in case of accidents.

4. Tsyhanka Arm Channel
This alternative is an improvement of the Starostambulsky alternative as it does not pass through the protected bird habitat and the coastal zone reaches the -20m quicker than the other alternatives (shorter breakwater). However, it still lies in the Danube Delta. The other negative impacts are the same (breakwater + littoral current, drainage, bad accessibility etc), but additionally it is a narrow channel with some sharp bends, especially at the connection with the Starostambulsky Arm. This is not good for navigation.

Conclusion: does not pass through protected area, but still not a preferred option due to the sharp bends, breakwater and bad accessibility

5. Ust-Dunaysk Channel
The revival of this channel does not seem to be a viable option as it will be difficult to operate probably requiring permanent maintenance dredging. Furthermore, the channel connecting the Ochakov Arm and the Ust-Dunaysk (floating) has many bends making navigation difficult and maybe even impossible for the bigger ships.

Concerning the access channel, it appears that the Zhebriyanskaya Bay in which it lies is a sedimentation zone that is becoming shallower. It is unclear what the effect of a new deepened access channel will be in the bay but we assume that it will be prone to high rates of sedimentation and frequent maintenance dredging. The alternative has little effect on the coastal zone only very small breakwaters are needed.

A positive aspect is that the existing port can be revitalised as most of the facilities are still available in the area.

Another positive effect could be achieved if the dikes on both sides of the canal were removed and the canal was not separated hydraulically from the surroundings anymore. The natural flooding could allow the natural marshlands to return increasing the ecological value of the area.

Conclusion: Difficult to operate due to the probable permanent dredging works but only small effect on the coastal zone. Existing port can be revitalised. Chances for rehabilitation of natural marshlands

7.1.3 Alternatives outside the Danube Delta

As mentioned before, two alternatives lie outside the Danube Delta and do not affect the natural, protected Biosphere system. Both alternatives have good locations with freely available land for creation of ports; the Solomonov alternative also has a good location at the mouth of the channel for a floating port in the relatively well protected Zhebriyanskaya Bay. However, the presence of the existing inland ports of Reni, Kiliya and Izmail close-by ensure that a new port or a revival of an old port are economically and geographically not viable options.

The channels themselves are straight and easily navigable, but problems may occur at the connections with the Kiliya branch when the ships have to pass the lock and sluice complexes and make an almost 90^o turn. This extra manoeuvre and potential waiting time (berths and mooring points are needed) will affect the possibilities to compete with the already functional Sulina Channel. The manoeuvring and passage through the structures increases the chance of accidents.

The artificial channels have two other issues that need attention:

- The formation of ice. Due to the fact that there is hardly any natural water flow, ice can develop more quickly decreasing the amount of time per year ships can pass through the canal.
- An increase in sedimentation at the start of the canals. Sediment-laden water flows into the canal and settles in the calm waters just after the lock and sluice complex creating a shallow area. Additional dredging or a deepened sediment catchment area can mitigate this.

6. Solomonov Canal

The greatest impact of this alternative is the construction of a new artificial canal connecting the Danube with the Zhebriyanskaya Bay. It is unclear whether the effect this new canal on the current biodiversity and red list species in the area is positive or negative. At the moment, the vegetation in the area is anthropogenic (pine trees to stop the shifting dunes) and not natural to the Delta environment. This means that the effect on the natural environment is minimal as it is an artificially created environment not natural to the area (not a Biosphere hotspot). However, the wood has been there for a long time and created an own habitat. A new canal (water) combined with the removal of the pine trees will return the area into a natural dynamic dune habitat. The presence of red list species is unclear as the current list is based on data that is ca. 20 years old.

On the other hand, the new canal will create a barrier for the animals living in the area that can only be passed over by swimming, via the bridges or when there is ice. A new bridge has to be constructed at the connection with the Danube River (incorporated in the sluice and lock complex) to ensure that people can cross the channel.

As is the case with the Ust-Dunaysk Canal Alternative, a long sea access channel is needed through the shallow Zhebriyanskaya Bay, and in this case even longer. It is unclear what the sedimentation rates are in the bay and how much maintenance dredging is needed, but it is expected that they are high.

When looking at navigation, this option has two main difficulties: a bridge and the connection with the Kiliya Branch. Concerning the first, navigation and traffic have to be coordinated so that accidents and waiting times are minimal. In the second case, the ships have to make a passage through the lock and sluice complex. In some cases, and especially with laden ships, tugboats may be needed to help the ship make this passage and subsequent turn on to or from the Danube.

Finally, the land around the canal can be used to create a port zone for transshipment of goods and cargo from Sea going vessels to Sea-River and IWT vessels. There is enough room to make a rail connection so goods can be transported to and from the port area, at the moment there is no connection so it will be expensive to make. Finally, there is a workforce nearby in Vilkove that can be trained to work in the Port area. As mentioned before, it is not expected that this is a viable option.

Conclusion: This alternative does not score well on navigation, construction costs (dredging and the lock and sluice complex) and probably has high costs for the maintenance of the sea access channel depth and sluice and lock complexes. However, it lies outside the Delta area and therefore does not affect the fragile ecosystem of the Danube Delta or the coastal zone in front of the Delta (no breakwaters). Also, there is enough room for port development and rail connections including a workforce nearby. There could be additional positive effects if the surrounding landscape is changed from pine woodland to an open (natural) dune system again. A large negative effect is the creation of an additional barrier for people and wildlife from the Ukrainian Danube Delta to the Ukrainian hinterland.

7. Danube-Sasyk Canal

This is the most expensive alternative that poses most difficulties for the navigation and operation of the canal. Two lock and sluice complexes are needed for the water management of the canal and Sasyk Lake. The main benefit of this alternative is that a larger canal connecting the Sasyk Lake (salt level 7-8 ppm) to the Danube and the Black Sea (salt level 15 ppm) can ensure that the water quality in the Sasyk Lake will improve due to circulation and refreshment of water. However, further studies needed to calculate the extent to which the water quality of the entire lake will improve as there are no high tides or estuary water flows that can help to permanently mix the water. The option to dismantle the entire dam between the Lake and the Black Sea in an effort to improve water quality was considered too costly. As the alternative foresees in a partial dismantling to create a passage for ships to the Black Sea, this can be considered beneficial and contributing to solving the problem. There remains the question if changing the present ecology in the lake (not natural to the area) is positive or negative.

Another advantage of this system is that the lock and sluice complex will stop sediment from leaving the Danube River system. This sediment can be used to heighten and 'strengthen' the Delta. Also, the stopping of this sediment means that only a small amount of maintenance dredging is required in this alternative (less costs).

One of the main disadvantages is that extra dredging works need to be carried out at the connection with the Danube River to enable large ships to make the turn via the lock complex into the channel (similar problem as the Solomonov Canal alternative).

As is the case with the Solomonov Channel, a bridge needs to be constructed to allow traffic to reach Vilkove and other settlements in the Danube Delta. This bridge must be movable and can be positioned at the height of the existing road and/or at the lock and sluice complex (combination lock / bridge). Furthermore, in this case, the lock and sluice complex hinders navigation (waiting time and manoeuvring) and ships will also have difficulty in making the tight turn from the canal into the Kiliya Branch and vice versa.

Conclusion: Positive aspects are: outside Danube Delta, room for port development, sediment and water stays in Danube system, water quality improvement in Sasyk Lake, low dredging maintenance costs. Negative aspects are high construction costs, operational and navigational difficulties due to bridge and lock and sluice complexes.

7.2 Results of the Assessment per Theme

The above results show that the alternatives differ in their attractiveness per theme. While an alternative can score very well in one theme, it can be a no-go in another. Therefore we have also compared the alternatives based on their impact per theme.

As is mentioned earlier, the Base Alternative with the operation of the Sulina Channel is the alternative that leaves the Delta untouched and thus scores best on all aspects in relation to the Ukrainian Danube Delta.

The paragraphs below correspond with the themes used in the comparison of the alternatives (see Table 2-2).

7.2.1 Construction

The construction of the channel forms the major short- and long-term impact on the natural environment. The major influence will be the breakwater construction and dredging works in the channel itself and in the natural sandbar at the mouth of the various arms. The construction of the lock- and sluice complexes is local and will not affect the activities in the channels.

The construction will affect the environment as a whole (mainly air, noise and water pollution), cause hindrance for fishermen in the channels and cause a nuisance to inhabitants that need to travel to the mainland (increase traffic and blocked roads / bridges). This effect is temporary.

If possible, dredged material from the construction and maintenance works can be reused in the system as much as possible e.g. for agriculture, heightening of land for construction of housing, dikes to protect settlements, of simply in the floodplains to allow them to keep up with the relative subsidence of the Delta. The extent to which sediments can be reused are based on their composition (sand, clay, silt) and quality. In most cases along the Kiliya and Bystroe branches, the dredged material consists of very hard sand that can also be found in Ermakov depositions but cannot be used for agriculture.

When looking at the construction costs, the two alternatives outside the Delta are much more expensive due to the lock and sluice complexes.

Conclusion: Construction of new or deepened channels will affect the Delta. The alternatives outside of the Delta are most expensive and take most time to construct, the rest of the alternatives require dredging and breakwater construction. However, any alternative inside the Danube Delta Biosphere is not acceptable due to the effect on the ecology and environment.

7.2.2 Operation

Operational aspects are important for the quality of the navigation; the simpler the operation of the channel, the better it is for the safe passage of ships and the quicker they can make the passage.

The major operational difficulties occur during the maintenance works, and especially during the dredging works of the channels. In the case of the Sasyk and Solomonov alternatives, there will be less dredging needed because the locks stop a lot of sediment from entering the channel. However, in case of Solomonov, the long sea access channel increases the amount of dredging needed, in the same way as the Starostambulsky channel.

Next to the dredging works, the two alternatives that lay outside of the Danube Delta have an additional navigational obstacle; a bridge. The bridge is needed to connect the settlements in the Delta to the Ukrainian main land. The bridge will probably be a movable bridge or a ferry system, but both remain a safety risk for the passing ships and operation of the channel.

The two alternatives lying furthest from Vilkove can only be reached by boat making operation more difficult.

Conclusion: Major operational difficulties are the maintenance dredging (all alternatives), the bridges and lock and sluice complexes (Solomonov and Sasyk alternatives) and accessibility (Tsyhanka and Starostambulsky).

7.2.3 Navigation

Wider channels are generally better for navigation unless strong winds affect the navigation and wind-breaks such as high trees are needed. Embankment protection, buoys, lighthouses, VTS and other traffic controls are needed to ensure safe navigation in all alternatives, although some more that others.

When considering navigation, the best alternative is the Sulina Channel as all infrastructure exists and the route has been straightened. For the studied alternatives, the best approach route and straightest channel (easiest navigation) are the Bystroe and Starostambulsky Channels. The other alternatives have difficult bends, bridges and lock- and sluice complexes.

Conclusion: Sulina Channel is the best alternative as infrastructure exists and route is straightened. Bystroe and Starostambulsky channels are relatively straight and have no locks and sluices.

7.2.4 Port

The only possibilities for construction of ports on land are for the two alternatives outside the Delta and the revival of the Ust-Dunaysk (floating) Port. These are the only locations where land is available that can be developed and that have relatively easy access to the hinterland. Next to the fact that it is prohibited to build in the Delta, the alternatives in the Delta cannot be reached by truck or rail. The only option for these alternatives is a floating transhipment port at sea. However, the economic study showed that a new port is not necessary, as the existing ones at Reni and Izmail are sufficient.

Conclusion: No new ports are needed, but can be constructed along the Solomonov and Sasyk alternatives. Floating transhipment ports at sea can be made for Ust Dunaysk, other alternatives will have too much downtime

7.2.5 Economy

Obviously, the best scoring alternative is the base alternative i.e. Sulina Channel as it requires no construction and maintenance costs. However, the tariffs for a ship passage are high making it unattractive for shipping. A governmental subsidy or agreement with the Romanian authorities can solve this issue.

On a local level it is unclear if the welfare and employment benefits will increase as the skill level and willingness of the workforce is unknown. Furthermore, it is unclear if workers will be taken from other existing ports such as Reni, Izmail and Kiliya instead of from local settlements. On a regional and national level, the economy will improve with a boost in shipping and transport of goods and cargo.

The alternatives with lower maintenance costs will ensure lower tariffs and more passages.

Conclusion: Increase in navigation and transport of goods is good for the national economy and the economies of the inland port towns. It is unclear what the benefit will be for the local population.

7.2.6 Ecology

Passing ships create a multitude of currents along the entire channel profile. Currents along the sides of the channel can cause erosion; those along the bottom affect benthos. These latter currents are reverse currents producing turbidity and flowing against the natural orientation of the benthos thus affecting their growth. The turbidity can also affect fish and predatory fish eating birds.

Furthermore, the ships should be controlled carefully to make sure they adhere to the latest International (IMO) and National laws and regulations concerning emissions to air and water, solid waste disposal, TBT coatings, leakages, ballast water etc. If they are not controlled, the ships will affect the quality of the water- and land environment around the navigation channels.

Especially in the Delta areas, spawning areas of fish should be protected for shipping including the currents produced by their passages.

Sloping embankments will allow animals that want to cross the channels to exit the water, steep protected embankments can be such a barrier that animals will drown.

At the moment there is a fair amount of smaller local traffic and tourism related shipping that already affects the tranquillity and quality of the area.

Conclusion: The ecology in the channels will be affected by the return bottom currents caused by the passing ships, especially concerning bottom creatures and spawn. Land based creatures and fish (lesser extent) will experience hinder from passing ships (noise, air, light, waste, etc), the more ships the more hindrance. Ships must be controlled carefully to make sure they adhere to International and National regulations concerning emissions.

7.2.7 Landscape

For all the alternatives except for the Solomonov and Danube-Sasyk alternatives, the landscape will remain the same except for the visible passage of ships. The greatest effect will be on the Solomonov alternative where a channel will be dug through a forest changing the landscape from woodland to water and creating a new barrier.

Conclusion: No large scale effect except for the new channel in the Solomonov alternative.

7.2.8 Morphology

There are two main areas in which the morphology will be affected by the construction and operation of a navigational channel: in the channel itself and in the near shore coastal zone (sea).

<u>Channel</u>

Where possible, the alternatives should use natural embankments that allow flooding of the land and floodplains. The floodwaters are an essential part of the Delta environment and should not be retained with high, solid embankments. If necessary, the embankments can be strengthened and protected against extreme erosion by planting trees such as willows.

Passing ships, even at a reduced speed of 8 knots, can still produce water level fluctuations of 25cm and related high waves that can erode the embankments. Depending on the development of the shipping, this can be temporary until a new equilibrium profile has been created. This erosion has to be taken into account when designing the embankments and determining the dimensions of the channels. Obviously, the wider the channel the better it is. Again, it is expensive and undesired to protect the entire length of the embankments; hard defences should be constructed only near settlements to protect them from the waves caused by the ships. Along the rest of the channel, the water should be allowed to be free to flood the land behind the natural levees. Not all ships produce the same waves and currents at the same speed, a study on ship sizes and related embankment erosion can reduce the effect even more.

The removal of the sandbars at the mouth of the arms will affect the morphology inland. These important morphological forms block or slow down free flow of water into the Black Sea and ensure that levees and floodplains are created in the branches. By removing the bar, there will be a quicker discharge of water and thus lower water levels in the channels and less natural flooding of the embankments.

Sea

The breakwaters that are planned/constructed in sea to protect the access channel from sedimentation and ships from high waves, will affect the coastal morphology underwater and along the coastline. Where possible (financing and sedimentation volumes), the choice for breakwaters can be 'replaced' with frequent maintenance dredging so that natural sediment flows can continue to take place along the coast.

Often the breakwaters will affect the coastal morphology up to several kilometres downstream of the dominant littoral current. By diverting the sediment-laden currents to deeper water, sediment is lost to the natural system and a new morphological equilibrium has to be found meaning that the shape of the coast and landscape of the near shore zone will change.

Finally, a breakwater is not a natural sight along a Deltaic coastal and may seem out of place along the coast, even though it can turn into an interesting ecological haven for many smaller species.

Conclusion: Embankment erosion due to passing ships affects all alternatives, planting willows and creating wider channels will counter this. Hard defences should be made along the embankments in front of settlements, the rest of the channel should be free to allow water to flood the hinterland. Breakwaters will affect the coastline and morphology of the near shore zone; alternatives in the Zhebriyanskaya are favored as they don't need breakwaters.

7.2.9 Social

Although an increase in navigation can contribute to an increase in employment and economic benefits for the region, many people live from fishing and reed harvesting. Both these industries need clean water circulation to operate. Alternatives must therefore ensure that (flood) waters can reach the fishing areas and flood the reed fields and not fix the channel profile and embankments in such a way that water cannot reach the floodplains on both sides of the channel.

If shipping revitalizes, it can also attract recreational navigation which in turn will be beneficial to the local population. However, adequate facilities will have to be made to serve the visitors. On the other hand, the passage of large ships through a protected Delta environment will negatively affect tourism as people want to see nature of the Delta and not large ships.

Construction and maintenance works will hinder the local fishermen but can offer chances of (temporary) alternative employment. The construction and operation of the bridges will affect the locals as they will experience a greater delay when travelling to the Ukrainian hinterland.

The alternatives outside of the Delta include movable bridges to allow people cross the water, a negative aspect as they can cause waiting times and increased costs if ferries are used. This can be mitigated by making the connection over the lock (always one road open), but even in this case, the population will only have one connection route. The local population has already mentioned that it does not want to live on “an island” but have a permanent connection to the mainland.

Conclusion: A navigation canal can be beneficial for the local population especially if job opportunities (and training) are created including recreational spin-off. The movable bridges of the alternatives that lay outside of the Delta are considered negative.

7.2.10 Environment

The passage of ships will affect the local environment, bringing air, noise and light pollution and accident risks to the Delta and the people living in the Delta, even though on a large scale cargo transport by (modern) ships is considered to be the most environmentally friendly transport method in terms of carbon emissions. The Alternatives lying outside the Delta have a more positive score as they are further from the protected Biosphere environment.

The water quality can deteriorate with the passage of (old) ships, especially in the Delta Area (TBT, solid waste and sewage, turbidity). The same applies to the quality of the air and noise. Obviously there are national and international (IMO) laws and regulations on e.g. waste disposal and bilge water changes, however all alternatives can have potential disposal in the waters. However, there is always a chance of an accident and a local negative impact on the environment.

On a larger scale, the Sasyk channel will have a positive effect on the extra water flow into the Sasyk Lake due to the opening of the lake to sea can lead to water circulation and improvement of the current quality.

Conclusion: All alternatives (except Sulina) will have shipping and thus affect the local environment, those in the Danube Delta are considered more unfavourable. For the alternatives outside of the Delta this is considered less important as they are further from protected Biosphere Areas.

7.3 Summary

The table below summarizes the results of the considerations above.

Table 7-1: Advantages and disadvantages of the alternatives

Alternative	Advantages	Disadvantages
0. Base Alternative BA (Sulina)	• No influence on the Danube Biosphere Reserve, Ukraine • No costs for Ukrainian Government	• No Ukrainian access channel to the Danube • More expensive passage (higher tariffs)
1. BA+Bystroe First Phase	• Most of the construction works already carried out, no expenses • Good navigation route • Natural deep water, less maintenance	• Lays in Danube Biosphere Reserve, Ukraine • Breakwater affects coastal zone • Increased dredging in coastal zone
2. BA+Bystroe Second Phase	• Good navigation route	• Lays in Danube Biosphere Reserve, Ukraine • Expensive breakwater affects coastal zone • Dredging works for deepening and breakwater hinder navigation Phase 1 • Increased dredging coastal zone + channel

Alternative	Advantages	Disadvantages
3. BA+Starostambulsky Channel	• Wide channel for 2-way traffic • Good navigation route	• Lays in Danube Biosphere Reserve, Ukraine + protected bird habitat zone • Breakwater affects coastal zone • Breakwater and access channel end in Romanian territory • Bad accessibility (only boat) • Expensive maintenance • Increased dredging in coastal zone
4. BA+Tsyhanka Channel	• Short breakwaters steep coast	• Lays in Danube Biosphere Reserve, Ukraine • Breakwater affects coastal zone • Sharp bends difficult navigation • Bad accessibility (only boat) • Increased dredging in coastal zone
5. BA+Ust-Dunaysk Channel	• Existing Port infrastructure • Less effects on coastal zone	• Lays in Danube Biosphere Reserve, Ukraine • Expensive maintenance
6. BA+Solomonov Channel	• Outside Danube Biosphere Reserve, Ukraine • Land available for port development • Good accessibility • Change woodland to marshland	• Sharp bend at connection with Kiliya • High investment costs (new channel) and maintenance dredging works • Bridge needed to connect Vilkove • Lock and sluice complex
7. BA+Danube-Sasyk Channel	• Outside Danube Biosphere Reserve, Ukraine • Improvement of Sasyk water quality • Low dredging maintenance costs • Creation of natural marshland • Land available for port development • Good accessibility	• 2 expensive lock- and sluice complexes • Bridge needed to connect Vilkove • Sharp bend at connection with Kiliya • High investment costs

8 CONCLUSIONS AND RECOMMENDATIONS

1. The Ukraine Government is creating a sea entrance to the Danube through the Danube Biosphere Reserve Ukraine, the Bystroe Channel, as an alternative access route to the Sulina Channel in Romania. The procedure and construction are currently under International investigation.

2. Sea access routes lying inside the Ukrainian Danube Delta Biosphere are considered unacceptable due to their impact on the ecology, coastal morphology (breakwaters) and environment of the Delta and infringement of International Laws. WWF therefore requested DHV to look at potential alternatives to the Bystroe Channel and/or a new location of a harbour and related industry that take the delicate nature and ecology of the Delta in relation to air, water- and noise pollution into account. In this study,

3. Seven alternatives were defined by a group of international experts; five inside the Danube Delta Biosphere, Ukraine and two outside. The alternatives were discussed and compared to the Base Alternative i.e. the situation with only the Sulina Channel and no access route in Ukraine. The following themes were used to support the discussion:
   - Economy
   - Navigation
   - Ecology / Environment
   - Morphology
   - Maintenance

4. The likely effects of each alternative were discussed using the abovementioned themes on the basis of expert knowledge and judgment. Each of the alternatives had different effects per theme. This means that the ‘weight’ or importance given to the effect of any of the themes determines the choice alternative. In some cases the major effects were on (coastal) Morphology whilst in others effects on Ecology and Environment or Navigation were considered largest. The results of these discussions were used as input for a preliminary economic feasibility study (CBA) together with benchmark figures for construction and maintenance costs as well as benchmark figures of economic effects of shipping.

5. The main conclusion is that, when considering the Ukraine Danube Delta Biosphere, using the existing Sulina Channel as an access route to the Ukrainian Danube is the best option. This route already exists and has the least impact on the Delta as shipping does not pass through the strictly protected areas of the Ukraine Danube Delta.

6. In addition, the economic viability of any of the alternatives is based on the relative tariff rates of the Sulina Channel. If the rates for ship passages through Sulina Channel are made comparable to the tariff rates defined for Bystroe Channel, there is no viable economical argument left to make a new access route on Ukrainian territory. We therefore recommend investing in making both tariff structures comparable.

   However, when the total maintenance costs of Sulina Channel become larger than the investment- and maintenance costs of a new Ukrainian access route to the Danube, the economic feasibility for a new entrance could be generated. It is important to note that the environmental and ecologic costs should be considered and incorporated into the equation.

7. If, in spite of the above mentioned points, an access route through Ukrainian territory is still desired, there are two realistic alternatives that lie outside the Danube Biosphere Reserve, Ukraine; the Danube –Sasyk Channel and the Solomonov Channel. Both alternatives have no or minimal effect on the ecology and the environment of the Danube Delta Biosphere.

   However, both alternatives include the construction of a new channel through existing landscape, a new bridge and need respectively two and one lock- and sluice system. This system will slow down shipping and probably mean that tug assistance is required for the larger less manoeuvrable ships when entering or leaving the Danube River (Kiliya branch). Although not optimal for navigation, it is an acceptable solution especially in combination with the alternative access route through Sulina Channel.

   In both cases, the channels will not be constructed to accommodate maximum ship sizes. This will decrease construction and maintenance costs. The largest ships (10-20%) should continue to use the Sulina Channel and the medium and smaller ships can use the access route through Ukraine. Considering the data from the Sulina Channel, a minimal draught is needed of 5.5-6m for most of the year with a guaranteed year-round depth of e.g. 5m - during low waters the ships can pass through the Sulina Channel.

8. The Danube-Sasyk Channel requires the largest investment costs and is probably not economically feasible without additional funding (e.g. EU or national subsidies). This funding should be given to cover the higher costs that stem from the choice to stay outside of the Danube Delta protecting it from environmental and/or ecological impacts and to improve the water quality in the Sasyk Lake (important additional benefit of this alternative). DHV recommends analyzing this alternative further, and especially the relation between required additional investment costs and possible improvement of water quality in Sasyk Lake. Ultimately, this alternative can provide a combined solution for the creation of a sea access to the Ukraine Danube ports and the urgent need for improvement of the water quality in the Sasyk Lake.

9. The Solomonov Channel requires less investment, but has some uncertainty on the required volumes of maintenance dredging in the Zhebriyanskaya Bay. Furthermore, the change in the local landscape from woodland to marshland with the construction of a channel might be valued as a negative impact. If the additional research on water quality improvement in combination with a lack of funding, show that the Danube-Sasyk Channel is not a feasible alternative, this is could prove to be a good solution. Again, DHV recommends analyzing this alternative further, and especially the relation between required additional investment costs and sedimentation rates (maintenance dredging costs) in the Zhebriyanskaya Bay.

Recommendations

We recommend investing in making the tariff structures of the Bystroe and Sulina Channels comparable. In addition, we suggest carrying out various studies and including the results in a Feasibility Study Report before making a final choice for the best alternative. If the water quality in the Sasyk Lake does not appear to improve sufficiently, the choice can be made to use the Solomonov Channel if sedimentation rates in the Zhebriyanskaya Bay are considered low enough implying low maintenance dredging costs.

In all cases, we recommend that the new policy should be coordinated with ecological priorities on the one hand and with different EU policies on the other: e.g. EU transport policy for the Danube, policy of International Commission for the Protection of the Danube River (ICPDR) stated in Joint Statement on

Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin.

Finally, additional studies are needed in the following areas:

- Extent of water quality improvement Sasyk Lake due to construction of the Danube-Sasyk channel;
- Sedimentation rates in the Zhebriyanskaya Bay and in particular within an access channel through the Bay;
- Detailed investigation of the maintenance costs of the Sasyk and Solomonov alternatives in terms regular dredging and lock and sluice maintenance;
- Availability of funding + subsidies for realising the construction works of the lock and sluice complexes;
- Preliminary design and cost estimate for the Danube- Sasyk and Solomonov Alternatives.

9 COLOPHON

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