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WP2: INLAND WATERWAYS FAIRWAY TECHNOLOGIES

2.1 FEASIBILITY STUDY ABOUT PROLONGING THE NAVIGATION PERIOD IN INLAND FAIRWAYS AND CANAL ROUTES

Final report of 2.1 part of WP2

Project «Future potential of inland waterways» («INFUTURE»)

Financed by EU, Russian Federation and Republic of Finland

CBC 2014-2020
SOUTH-EAST FINLAND - RUSSIA

INFUTURE

Admiral Makarov SUMIS

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INTRODUCTION

This scientific work executed within the framework of international project "Future potential of inland waterways" ("INFUTURE") in conformity with Cross-border cooperation program with financing from the European Union, the Russian Federation and the Republic of Finland.

This report contains Final report of part No. 2.1 Feasibility study about prolonging the navigation period in the inland fairways and canal routes of WP2.

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LIST OF ABBREVIATIONS

The following abbreviations are used in this report:

IWW	Inland Waterways
UDWS	Unified Deep Water System
RF	Russian Federation
FBI	Federal Budgetary Institution
ENC	Electronic Navigational Chart

1. ANALYSIS OF STATIC CARTOGRAPHIC DATA OF ATLASES AND STATISTICAL DATA REGARDING NAVIGATION PERIODS IN RECENT 10 YEARS ON THE UNIFIED DEEP WATER SYSTEM OF INLAND WATERWAYS OF EUROPEAN RUSSIA

Since from the point of view of extending the navigation period, the most interesting is the variability of the navigation parameters of inland waterways and the corresponding cartographic data, which directly affect the navigation safety level and require timely informing navigators about the changes taking place in order to solve the problem, the analysis of corrections for the navigational maps of the UDWS of Inland Waterways of European Russia was carried out.

In case of significant changes in the navigation map or the UDWS Atlas data sheets, the specialists of the cartographic service of the corresponding basin authority usually create a sheet insert. This requirement is due to the need to provide the user with quality cartographic material with a minimum of corrections on the sheet and an unambiguous data interpretation.

Examples of inserts created for the UDWS Atlas are shown in Figures 1.1 through 1.3.

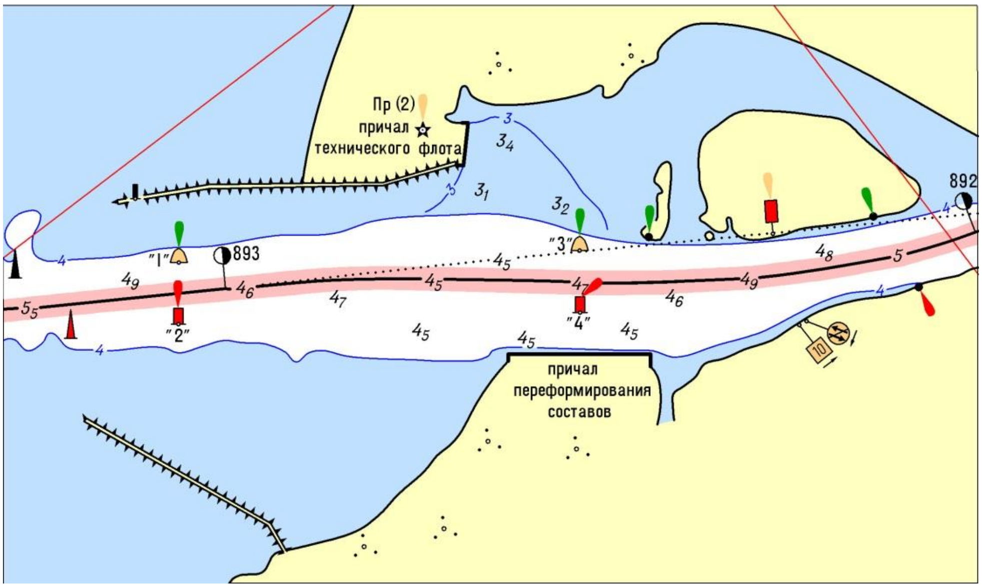

Figure 1.1 Example of the UDWS Atlas correction

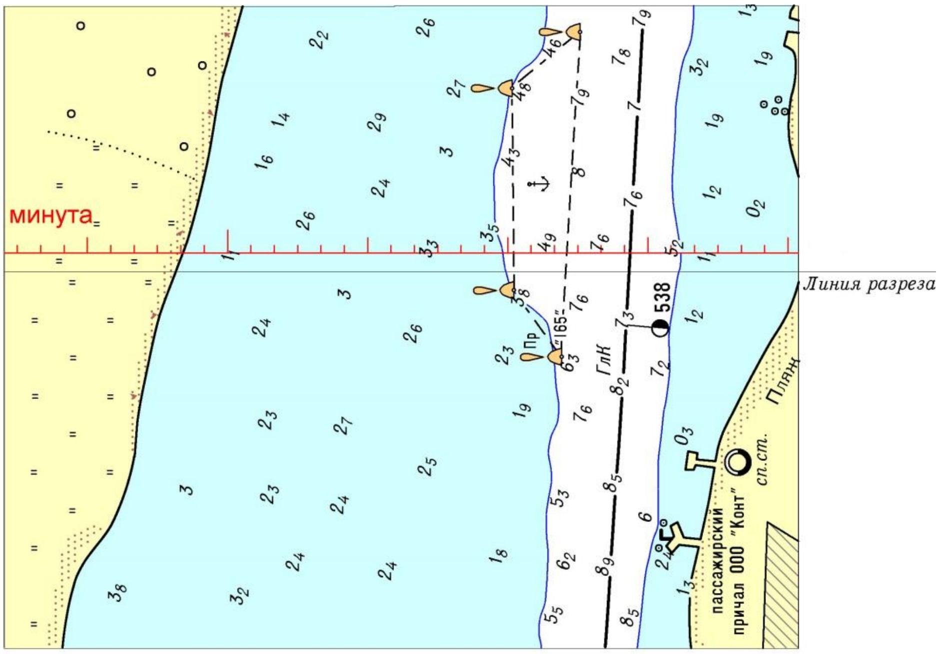

Figure 1.2 Example of the UDWS Atlas correction

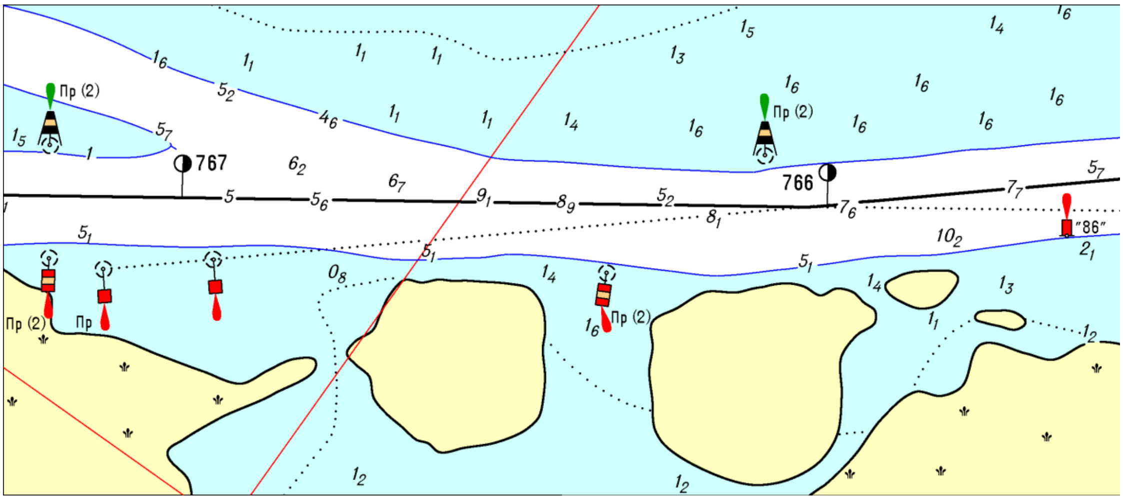

Figure 1.3 Example of the UDWS Atlas correction

Subject to the above, data were presented for recent years on the number of significant changes in cartographic materials that required the creation of inserts with gradation by basin. The obtained results are given in Table 1.1.

Table 1.1 - Data on the number of significant changes in cartographic materials with gradation by basin

Authority	Year	Correction at the beginning of navigation	Master notice-1	Master notice-2	Total per year	Summary total	Total %
FBI Administration of the Volga Basin	2010					137	**51**
	2011						
	2012	11	6	20	37		
	2013		5		5		
	2014	4	9		13		
	2015	6	3		9		
	2016	8	6	1	15		
	2017	11	3	6	20		
	2018	8	9	7	24		
	2019	14			14		
FBI Administration of the Volga-Baltic Basin	2010					40	**15**
	2011						
	2012						
	2013						
	2014		1	3	4		
	2015		1	1	2		
	2016	11	3	2	16		
	2017		3	6	9		
	2018		4	5	9		
	2019						
FSBI Moscow Canal	2010					37	**14**
	2011						
	2012						
	2013						

	2014	3			3		
	2015	4	1		5		
	2016	4			4		
	2017	2			2		
	2018	3		1	4		
	2019	12	7		19		
FBI Administration of the Kama Basin (Kamvodput)	2010					21	**8**
	2011						
	2012						
	2013						
	2014	1		3	4		
	2015	4		2	6		
	2016	2	1		3		
	2017						
	2018	1	2		3		
	2019	5			5		
FBI Administration of the Azov-Don Basin	2010					16	**6**
	2011						
	2012						
	2013						
	2014	2			2		
	2015						
	2016	7			7		
	2017	4			4		
	2018	1			1		
	2019	2			2		
FBI Administration of the White Sea – Onega Lake Basin (Belomorcanal)	2010					16	**6**
	2011						
	2012						
	2013						
	2014						

	2015						
	2016	5			5		
	2017		3		3		
	2018	4			4		
	2019		4		4		

Figure 1.4 shows the percentage of new cartographic data for basin administrations over 10 years.

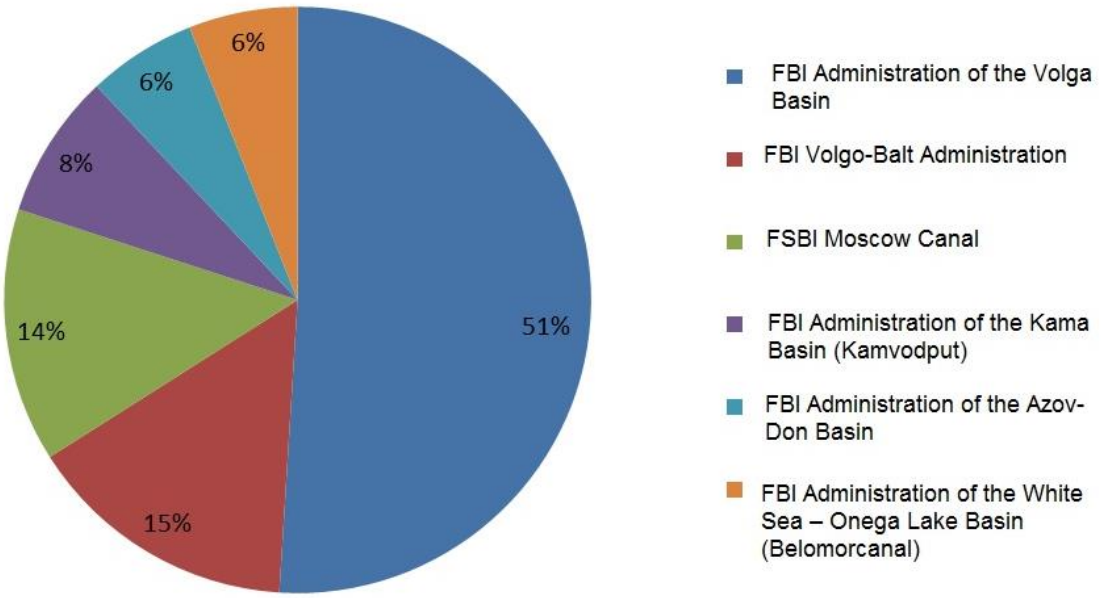

Figure 1.4 Percentage of new cartographic data by basin administrations

Thus, it is shown that on the Volga-Baltic Basin waterways the stream bed variability is average that allows to extend navigation but requires the use of modern methods of information and navigation support for navigators.

2. ANALYSIS OF NAVIGATION CONDITIONS OF THE VOLGA-BALTIC BASIN

The Volga-Baltic Basin (Figure 2.1) was selected to consider the possibility of navigation period extension.

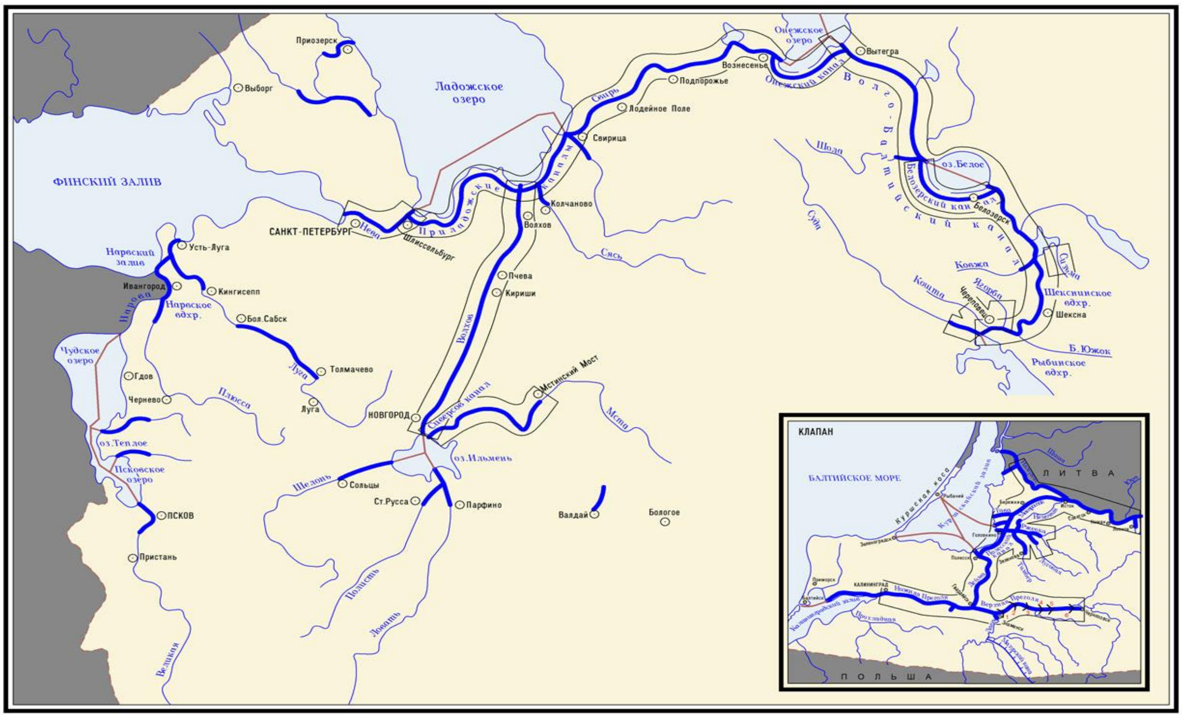

Figure 2.1 The Volga-Baltic Basin

Data on navigation conditions in this basin were collected and systematized.

The Neva and the Svir are the main rivers and Lake Ladoga is the largest water body of the basin.

The report provides basic data on the navigation conditions in the basins of these waterways, namely:

- climate pattern;
- currents;
- wind an wave conditions;
- probability of fog occurrence;
- number of days with limited visibility;
- precipitation;
- level regime;
- ice phenomena.

It was found that the Neva River is one of the most promising sections of inland waterways in terms of navigation extension. The Neva River length is 74 km (1,389.0–1,315.0 km); hazardous sections are considered from the mouth (St. Petersburg) to the source (Shlisselburg).

3. DESCRIPTION OF NAVIGATION CONDITIONS AND FORMATION OF LIST OF STREAM SECTIONS OF THE NEVA RIVER HAZARDOUS FOR NAVIGATION

To ensure a high level of navigation safety during the extended navigation period, based on the data obtained in the previous section, an analysis was carried out and a list of potentially hazardous sections of the Neva River was formed.

Sections with the following features and limitations were identified:

- heavy traffic of high-speed passenger and cargo ships (Figure 3.1)

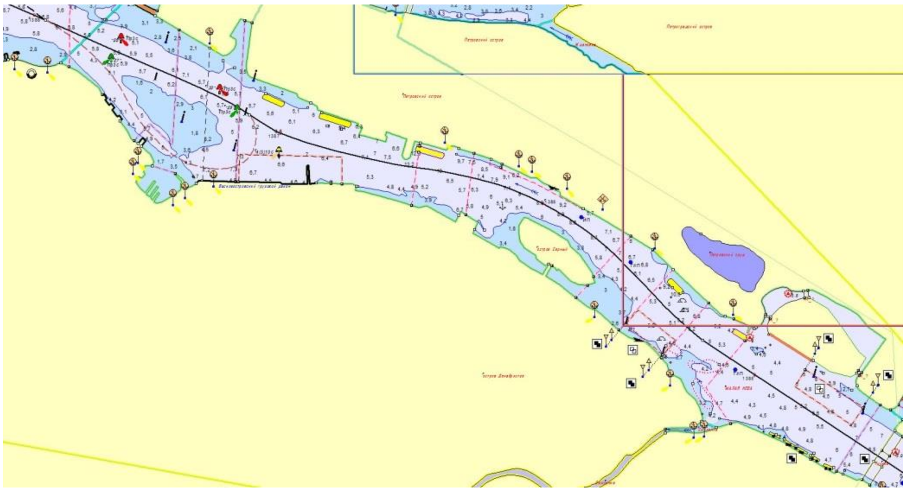

Figure 3.1 Section with heavy traffic of high-speed passenger and cargo ships

- fixed bridges (Figure 3.2);

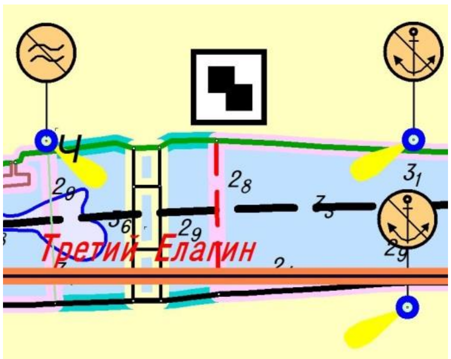

Figure 3.2 Fixed bridges in the Neva River delta

(The Third Elagin bridge)

- wrecked ships (Figure 3.3);

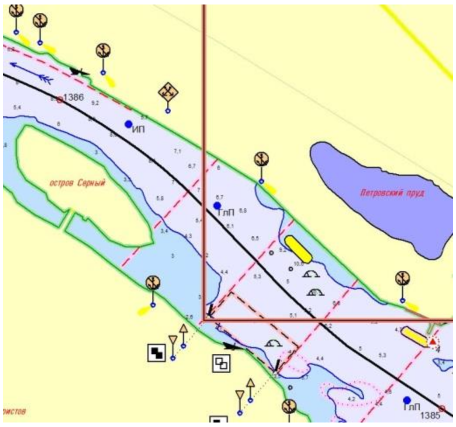

Figure 3.3 Wrecks at 1,386 km, right bank; 1,385.4 km, left bank

- traffic banning in conditions of limited visibility (Figure 3.4);

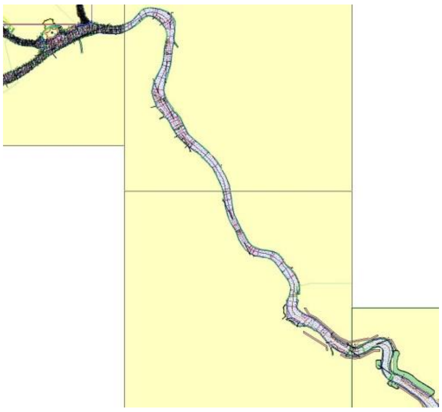

Figure 3.4 Section of 1,384.6–1,355.6 km

- cross currents and stream swirls (Figures 3.5-3.6);

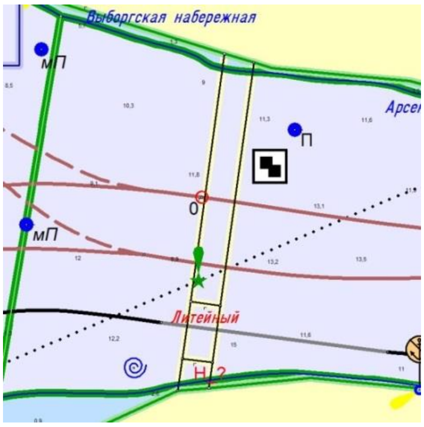

Figure 3.5 Stream swirl: Left bank — 1,380.6 km

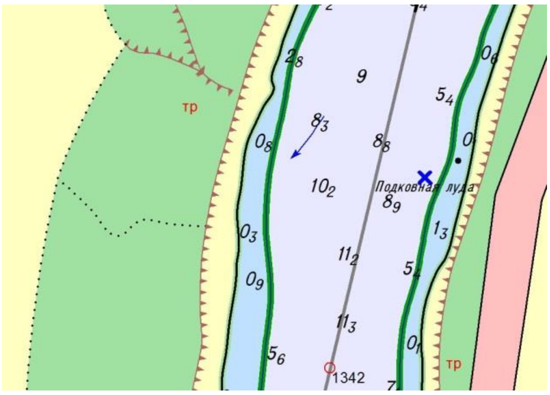

Figure 3.6 Cross current: 1,341.7 km, to the right bank

- prohibition of overtaking and passing of ships and convoys (Figure 3.7);

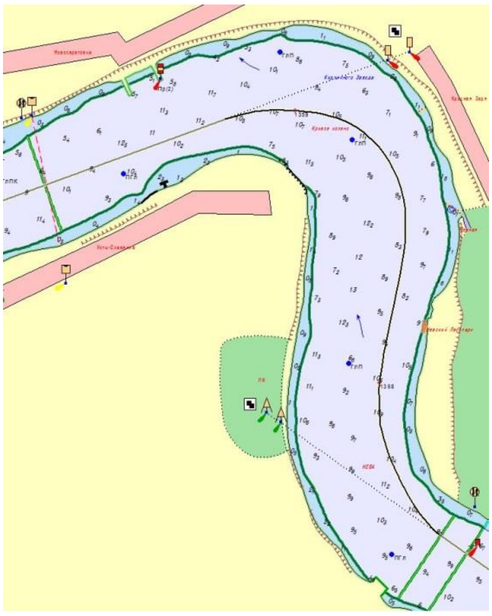

Figure 3.7 Section of 1,359.8–1,357.5 km

- movement in bridge spans (Figure 3.8);

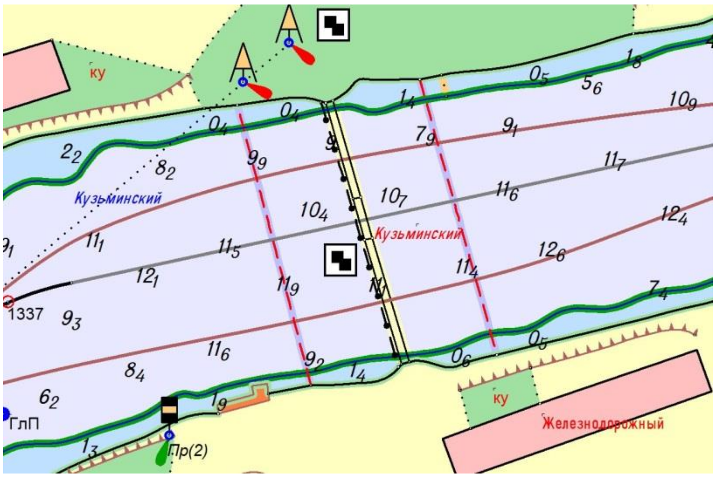

Figure 3.8 The Kuzminsky Bridge

- ferry crossings (Figure 3.9).

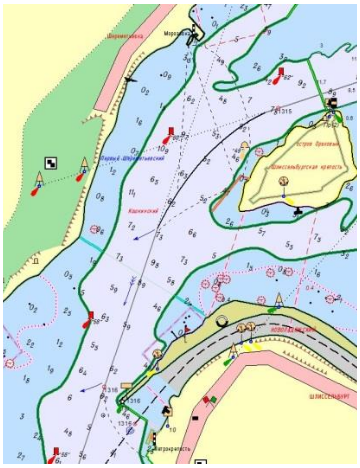

Figure 3.9 Ferry crossing in the area of Shlisselburg

4. FORMATION OF A CLASSIFICATION LIST OF ORGANIZATIONAL AND TECHNICAL MEASURES AIMED AT IMPROVING THE SAFETY OF NAVIGATION DURING THE NAVIGATION EXTENSION PERIOD

The instability and variability of the factors ensuring the navigation safety during a given period from the phase of safe navigation to the phase of its prohibition within a short period of time is a distinctive feature of navigation conditions during the navigation extension period. To improve the navigation safety during the navigation extension period, it is necessary to pay close attention to the monitoring of factors that directly affect the navigation safety and are actively changing over a short period of time.

The main factors influencing the navigation safety during the navigation extension period were identified.

Changes in water levels

To ensure the navigation safety, constant monitoring of water levels along the entire waterway is necessary. On the Neva River the monitoring is carried out using water measuring posts. The Federal Budgetary Institution Volgo-Balt Administration uses data both from its own water measuring posts and from Roshydromet measuring stations. Data from Roshydromet are provided on a contractual basis and registered in the form of values of the water level rise by “0” of the water measuring post in centimeters.

The water measuring post of the FBI Volgo-Balt Administration is located in the city of Shlisselburg. Roshydromet water measuring posts are located in St. Petersburg (the Mining University) and the settlement Ivanovskoe (Figure 4.1).

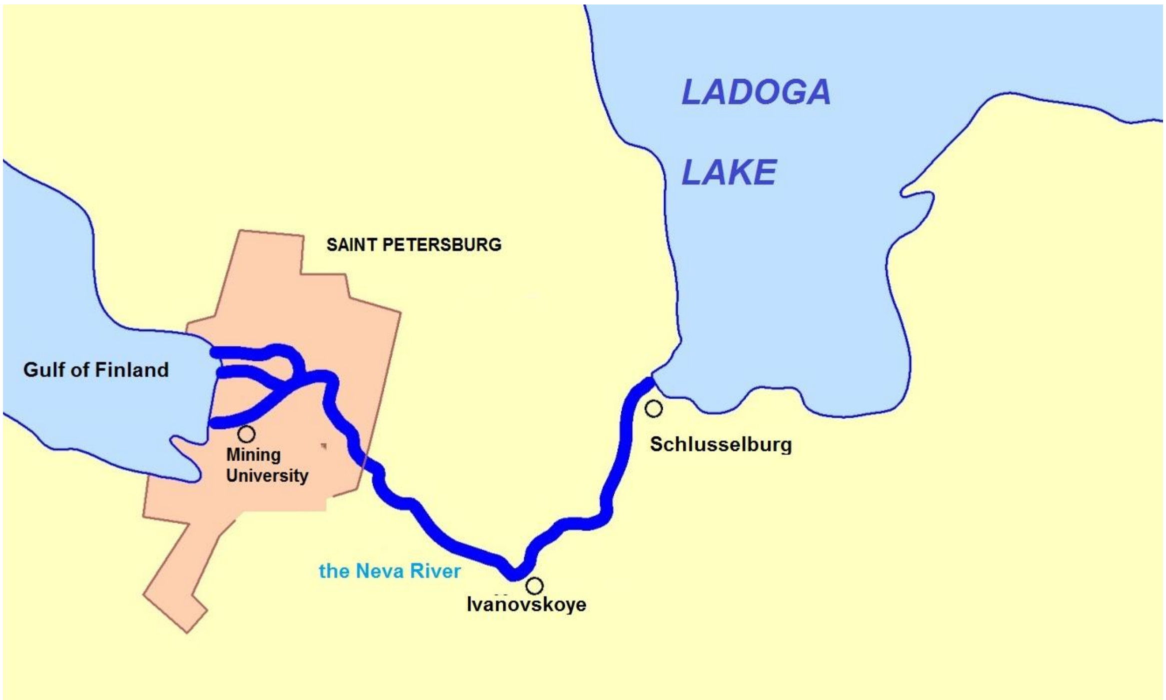

Figure 4.1 Location of measuring posts

Figure 4.2 shows the schematic longitudinal profile of a section of the Volga-Baltic Waterway from St. Petersburg to the Svir River mouth, including the Neva River.

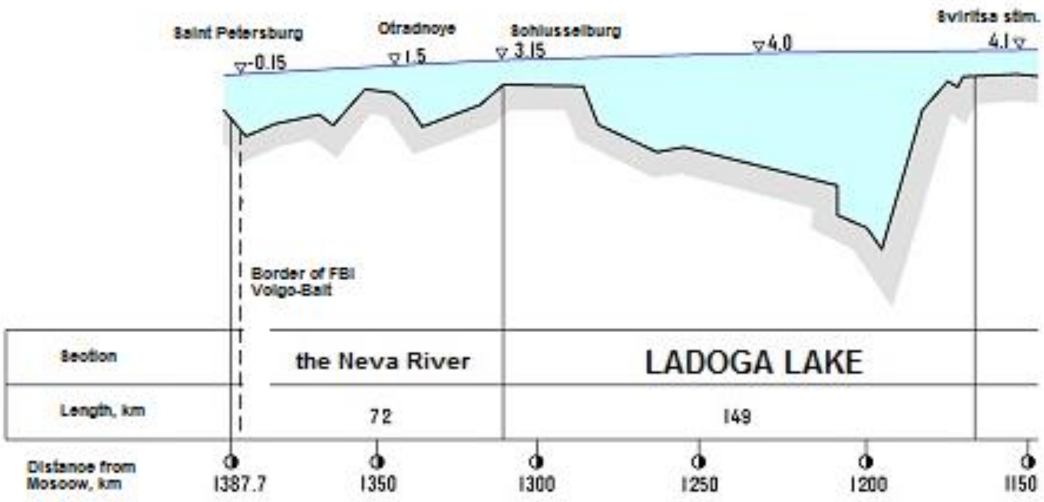

Figure 4.2 Schematic longitudinal profile of a section of the Volga-Baltic Waterway

Changes in hydrometeorological conditions

The FBI Volgo-Balt Administration receives this data from Roshydromet; there are no its own automated hydrometeorological posts. However for the navigation extention, it may be necessary to install several devices of this type. The quantity shall be determined by a separate project.

Changes in ice conditions

During the navigation extension period, ice conditions monitoring is one of the most important organizational and technical measures that directly affect the level of navigation safety. Since the weather conditions during this period are quite unstable and the formation of a thick ice cover is possible in a short period of time. An example of such a phenomenon is the events that took place in November 2016, when according to observations the beginning of November in St. Petersburg was the coldest one over the period of 46 years.

Changes in waterway depths

In order to ensure a high level of navigation safety during the navigation extension period, it is also necessary to control the waterway depths as in the main navigation period.

The depth control on the Neva River is carried out by the Nevsko-Ladozhsky Grand Division for Waterways and Shipping (the FBI Volgo-Balt branch) with the use of automated sounding systems.

An automated sounding system is a complex of technical (hardware) and software tools combined into a single system, necessary for the automated production and processing of the results of hydrographic and topogeodetic works during channel surveys on inland waterways in order to collect and process navigation, hydrographic information and geodetic data in order to create unified electronic cartographic support of the IWW, as well as for navigational and hydrographic support of dredging, river training and other engineering works, monitoring the state of ship fairways and the navigational buoyage system.

The schematic diagram of the automated sounding system (ASS) is shown in Figure 4.3.

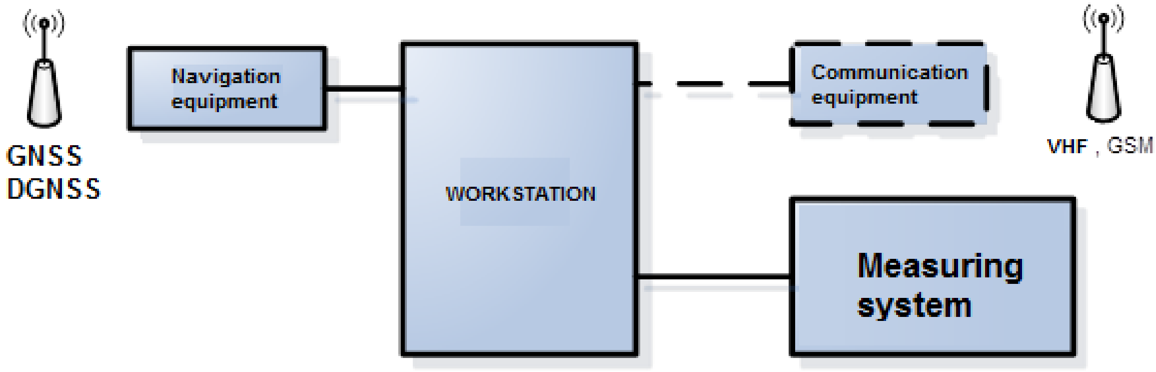

Figure 4.3 The schematic diagram of the automated sounding system (ASS)

Dispatching control on the Neva River and Lake Ladoga

The organization of the dispatching service is regulated by the Procedure for dispatching regulation of the movement of ships on the Russian Inland Waterway System, which applies to all ships navigating along the Volga-Baltic Waterway route, regardless of their ownership.

The movement and anchorage of vessels performing voyages along the Volga-Baltic Waterway route and lakes are subject to mandatory control and monitoring at control points (CPs).

Dispatching control on the Volga-Baltic waterway is carried out on the basis of the document Procedure for dispatching control of vessel traffic on inland waterways of the Russian Federation.

Timely informing for navigators

During the navigation extention period, it is especially important to timely inform navigators about all changes along the waterway. This information is provided using radio communication aids.

The navigators sailing along the Volga-Baltic Waterway shall be guided by the Instructions on the organization and maintenance of radio communication with vessels when navigating on inland waterways of the European part of the Russian Federation. While the vessel is in motion, the VHF radio station shall be constantly switched on channel 5 (frequency 300.2 MHz), which is used by coastal radio stations to call ships, and to ship stations - to call each other, to answer a call, brief negotiations on overtaking, passing of ships and messages about the transition to another frequency.

In the event of an emergency, the master (watch officer) is obliged to call the nearest vessels and coastal radio stations on channel 5 (frequency 300.2 MHz) and report the incident.

In case of changing the communication channel number, in order to exclude the occurrence of an emergency situation due to errors when using the inter-ship communication channels, the watch officer is obliged to ensure that channel 5 is monitored at the backup radio station.

Icebreaker support

During the navigation extension period on the Neva River, it may be necessary to use icebreakers and/or ice-class tugs.

Ice pilotage is ordered by the ship owner, therefore it is necessary to strike a balance between additional costs and the navigation safety. The number of icebreakers, as well as the schedule of their operation, shall be determined based on the intensity of vessel traffic during the navigation extension period. With a large number of ships and unfavorable ice conditions, icebreaker duty can be organized.

Based on the above factors, a classification list of organizational and technical measures was formed to improve the safety of navigation during the navigation extension period (Figure 4.4):

- water level monitoring;
- monitoring of hydrometeorological conditions;
- monitoring of ice conditions;
- monitoring of waterway depths;
- dispatching control of navigation;
- informing for navigators in near-real time;
- use of icebreakers.

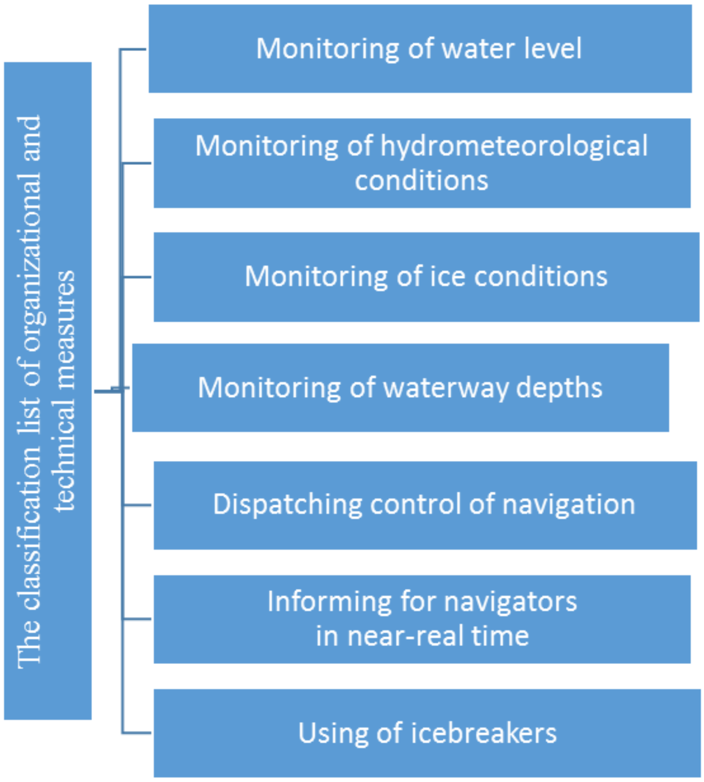

Figure 4.4 Recommended list of organizational and technical measures

5. ANALYSIS OF THE POSSIBILITY OF ICE NAVIGATION IN THE WATER AREA OF THE NEVA RIVER

Depending on meteorological conditions the Neva River freezes for a period of 2 to 6 months. It is characteristic that the river freezes upstream (from the mouth to the source), and conversely the ice breaks downstream (from the source to the mouth).

Autumn ice drift across the river is observed in the second half of November; its average duration is about two weeks. The river freezes in an abrupt manner: the ice cover quickly spreads upstream, then stops and moves down; and sometimes, especially in the middle part of the Neva, ice jams form.

The spring ice drift on the Neva, as a rule, is divided into two periods. In the first, so-called period of the Neva ice drift, the river thaw out from ice for 3–5 days. Then, after a few days, the second period of the Ladoga ice drift begins, when within 8–12 days ice goes down from Lake Ladoga. Sometimes the Ladoga ice drift is delayed for a month with interruptions. In rare cases, in the absence of northeast winds, ice melts in the lake, and there is no repeated ice drift on the Neva. In general the spring ice drift from breakup to clearance of ice usually lasts about three weeks.

The ice conditions of the Neva River are greatly influenced by Lake Ladoga, since it is the source of the Neva River. In the event of an ice drift, a large amount of ice appears in the river bed.

The ice regime of Lake Ladoga is very complicated. ice cover in different parts of the lake is established at different times; in this case, ice formation occurs in circles from the shores to the center of the lake. In the coastal part of the lake, ice appears in the form of shore ice, land fast ice or bottom ice that floats to the surface of the lake. In addition, ice is carried in large quantities by rivers flowing into Lake Ladoga.

Usually ice appears at the end of the first - beginning of the second decade of November, primarily in the shallow southern part and then in the deeper northern part of the lake. As a rule, in the open part of the lake ice forms from 12 to 26 November.

Freeze up occurs primarily in the southern part of the lake (at the beginning of December); in this case, as a rule, the eastern part of the Svir Bay and the southern parts of the Petrokrepost Bay and the Volkhov Bay freeze first. Then freezing spreads to the center of the lake, and by February 15–20 (and in severe winters by the end of January - early February) the lake is completely covered with motionless ice.

In mild winters, continuous ice cover does not form on Lake Ladoga; in such winters, the edge of motionless ice usually does not extend beyond the areas bounded by the 20 m isobath. Behind the edge of stationary ice, there is a strip of drifting ice; in the central part of the lake, ice-free water is retained throughout the winter.

The thickest ice cover is formed in the coastal zone, in creeks and bays. In the central part of the lake, ice is usually thinner and less snowy; it is characterized by dry cracks. The ice reaches its maximum thickness in March.

During the winter, ice is subjected to rather strong hummocking, as a result of which hummocked ridges are formed, separated from each other by strips of level ice.

Usually the breaking up of ice on Lake Ladoga occurs at the end of March in the reverse sequence of freezing.

The breaking of fixed ice begins around mid-April. In the second half of April, the ice cover is destroyed in all parts of the lake; most of the ice melts in place, and a smaller part (about 20%) is carried into the Neva River. Part of the ice is thrown ashore and sometimes remains here until the first half of July.

The ice is cleared from the lake first (at the end of April) in a narrow coastal zone. The lake is finally cleared from ice in mid-May.

Ice navigation on the Neva River is possible only if the vessel has an ice class, or when icebreaker assistance is provided. At the same time, it should be noted that in the last decade there has been a tendency towards a decrease in the thickness of the ice cover and even its absence in winter. The results of the analysis indicate a favorable forecast for the navigation during the navigation extension period. Table 5.1 shows the average annual temperature values for the last 10 years in St. Petersburg.

Table 5.1 Average annual temperatures

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PER AN.
2010	-12.1	-8.4	-2.4	6.7	13.4	15.5	24.4	19.6	12.3	5.5	0.4	-8.3	5.6
2011	-5.8	-11.0	-1.9	5.7	11.0	17.7	22.5	17.5	13.1	7.6	3.6	1.9	6.8
2012	-4.8	-10.4	-1.0	4.9	12.7	15.2	19.5	16.3	12.9	6.6	2.9	-7.9	5.6
2013	-6.1	-2.6	-6.6	4.2	14.4	19.8	19.0	18.6	12.1	7.3	4.4	0.9	7.1
2014	-7.0	0.0	2.2	6.5	13.0	15.0	21.2	18.8	13.5	5.2	0.8	-1.0	7.4
2015	-2.7	-0.6	2.6	5.1	11.8	15.9	16.9	18.3	14.0	5.6	3.1	2.1	7.7
2016	-11.2	0.0	1.0	6.3	14.7	16.5	19.0	17.2	12.9	5.0	-1.8	-1.2	6.5
2017	-3.9	-3.5	1.3	2.8	9.4	13.6	16.5	17.4	12.5	5.6	2.3	0.4	6.2
2018	-2.9	-7.7	-4.4	6.0	15.1	16.2	20.9	19.2	14.5	7.3	2.8	-3.2	7.0
2019	-6.5	-0.5	0.0	7.3	12.1	18.7	16.6	17.0	12.2	6.1	1.9	1.8	7.2
2020	1.5	0.6	2.2	4.2									

In addition to the sharply distinguished 2016, there is a trend towards an increase in winter temperatures, so over time, an increasingly longer period of extended navigation can be without ice conditions.

6. DEVELOPMENT OF RECOMMENDATIONS FOR ENSURING ICE CHANNELING OF SHIPS IN THE WATER AREA OF THE NEVA RIVER

In winter, even in the absence of ice cover, most floating navigation signs are removed from their original positions, but positions of all coastal navigation signs are remained unchanged.

In the considered conditions coastal navigation signs are the most reliable aids, they can be affected neither by malfunctions in the operation of navigation information systems, nor by the negative impact of the environment (with a low probability).

In total 327 signs have been installed on the banks of the Neva River from the Blagoveshchensky Bridge to Orekhovy Island (Shlisselburg Fortress). Conventionally they can be divided into two groups: navigation fairway signs and information signs (Figure 6.1).

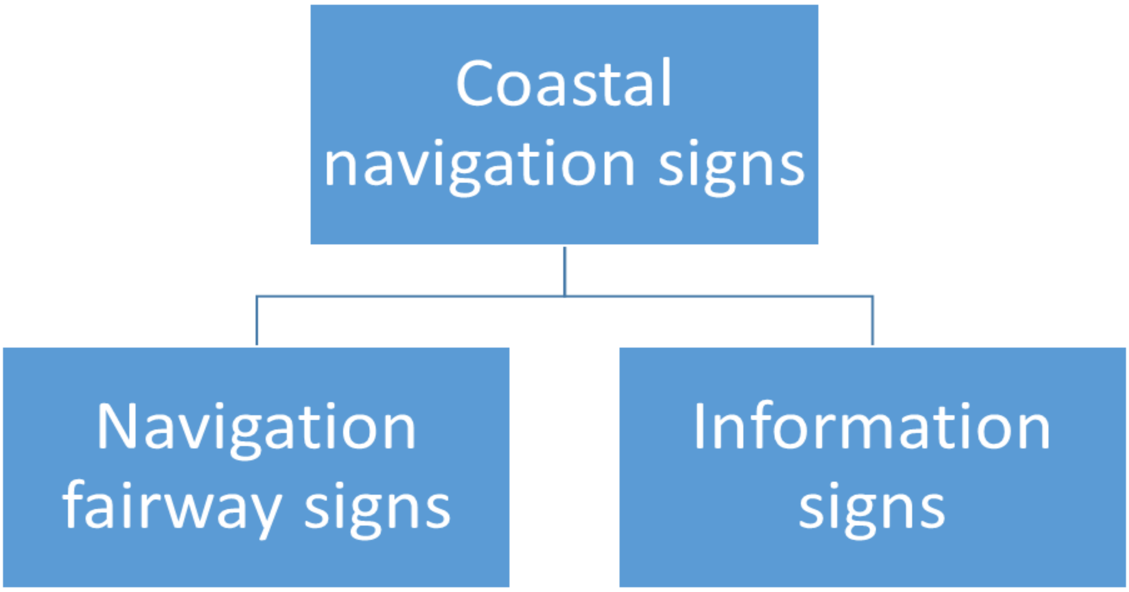

Figure 6.1 Coastal navigational signs

In total, on the Neva River there are 264 information signs and 63 navigation fairway signs.

The range signs are the basis of the navigation fairway signs group. They are used to determine the vessel position relative to the axis of the navigable fairway, most often they are installed on areas difficult for navigation (Ivanovskiye Porogy rapids, Koshkinsky fairway). The range signs are painted white or red, depending on the background on which they are visible from the river. The signs of the left bank are equipped with green light, and the signs of the right bank with red one (Figures 6.2, 6.3).

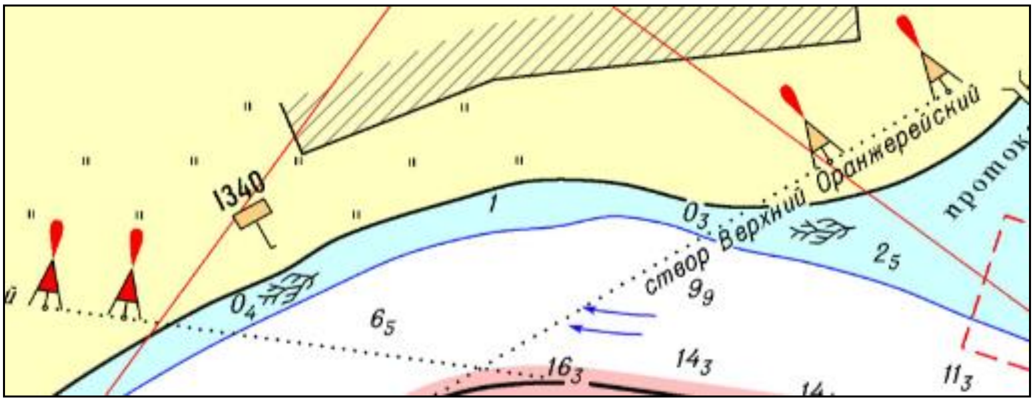

Figure 6.2 Range signs of the right bank

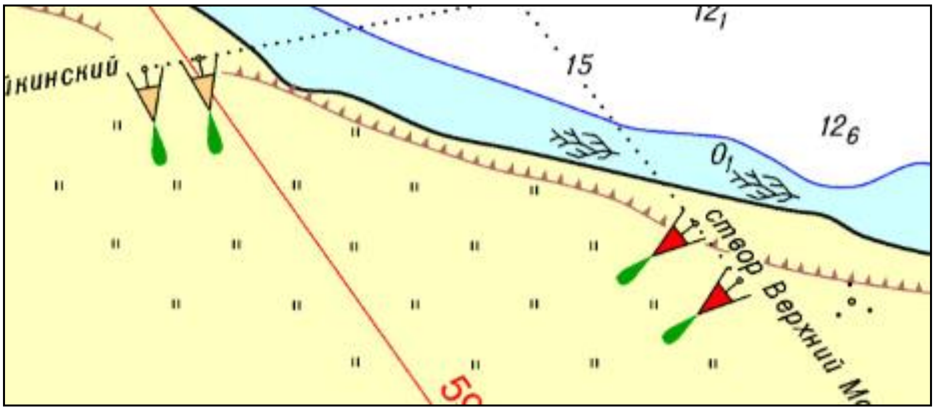

Figure 6.3 Range signs of the left bank

The distribution of range signs along the Neva River bed is fairly uniform over the entire distance (Figure 6.4).

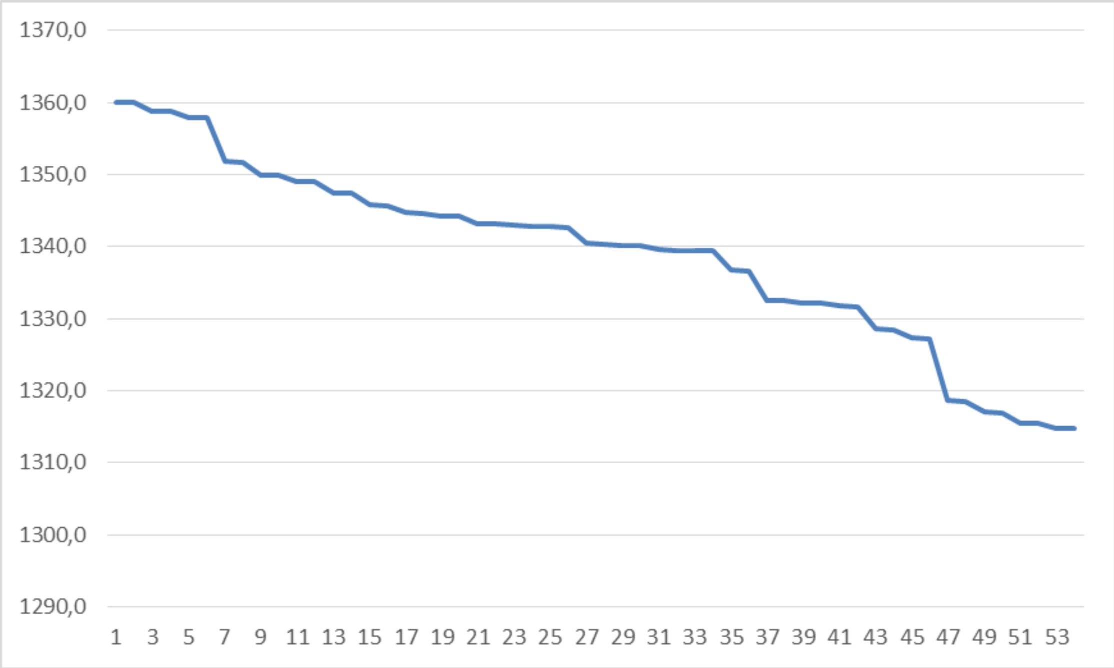

Figure 6.4 Distribution of range signs by distance

The main signs included in the Information signs group:

- sign "Do not drop anchor";
- sign "Passing and overtaking are prohibited";
- sign "Do not exceed air draught";
- roadside mark (road stead range lines);
- sign "Place of turn of ships";
- distance sign

During the inter-navigation period, not all floating navigation signs are removed, special ice buoys remain in their regular places. During the navigation extension period, the navigator is recommended to use them as one of the navigation aids. Let's consider them in more detail. These navigation aids are cigar-shaped buoys. The cigar color corresponds to the color of the buoy it is paired with; after the end of the navigation period, the main buoys are removed (Figures 6.5, 6.6).

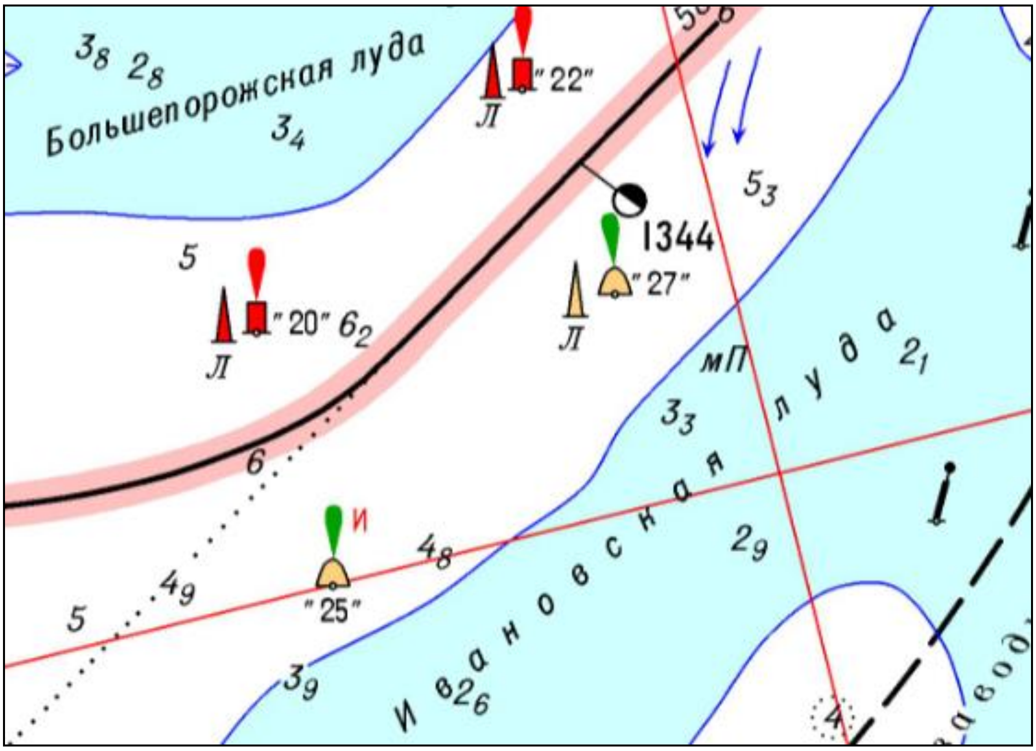

Figure 6.5 Ice buoys-cigars of the left and right edges of the fairway

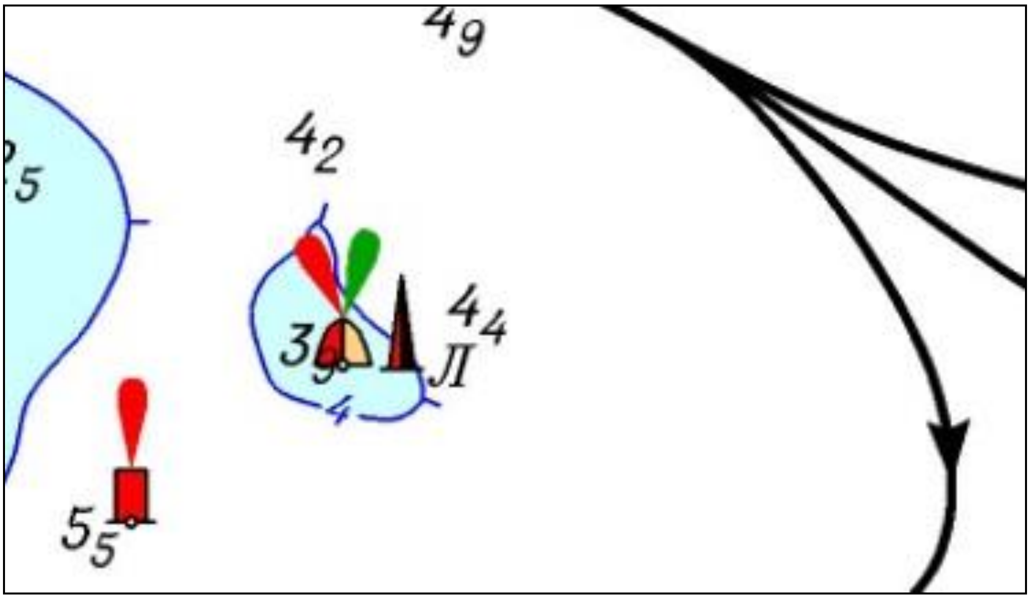

Figure 6.6 Pivot Cigar Buoy

Ice marks during the main navigation period are installed as duplicate ones (Figure 6.7), and during the extended navigation period they remain as the main floating navigational signs.

Figure 6.7 Ice mark on the Neva River

Ice marks on the Neva River are installed in the most dangerous sections of the fairway, a dense arrangement is observed in the area of the Ivanovskiye Porogy rapids and the Koshkinsky fairway (Figure 6.8).

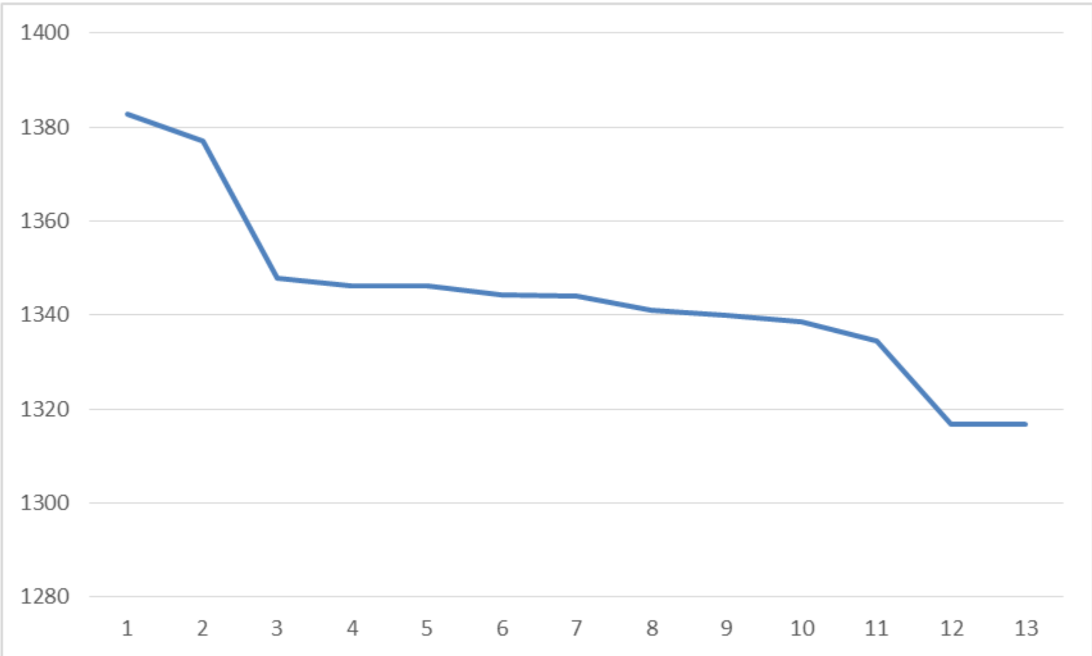

Figure 6.8 Schedule of distribution of ice marks on the Neva River

It is recommended for navigators to use ENCs as the primary navigation aids and coastal navigation signs as an additional aids. Ice buoys are installed in the most difficult navigation areas. In case of ice coverage escorting will be carried out using icebreakers (Figure 6.8).

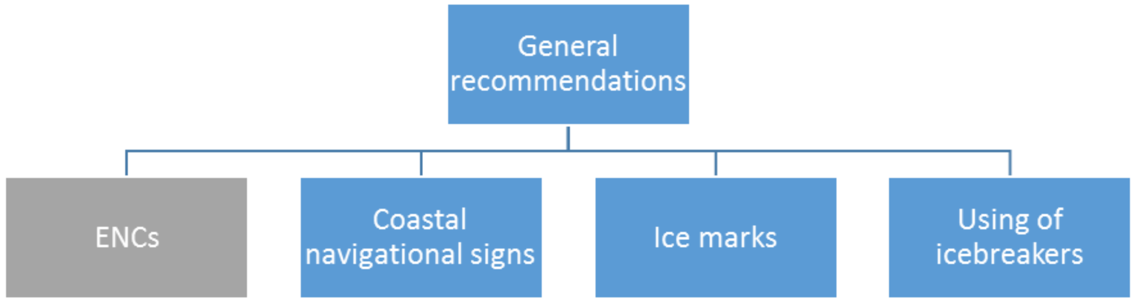

Figure 6.8 General recommendations for ice channeling

CONCLUSIONS

The final report on the event "Feasibility study of the possibilities for extending navigation on the routes of inland waterways and canals" was prepared.

The following steps were completed:

1. Analysis of static cartographic data of atlases and statistical data regarding navigation periods in recent 10 years on the Unified Deep Water System of Inland Waterways of European Russia.

2. Analysis of navigation conditions of the Volga-Baltic basin.

3. Description of navigation conditions and formation of list of stream sections of the Neva River hazardous for navigation.

4. Formation of a classification list of organizational and technical measures aimed at improving the safety of navigation during the navigation extension period.

5. Analysis of the possibility of ice navigation in the water area of the Neva River.

6. Development of recommendations for ensuring ice channeling of ships in the water area of the Neva River.

At the first stage, it was found that on the North-Western waterways (FBI Volgo-Balt Administration) the stream bed variability is average that allows to extend navigation but requires the use of modern methods of information and navigation support for navigators. Further, the navigation conditions on the main waterways of the North-West region were analyzed and it was established that the Neva River is one of the most prospect sites of inland waterways in terms of navigation extension. The Neva River length is 74 km (1,389.0–1,315.0 km).

The navigation conditions were analyzed and a list of stream sections of the Neva River hazardous for navigation was prepared.

To ensure a high level of safety of navigation during the navigation extension period, it is necessary to implement modern methods of information and navigation support for navigators. To solve this problem, a number of organizational and technical measures are required on a regular basis. The classification list of organizational and technical measures aimed at improving the safety of navigation during the navigation extension period was prepared.

The classification list of organizational and technical measures aimed at improving the safety of navigation during the navigation extension period is as follows:

- water level monitoring;
- monitoring of hydrometeorological conditions;
- monitoring of ice conditions;
- monitoring of waterway depths;
- dispatching control of navigation;
- informing for navigators in near-real time;
- the use of icebreakers.

Since extended navigation is expected during the season with prevailing near-zero and negative temperatures and, accordingly, a high probability of ice formation, an analysis was made of the possibility of ice navigation in the water area of the Neva river, and it was established that this is possible under certain conditions. There was also a trend towards a general increase in average temperatures in winter.

After that, recommendations were developed to ensure ice escorting of ships in the water area of the Neva river, including the following main points: it is recommended to use ENCs as the primary navigation aids and coastal navigation signs as an additional aids. Ice buoys are installed in the most difficult navigation areas, and their number is sufficient. In case of ice coverage, it will be necessary to ensure the watch of icebreakers or ice-class tugs in order to conduct pilotage.

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