MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

National Technical University
«Kharkiv Polytechnic Institute»

Educational and Scientific Institute
of Mechanical Engineering and Transport (MET)

Department Occupational and Environmental Safety

Methodical instructions for independent work «Assessment of the situation in the event of an accident on water objects. Part 1» in the discipline «Technogenic and Environmental Safety in the Conditions of Industrial and Economic Activity» for applicants for the second (master's) l evel of higher education all forms of education

Kharkiv
NTU KhPI
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CONTENT

INTRODUCTION

These methodological instructions are intended for the independent work of students studying the discipline "Technological and ecological safety in the conditions of industrial and economic activity" in order to clarify the methodology for calculating the assessment of the situation in the event of an accident on water bodies. According to the study and work plans of the specialty 263, the educational program of the II (master's) level of higher education "Occupational safety", as part of the study of the mandatory professional discipline "Technogenetic-ecological safety in the conditions of industrial and economic activity", students are expected to independently perform the calculation task. Methodical instructions contain practical tasks that will help students to master the modern problems of emergency situations.

Independent work of students of higher education is a form of organization of the educational process, which ensures their mastery of educational material in the time free from compulsory educational classes. The existence of this form of organization of the educational process in institutions of higher education is provided for by the Law of Ukraine "On Higher Education" (Article 50). The content of the independent work of a student of higher education in the academic discipline "Technogenetic-ecological safety in the conditions of industrial and economic activity" is determined by its program, these methodical instructions for independent work, tasks and instructions of the teacher.

The purpose of independent work is:

- assimilation of theoretical knowledge;
– formation of general educational skills and abilities;
– formation of motivation for self-education during professional activity;
- development of cognitive interests and abilities

- development of critical thinking and abilities to check the information received from various sources;

- increasing the efficiency of the educational process by organizing out-of-classroom training in accordance with the personal abilities of each student of higher education.

Independent work is provided by a system of educational and methodological tools provided for studying the academic discipline, namely:

− electronic materials that are placed in the system of electronic education support;

− textbooks, educational and methodical guides, lecture, workshops, etc.;

- scientific and professional monographic and periodical literature recommended by the responsible scientific and pedagogical worker.

The main forms of independent work are:

- revision of lecture materials;

- working with textbooks, manuals and other methodical materials;

- work in information networks;

- development of additional literature;

- work with periodicals;

- preparation and presentation of abstracts;

– preparation of individual calculation tasks issued by the teacher;

− preparation for consultation with the teacher;

- preparation for a test or exam.

Since in recent years, students have been studying online, when communication between students and teachers is difficult due to low-quality Internet connections, the importance of independent work has increased.

All this required the preparation and publication of improved methodological instructions for independent work on the calculation of the assessment of the situation in the event of an accident on water bodies.

TOPIC 1

ASSESSMENT OF THE SITUATION IN THE EVENT OF AN ACCIDENT ON A HYDRAULIC STRUCTURE

1.1. Individual tasks

The purpose of the task is to master the practical skills of calculating the assessment of the situation in the event of an accident on a hydraulic structure

It is necessary to assess the situation in the event of an accident on the hydraulic structure, namely the destruction of the dam.

With the help of calculations,determine the following parameters:

– maximum breakthrough wave height *h, m*;

– maximum flow velocity of the breakthrough wave *V, m/s*;

– average velocity of water flow at the flooded object V_{cp} *, m/s*;

– flooding height of the object $h_{зат}$*,, m*;

– time of arrival of the front of the breakthrough wave $t_{фр}$*, h (hours)*;

– time of arrival of the crest of the breakthrough wave $t_{гр}$*, h (hours)*;

– duration of flooding of the object τ*, h (hours)*.

– total losses among the population that found themselves in the zones of catastrophic flooding $N_{втр}$ (people), and the distribution of these losses into irretrievable $N_{втр\ бп}$ (people) and sanitary $N_{втр\ сан}$ (people) losses.

Table 1. 1 – Task Options

Variant	*L, m*	h_0, *м*	$h_м$, *м*	H_0, *м*	*l, м*	$H_п$, *м*	$H_м$, *м*	$b_к$, *м*	*B, м*	$S_{пер}$, *м*^{2}	$N_{зам}$, *people*	*Time of day*
1,11,21	5000	5	2	50	154	170	165	140	154	162	5000	day
2,12,22	5000	2,5	1,2	50	140	170	165	145	70	163	5100	day
3,13,23	5000	2,5	0,7	25	120	170	165	100	30	164	5200	day
4,14,24	10000	2	0,6	20	154	170	169	45	154	165	5300	day
5,15,25	10000	1	1	20	140	170	169	100	70	166	5400	day
6,16,26	10000	5	1,3	50	120	180	170	100	30	167	5500	day
7,17,27	10000	2,5	0,4	25	154	180	170	100	154	168	5600	day
8,18,28	20000	2	0,7	20	140	180	178	100	70	169	5700	day
9,19,29	20000	5	1	50	120	180	160	100	30	170	5800	day
10,20,30	20000	2,5	0,3	25	154	180	160	100	154	180	5900	day

1.2 Example of the task

To assess the situation during the destruction of the dam, it is necessary to form a table of the initial data of the object (Table 1.2)

Table 1. 2 – Imprint

Parameter name, designation, and dimension	Value
Removal of this section of an industrial facility *L, m*	8000
Average depth of the river in the downstream of the dam h_0, *m*	8
The height of the object in relation to the river level in this alignment is $h_м$,, *m*	2
Height of the water level in the upper reaches of the dam H_0, *m*	80
Dam length *l, m*	154
Absolute height of the river bottom surface in the downstream $H_п$, *m*	227
Absolute height of the surface of the river bottom in the alignment of the industrial facility $H_м$, *m*	219
Width of the river in the alignment of the industrial facility b_k, *m*	140
The size of the dam of the hydro complex *B, m*	154
Area of the wetted perimeter $S_{пер}$,, *m*^{2}	162
Number of people in catastrophic flood zones $N_{зам}$, *people*	5000
Time of day	day

Calculation

1. Determine the relative value of the dam hole:

$$\boldsymbol{B_{відн}} = B / l = 154 / 154 = \mathbf{1{,}0}$$

2. Determine the value of the hydraulic slope of the water surface in this section of the river:

$$\boldsymbol{i} = (H_п - H_м) / L = (227 - 219) / 8000 = \mathbf{0{,}001}$$

3. Determine the auxiliary parameter of the value of the hydraulic slope of the water surface in this section of the river Θ:

$$\boldsymbol{\Theta} = i \cdot L / H_0 = 0{,}001 \cdot 8000 / 80 = \mathbf{0{,}1}$$

4. According to Table 1.3 Determine the size coefficients:

$$\boldsymbol{A_1} = 300,\ \boldsymbol{B_1} = 60,\ \boldsymbol{A_2} = 62,\ \boldsymbol{B_2} = 29.$$

5. Determine the height of the breakthrough wave in the alignment of the object:

$$h = \frac{A_1}{\sqrt{B_1 + L}} = \frac{300}{\sqrt{60 + 8000}} \sim 3{,}3\ m$$

6. Determine the maximum velocity of the breakthrough wave in the alignment of the object:

$$V = \frac{A_2}{\sqrt{B_2 + L}} = \frac{62}{\sqrt{29 + 8000}} \sim 0{,}7\ m/s$$

7. Determine the height of flooding of the object:

$$\boldsymbol{h_{зат}} = h - h_м = 3{,}3 - 2{,}0 = \mathbf{1.3}\ m.$$

8. Determine the average flood height:

$$\boldsymbol{h_{cp}} = S_{nep} / b_{\kappa} = 162/140 = \mathbf{1,2}\ m.$$

9. Determine the average water flow rate at the flooded facility:

$$\boldsymbol{V_{cp}} = h_{зam}/h_{cp} = 1,3 / 1,2 = \mathbf{1,1}\ m/s.$$

10. According to Table 1. Figure 4 determines by interpolation the time of arrival of the breakout wave front to the object:

$$\boldsymbol{t_{фp}} = \mathbf{0.1},\ h\ (hours).$$

11. According to Table 1. determines by interpolation the time of arrival of the crest of the breakthrough wave to the alignment of the object:

$$\boldsymbol{t_{гp}} = 0,2 + (0,4-0,2)/(10-5) \cdot (8-5) = \mathbf{0.32},\ h\ (hours).$$

12. Define the auxiliary parameter *k*:

$$\boldsymbol{k} = H_0/h_0 = 80/8 = \mathbf{10}.$$

13. Table 1.4 is used to determine the auxiliary coefficient

$$\boldsymbol{\beta} = \mathbf{14}.$$

14. Determine the duration of flooding of the territory in the area of the object after the arrival of a breakthrough wave in this direction:

$$\tau = \boldsymbol{\beta} * (t_{гр} - t_{фр}) * \left(1 - \frac{h_m}{h}\right) = 14 * (0{,}32 - 0{,}1) * \left(1 - \frac{2}{3{,}3}\right) = 1{,}2\ hours$$

15. We determine the total losses among the population and their distribution into irretrievable and sanitary.

Total losses:

$$\boldsymbol{N_{loss}} = 0{,}2 * N_{зам} = 0{,}2 * 5000 = \mathbf{1000}\ people$$

Irretrievable losses among total losses:

$$\boldsymbol{N_{lossIr}} = 0{,}15 * N_{loss} = 0{,}15 * 1000 = \mathbf{150}\ people$$

Sanitary losses among total losses:

$$\boldsymbol{N_{lossSan}} = 0{,}85 * N_{loss} = 0{,}85 * 1000 = \mathbf{850}\ people$$

1.3 Reference tables required for calculations

Table 1. 3 – Coefficients for calculating the parameters of the breakout wave

$B_{відн}$	H_0, м	Value of Design Coefficients at Hydraulic Slope of Water Surface											
		i =0,0001				*i =0,0005*				*i =0,001*			
		A_1	B_1	A_2	B_2	A_1	B_1	A_2	B_2	A_1	B_1	A_2	B_2
1	20	100	90	9	7	70	50	13	10	40	18	16	21
	40	280	150	20	9	180	76	24	12	110	30	32	24
	80	720	286	39	12	480	140	52	16	300	60	62	29
0,5	20	128	204	11	11	92	104	13	23	56	51	18	38
	40	340	332	19	14	224	167	23	25	124	89	32	44
	80	844	588	34	17	544	293	43	31	320	166	61	52
0,25	20	140	192	8	21	60	200	4	33	40	38	15	43
	40	220	388	13	21	192	276	19	36	108	74	30	50
	80	880	780	23	21	560	320	41	41	316	146	61	65

Table 1. 4 – Time of arrival in hours of the crest ($t_{гр}$) and front ($t_{фр}$) of the breakthrough wave in a given target

L, m	H_0 = 20 м				H_0 = 40 м				H_0 = 80 м			
	i =0,001		*i =0,0001*		*i =0,001*		*i =0,0001*		*i =0,001*		*i =0,0001*	
	$t_{фр}$	$t_{гр}$	$t_{фр}$	$t_{гр}$	$t_{фр}$	$t_{гр}$	$t_{фр}$	$t_{гр}$	$t_{фр}$	$t_{гр}$	$t_{фр}$	$t_{гр}$
5000	0,2	1,8	0,2	1,2	0,1	2,0	0,1	1,2	0,1	0,2	0,1	1,1
10000	0,6	4,0	0,6	2,4	0,3	3,0	0,3	2,0	0,1	0,4	0,2	1,7
20000	1,6	7,0	2,0	5,0	1,0	6,0	1,0	4,0	0,4	1,0	0,5	3,0
40000	5,0	14	4,0	10	3,0	10	2,0	7,0	1,0	2,0	1,2	5,0
80000	13	30	11	21	8,0	21	6,0	14	3,0	4,0	3,0	9,0

Table 1.5 – Time calculation coefficient when the territory is flooded by a breakthrough wave

$\boldsymbol{\Theta}$	Value at the height of the dam in proportions of the average depth of the river in the downstream $\boldsymbol{\beta}$	
	k=10	*k=20*
0,05	15,5	18,0
0,1	14,0	16,0
0,2	12,5	14,0
0,4	11,0	12,0
0,8	9,5	10,8
1,6	8,3	9,9
3,0	9,9	9,6
5,0	7,6	9,3

TOPIC 2

PREDICTIVE ASSESSMENT OF POLLUTION OF OPEN WATER SOURCES BY EMERGENCY CHEMICALLY HAZARDOUS SUBSTANCES (CHS) IN EMERGENCY SITUATIONS

2.1. Individual tasks

The goal is *to master the practical skills of calculating* the *pollution of open water sources with chemically hazardous substances in emergency situations*.

It is necessary to calculate the forecast estimates of river pollution in the event of an emergency discharge of CHS into them, namely:

a) preparation of initial data;

b) determination of the main characteristics of pollution:

- time of approach of the pollution zone with the maximum concentration of HCP to a given site;
- maximum value of CHS concentration in the river pollution zone;
- duration of passage of high (extremely high) concentrations of HCP in a given section of the river.

At the location with the coordinates of $X_{скид}$, $Y_{скид}$, there was a spill to the chemically hazardous substances (CHS) river with a volume of W and a concentration of C_a and lasted for time t_o.

The information required for the calculations is given in Table 2.1. The abbreviations given in the table have the following abbreviations:

НСУ – rivers in extremely favorable conditions;

СУТ - rivers in favorable flow conditions;

ВСУ – rivers in relatively favorable conditions;

ВЧР – are rivers with relatively clean beds.

winter1 – the first 10 days after the freeze-up;

winter2 – 10th-20th day after freeze-up;

winter3 – 20th-60th day after freeze-up;

winter4 – 60th-80th day after freeze-up;

spring – is the 80th-110th day after the freeze-up.,

Table 2.1 - Initial data for calculations

Вар	***Name CHS***	$X_{скид}$	$Y_{скид}$	$X_{ств}$	$Y_{ств}$	***H, м***	***W, м^3***	***t_o, h***	***L, кm***	***C_a, mg/l***	***$T_в$, ^0C***	***Time Year***	***River beds***
1	Petrol	5040800	1264000	5043666	1260800	1,3	32	1,1	4,8	700	20	summer	НСУ
2	Petrol	5040800	1264000	5044000	1260333	1,3	92	0,8	5,7	700	2	Winter1	НСУ
3	Petrol	5040800	1264000	5044466	1259733	1,3	69	0,7	6,5	700	2	Winter2	СУТ
4	Petrol	5049600	1266000	5050800	1261200	1,3	77	1,4	6	700	2	Winter3	СУТ
5	Petrol	5049600	1266000	5050660	1260000	1,3	83	1,5	7,4	700	2	Winter4	ВСУ
6	Petrol	5049600	1266000	5050800	1258000	1,3	92	1,2	9,8	700	5	spring	ВЧР
7	Phenol	5040800	1264000	5043666	1260800	1,3	20	1,1	4,8	1030	20	summer	НСУ
8	Phenol	5040800	1264000	5044000	1260333	1,3	9	0,7	5,7	1030	2	Winter1	НСУ
9	Phenol	5040800	1264000	5044466	1259733	1,3	11	0,8	6,5	1030	2	Winter2	СУТ
10	Phenol	5049600	1266000	5050800	1261200	1,3	25	0,9	6	1030	2	Winter3	СУТ
11	Phenol	5049600	1266000	5050660	1260000	1,3	29	1	7,4	1030	2	Winter4	ВСУ
12	Phenol	5049600	1266000	5050800	1258000	1,3	30	0,6	9,8	1030	5	spring	ВЧР
13	Lead ions	5040800	1264000	5043666	1260800	1,3	40	1,1	4,8	400	20	summer	НСУ
14	Lead ions	5040800	1264000	5044000	1260333	1,3	56	1,2	5,7	400	2	Winter1	НСУ
15	Lead ions	5040800	1264000	5044466	1259733	1,3	200	1,3	6,5	400	2	Winter2	СУТ
16	Lead ions	5049600	1266000	5050800	1261200	1,3	50	1,4	6	400	2	Winter3	СУТ
17	Lead ions	5049600	1266000	5050660	1260000	1,3	60	1,5	7,4	400	2	Winter4	ВСУ
18	Lead ions	5049600	1266000	5050800	1258000	1,3	70	1,6	9,8	400	5	spring	ВЧР
19	Chlorobenzene	5040800	1264000	5043666	1260800	1,3	8	1,5	4,8	1110	20	summer	НСУ
20	Chlorobenzene	5040800	1264000	5044000	1260333	1,3	105	0,8	5,7	1110	2	Winter1	НСУ
21	Chlorobenzene	5040800	1264000	5044466	1259733	1,3	32	1,1	6,5	1110	2	Winter2	СУТ
22	Chlorobenzene	5049600	1266000	5050800	1261200	1,3	44	1,2	6	1110	2	Winter3	СУТ
23	Chlorobenzene	5049600	1266000	5050660	1260000	1,3	28	1,3	7,4	1110	2	Winter4	ВСУ
24	Chlorobenzene	5049600	1266000	5050800	1258000	1,3	39	0,9	9,8	1110	5	spring	ВЧР
25	Dichloroethane	5040800	1264000	5043666	1260800	1,3	7	1,2	4,8	1250	20	summer	НСУ
26	Dichloroethane	5040800	1264000	5044000	1260333	1,3	41	0,8	5,7	1250	2	Winter1	НСУ
27	Dichloroethane	5040800	1264000	5044466	1259733	1,3	22	1,1	6,5	1250	2	Winter2	СУТ
28	Dichloroethane	5049600	1266000	5050800	1261200	1,3	26	1,2	6	1250	2	Winter3	СУТ
29	Dichloroethane	5049600	1266000	5050660	1260000	1,3	18	1,3	7,4	1250	2	Winter4	ВСУ
30	Dichloroethane	5049600	1266000	5050800	1258000	1,3	15	1,2	9,8	1250	5	spring	ВЧР

2.2 Example of the task

To assess the situation during the destruction of the dam, it is necessary to prepare initial data, form a table of initial data and determine the main characteristics of pollution

2.2.1 Preparation of initial data.

We record the initial data given in Table 2.1, namely:

1. The coordinates of the CHS drop site are $X_{скид}$ = 5049600, $Y_{скид}$ =1266000.

2. The coordinates of the water intake site are

$$X_{ств} = 5050800, \quad Y_{ств} = 1258000.$$

3. The name of CHS is - ***gasoline***.

4. Emergency Discharge Volume $W = 92\ м^3$.

5. Emergency reset time $\boldsymbol{t_o}$ = 1.2 hours.

6. The concentration of CHS in the emergency discharge C_a = 700 mg/l.

7. Water temperature $T_в = 5\ ^0C$.

8. The season is **- spring**.

9. The characteristic of the riverbed is ***rivers with relatively clean beds***.

10. The average depth of the river section H = 1,3 м.

We put preliminary information about the reset on the map (Fig. 2.1), namely:

- mark in accordance with the specified coordinates the place of CHS discharge and the place of water intake (with bold red dots);

- apply a conventional sign of the discharge site (in black, the side of the square of the conventional sign – 1,5 см) and make an explanatory inscription in the form of a fraction next to it in black (in the numerator – the name of the CHS, in the denominator – the volume of the emergency discharge W and the time of the emergency discharge $\boldsymbol{t_o}$);

- apply the conventional sign of the water intake site (in black, the side of the square of the conventional sign – 1,5 см, the side of the equilateral triangle of the conventional sign – 1,5 см) and leave free space near it for explanatory inscription;

- the distance along the river between the marked points is boldly given in blue.

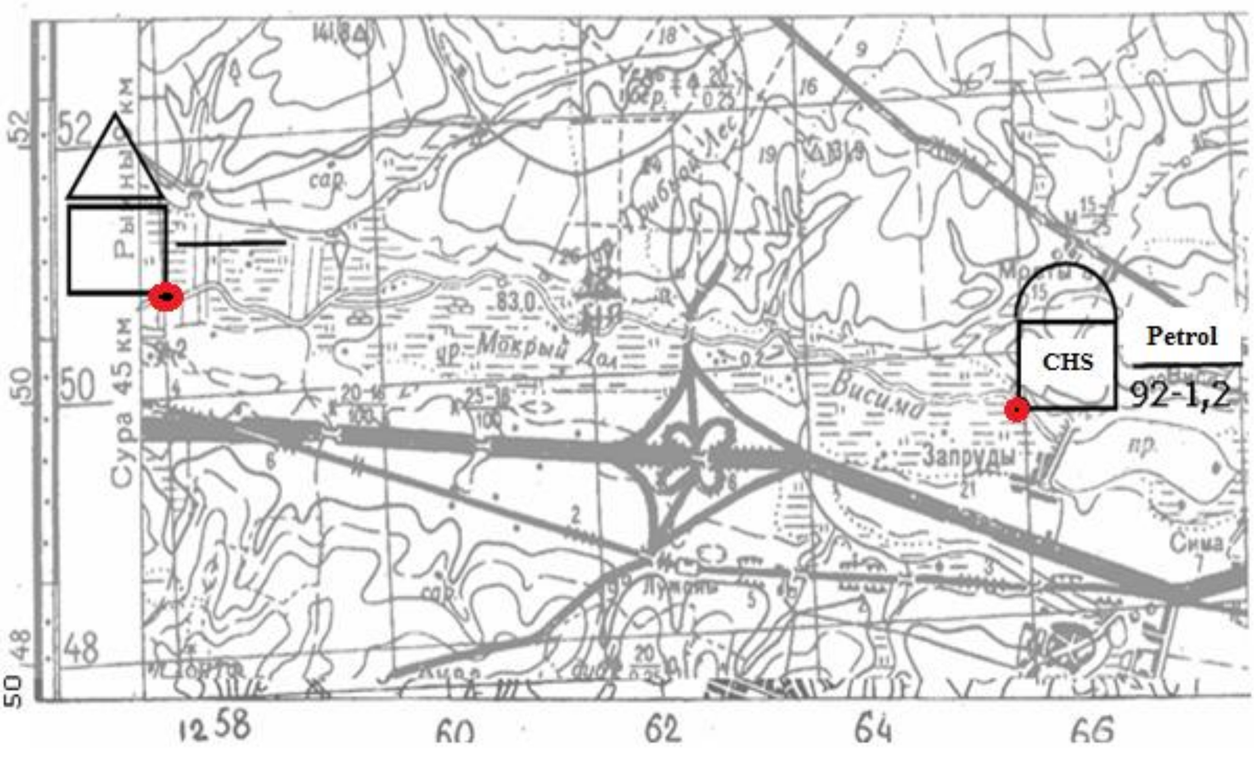

Figure. 2.1 Mapping Preliminary Pollution Information

Additionally, we determine:

11. The length of the section L = 9,8 кm.

12. Average width of area B = 18 m.

13. The average velocity of the river flow in a given section is V = 0.2 m/s.

14. Coefficient of roughness for open channel $n_ш = 0,04$ (Table2.2);

Coefficient of roughness of the lower ice surface $n_л = 0,025$ (Table2.3);

15. Coefficient of longitudinal variance (reduced) (by interpolation):

$D_n = 17,17+(18,37-17,17)/(2-1) \cdot (1,3-1)=17,53$ m (Table 2.5).

16. Self-purification coefficient of **CHS** K = 0.06 1/day (Table 2.6).

17. MPC_B **CHS** MPC = 0.1 mg/l (Table 2.7).

18. The coefficient that takes into account the evaporation of **CHS** in the initial period of displacement with water is Y=1.

2.2.2 Determination of the main characteristics of pollution

1. We calculate the time of river water from the accident site to a given alignment:

$t_д$ = 9.8 km/(3.6·0.2 m/s) = 13.6 hours.

2. We calculate the time of approach of the pollution zone with the maximum concentration of **CHS** to a given section of the river:

$$t_{max} = 13.6 \text{ hours} + 1.2 \text{ hours} /2 = 14.2 \text{ hours.}$$

3. Determine the flow rate of CHS entering the river:

$$q = 92\ м^3 \cdot 1/3600 \cdot 1,2 \text{ hours} = 0,031\ м^3/\text{s}.$$

4. Determine the flow rate of water in the river above the place of discharge of CHS:

$$Q = 0,2\ м/s \cdot 18\ м \cdot 1,3\ м = 4,68\ м^3/\text{s}.$$

5. Determine the coefficient that takes into account the mixing of CHS in the mass of the water flow (Table 2.8):

j = 0.8

6. Determine the coefficient that takes into account the transverse dispersion of CHS in the river:

$$J = 0,031\ м^3/s /(0,8 \cdot 4,68\ м^3/s + 0,031\ м^3/s) = 0,0081.$$

7. Determine the coefficient of longitudinal variance (actual):

$$D = 17,53\ м \cdot 0,2\ м/s = 3,51\ м^2/s.$$

8. Define the Z parameter:

$$Z = 3.51\ m^2/s \cdot (14.2\ \textit{hours}\ /6) \cdot 0.2\ m/s \cdot 1.2\ \textit{hours} = 1.99.$$

9. Determine the coefficient that takes into account the longitudinal dispersion of CHS in the river:

$$S = 1 \text{ because } Z<3 .$$

10. Determine the coefficient that takes into account the non-conservatism of the NHR:

$$e = \exp(-(0.06\ 1/day \cdot 13.6\ \textit{hours}\ /24)\ ) = 0.97.$$

11. Determine the approximate maximum concentration of **CHS** in a given section of the river:

$$C_{max} = 700\ mg/l \cdot 0{,}0081 \cdot 1 \cdot 0{,}97 = 5{,}5\ \text{mg/l}.$$

12. Determine the values of high and extremely high concentrations of **CHS**:

$$C_{вк}=10 \cdot 0{,}1\ mg/l = 1\ mg/l; \qquad C_{евк}=100 \cdot 0{,}1\ mg/l =10\ mg/l.$$

Since $C_{вк} < C_{max} < C_{евк}$ *(1,0 mg/l <5,5 mg/l < 10,0 mg/l*, we use $C_{вк}$ in the calculations.

13. Determine the duration of passage of high concentrations of **CHS** in a given section of the river:

$\mathbf{T_{пк}} = t_o\ hours \cdot (1+Z)\cdot(1\text{-}1\ mg/l\ /\ C_{max}\ mg/l) = 1,2\cdot(1+1,99)\cdot(1\text{-}1\ /5,5) = \mathbf{2,92}\ hours.$

14. Determine the moment of passage of the front of the high pollution zone everywhere given area:

$$\mathbf{t_ф} = t_{max}\ hours - T_{пк}\ \ hours\ /2 = 14,2 - 2,92\ /2 = \mathbf{12,74}\ hours.$$

15. Determine the moment of passage of the tail section of the high pollution zone everywhere given area:

$$\mathbf{t_x} = t_{max}\ hours + T_{пк}\ \ hours\ /2 = 14,2 + 2,92\ /2 = \mathbf{15.66}\ hours.$$

We put information about the characteristics of pollution on the map (*Fig. 2.2*), namely: near the conventional sign of the water intake in a fraction, we write: in the numerator: C_{max} and $T_{пк}$,, in the denominator: $t_ф$ and t_x .

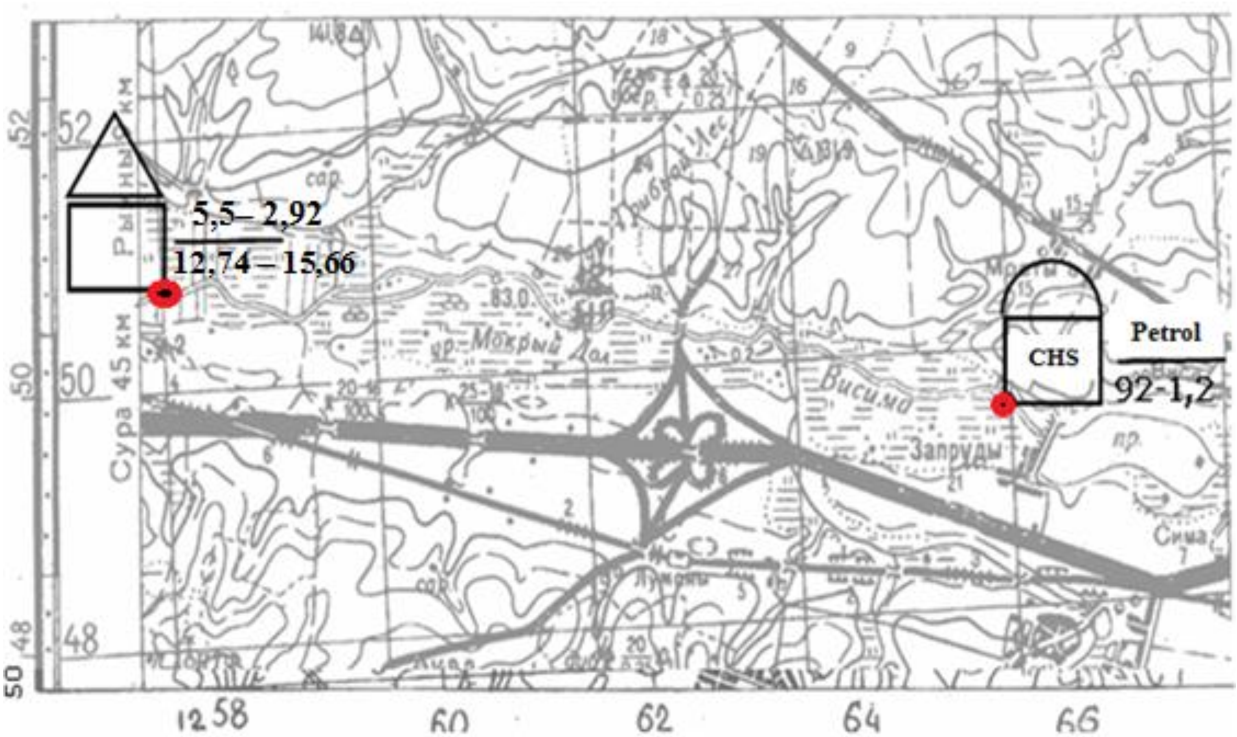

Figure. 2.2- Mapping information about pollution characteristics

2.3 Reference tables required for calculations

Table 2.2 - Roughness coefficients for open watercourse beds $n_ш$

Nature of the channel	$n_ш$
Rivers in extremely favorable conditions	0,025
Rivers in favorable flow conditions	0,030
Rivers in relatively favorable conditions	0,035
Rivers with relatively clean channels	0,040

Table 2.3- Roughness coefficients for the lower ice surface $n_л$

Freeze-up period	$n_л$
The first 10 days after the freeze-up (the first and second decade of December)	0,150
10th - 20th day after freeze-up (last decade of December and beginning of January)	0,100
20th - 60th day after freeze-up (mid-January and first decade of February)	0,050
60th - 80th day after freeze-up (end of February - beginning of March)	0,040
80th - 110th day after freeze-up (March)	0,025

Table 2.4 - Coefficients of longitudinal variance D_n , *m*

Depth, *N, m*	***Dn*** with roughness coefficient $n_ш$								
	0,025	0,030	0,035	0,040	0,050	0,067	0,080	0,100	0,133
≤1,0	2,6	4,3	6,4	9,1	16,3	35,2	56,1	100,8	213,4
2,0	3,6	5,6	8,2	11,2	18,9	37,2	59,8	101,0	215,2
3,0	4,6	7,0	10,0	13,6	22,5	42,0	63,0	105,0	220,6
4,0	5,5	8,4	12,0	16,2	26,8	50,9	74,3	118,3	225,9

Table 2.5 - Coefficients of longitudinal dispersion D_n, *m* (for conditions of ice cover)

Depth *H, m*	D_n at roughness coefficient for bottom surface ice $n_л$							
	0,010	0,015	0,025	0,030	0,040	0,050	0,100	0,150
$n_ш$ = 0.025								
1,0	3,12	4,21	7,70	10,23	17,29	27,59	155,78	499,43
2,0	3,91	5,15	8,92	11,54	18,49	28,02	126,33	336,66
$n_ш$ = 0.030								
1,0	4,79	6,12	10,21	13,10	20,97	32,20	166,77	519,46
2,0	5,79	7,24	11,51	14,41	21,96	32,12	133,90	347,81
$n_ш$ = 0.035								
1,0	7,00	8,59	13,34	16,62	25,38	37,65	179,26	542,04
2,0	8,19	9,85	14,65	17,84	26,02	36,86	142,39	360,27
$n_ш$ = 0.040								
1,0	9,84	11,71	17,17	20,88	30,61	43,99	193,29	567,13
2,0	11,14	13,03	18,37	21,87	30,71	42,27	151,81	374,00

Table 2.6 - Approximate values of self-purification coefficients of watercourse water from some CHS ***K, 1/day***

CHS	***K*** at water temperature		
	>15 ^{0}S	**10 -15 ^{0}S**	**<10 ^{0}S**
Ammonia	2,7	1,8	0,9
Petrol	2,4	0,15	0,06
Petroleum products	0,3	0,2	0,02
Phenols	0,6	0,4	0,2
Formaldehyde	3,0	2,1	0,6

Table 2.7 - Maximum permissible concentrations of some CHSs in watercourses and reservoirs of drinking water use ***MPC_B , mg/l***

CHS	***MPC_B***	CHS	***MPC_B***
Petrol	0,1	Mercury (in non-organic sp.)	0,0005
Benzene	0,5	Hydrogen sulfide	1,0
Hydrazine hydrate	0,01	Lead (in non-org. sp.)	0,03
Dichloroethane	0,02	Toluene	0,5
Kerosene Tech.	0,01	Phenol	0,001
Methanol	3,0	Formaldehyde	0,05
Oil	0,3	Furfural	1,0
Acetic acid	1,0	Chlorobenzene	0,02

Table 2.8 - Approximate values of *the* ***j*** coefficient for watercourses

Distance from the place of emergency discharge to the specified alignment, km	***j*** at water flow *rate* ***Q***, m^3/s		
	<10	10 - 100	>100
Up to 20	0,8	0,5	0,2
21 30	1,0	0,7	0,3

Table 2.9 - Approximate values of the ***Y*** coefficients, which take into account the evaporation of some boiling CHSs in the initial period of their mixing with water

CHS	***Y*** value at water temperature		
	0 ^{0}S	10 ^{0}S	20 ^{0}S
Ammonia	0,77	0,56	0,42
Methylamine	0,10	0,09	0,08
Hydrogen sulfide	0,25	0,20	0,15
Formaldehyde	0,73	0,71	0,68

TOPIC 3

DETERMINATION OF THE NECESSARY PERSONAL PROTECTIVE EQUIPMENT, DEGASSING SUBSTANCES AND THE NUMBER OF EMPLOYEES TO PERFORM EMERGENCY RESCUE OPERATIONS IN CONDITIONS OF NH INFECTION

3.1. Individual tasks

The goal is to *master the skills of calculating the necessary personal protective equipment, degassing substances and the number of employees to perform emergency rescue operations (ERO) in the conditions of CHS infection*

The work manager needs to organize *ERO* in the conditions of *CHS* contamination in three zones of the area – A, B, C.

To do this, perform the following tasks (task options are given in Table 3.1), namelyin the definition for each zone:

– personal protective equipment;

– degassing substance;

– percentage of decrease in labor productivity $K_{зн}$, *%*;

– specified labor costs $T_{уточн}$, *person -hours*;

– number of rescuers $N_{рят}$, *people.*

Table 3.1 – Task Options

Var	Zone A			Zone B			Zone C		
	CHS	T_{A}, *person - hours*	t_{A}, *hours*	*CHS*	$T_{Б}$, *person -hours*	$T_{Б}$, *hours*	*CHS*	$T_{В}$, *person -hours*	$T_{В}$, *hours*
1	Cl_2	110	6	SO_2	87	5	HCN	221	4
2	NH_3	120	3	Cl_2	94	4	SO_2	215	5
3	CS_2	130	5	NH_3	101	3	HCN	209	6
4	Cl_2	140	4	HCN	108	6	NH_3	203	3
5	NH_3	150	6	CS_2	115	5	SO_2	197	4
6	CS_2	160	3	SO_2	122	4	HCN	191	5
7	Cl_2	170	5	NH_3	129	3	SO_2	185	6
8	NH_3	180	4	SO_2	136	6	HCN	179	3
9	CS_2	190	6	HCN	143	5	NH_3	173	4
10	Cl_2	200	3	CS_2	150	4	SO_2	167	5
11	NH_3	210	5	SO_2	157	3	HCN	161	6
12	CS_2	220	4	Cl_2	164	6	SO_2	155	3
13	Cl_2	230	6	NH_3	85	5	HCN	149	4
14	NH_3	240	3	HCN	89	4	NH_3	143	5
15	CS_2	250	5	Cl_2	93	3	SO_2	137	6
16	Cl_2	260	4	SO_2	97	6	HCN	131	3
17	NH_3	270	6	Cl_2	101	5	SO_2	125	4
18	CS_2	96	3	NH_3	105	4	HCN	119	5
19	Cl_2	100	5	HCN	109	3	NH_3	113	6
20	NH_3	104	4	CS_2	113	6	SO_2	156	3
21	CS_2	108	6	NH_3	117	5	HCN	153	4
22	Cl_2	112	3	HCN	121	4	SO_2	150	5
23	NH_3	116	5	CS_2	125	3	HCN	147	6
24	CS_2	120	4	SO_2	129	6	NH_3	144	3
25	Cl_2	124	6	NH_3	133	5	SO_2	141	4
26	NH_3	128	3	Cl_2	137	4	HCN	138	5
27	CS_2	132	5	HCN	141	3	SO_2	135	6
28	Cl_2	136	4	CS_2	145	6	HCN	132	3
29	NH_3	140	6	SO_2	149	5	HCN	129	4
30	CS_2	144	3	Cl_2	153	4	SO_2	126	5

Note: Cl_2 – chlorine ; NH_3 - ammonia; CS_2 - carbon disulfide; SO_2 – sulphurous anhydrite; HCN – hydrocyanic acid.

3.2 Example of the task

To complete the task, it is necessary to form a table of the initial data of the object (Table 3.2).

Table 3.2 – Imprint

Parameter name, designation, and dimension		Value
Zone A	The name of the NHR with which the area is contaminated	Chlorine
	Labor costs for the implementation of *ERO* T_A, *person -hours*	110
	Duration of change t_A, *hours*	6
Zone B	The name of the NHR with which the area is contaminated	Ammonia
	Labor costs for the implementation of *ERO* T_B *person -hours*	100
	Duration of change t_B, *hours*	5
Zone C	The name of the NHR with which the area is contaminated	Carbon disulfide
	Labor costs for the implementation of *ERO* T_C, *person -hours*	130
	Duration of change t_C, *hours*	4

Calculation

1. Determine for zone A:

1.1 Required personal protective equipment (PPE) according to Table 3.3:

civilian gas masks CP-5, 7, or industrial gas masks with boxes V, G, KD, BKF, M, SO

1.2 Degassing substance according to Table 3.4: ***Slaked Lime***.

1.3 Percentage of decrease in labor productivity $K_{зн(A)},$, % according to Table 3.5.

$$K_{зн(A)}, = 30\%.$$

1.4 Specified Labor Costs:

$$T_{уточн(A)} = T_A + T_A \cdot K_{зн(A)}/100 = 110+110 \cdot 30 /100 =143 \text{ person -hours}$$

1.5 Number of rescuers:

$$N_{рят(A)} = T_{уточн(A)}/ t_A = 143 /6 \approx 24 \text{ people.}$$

2. Determine for zone B:

2.1 Required personal protective equipment (PPE) according to Table 3.3:

DP-2 with FPC gas masks CP-5, 7, or industrial gas masks with boxes TS, KD, M, SO.

2.2 Degassing substance according to Table 3.4: **Water**.

2.3 Percentage of decrease in labor productivity $K_{зн(B)},$ % according to Table 3.5:

$$K_{зн(B)} = 25\%.$$

2.4 Specified Labor Costs:

$$T_{уточн(B)} = T_B + T_B \cdot K_{зн(B)}/100 = 100+100 \cdot 25/100 =125 \text{ person- people}$$

2.5 Number of rescuers:

$$N_{рят(B)} = T_{уточн(B)} / t_B = 125 / 5 = 25 \ \ = 125 \ people.$$

3. Determine for zone C:

3.1 Required personal protective equipment (PPE) according to Table 3.3:

civilian gas masks CP-5.7, or industrial gas masks with boxes V, G, KD, BKF, M, SO.

3.2 Degassing substance according to Table 3.4:

Sodium sulfide or Potassium.

3.3 Percentage of decrease in labor productivity $K_{зн(C)}, \%$ according to Table 3.5:

$$K_{зн(C)} = 20\%.$$

3.4 Specified Labor Costs:

$$T_{уточн(C)} = T_C + T_C \cdot K_{зн(C)}/100 = 130 + 130 \cdot 20/100 = 156 \ \ person\text{-} \ people$$

3.5 Number of rescuers:

$$N_{рят(C)} = T_{уточн\ (C)} / t_C = 156 / 4 \ hours = 39 \ people.$$

3.3 Reference tables required for calculations

Table 3.3 – Brands of gas masks

CHS	Brands of gas masks
Ammonia	TS, KD, M, SO, DP-2 with FPC gas masks CP-5, 7
Hydrocyanic acid	A, V, G, E, CD, BKF, M, SO, CP-5, 7
Carbon disulfide	V, G, CD, BKF, M, SO, CP-5, 7
Chlorine	V, G, CD, BKF, M, SO, CP-5, 7
Sulfur dioxide	V, BKF, CP-5, 7

Table 3.4 – Degassing substances

CHS	Degassing solutions
Ammonia	Water
Hydrocyanic acid	Alkalis, ammonia water
Carbon disulfide	Sodium sulfide or potassium
Chlorine	Slaked lime
Sulfur dioxide	Slaked lime, ammonia water.

Table 3.5 – Decrease in labor productivity, % in protective equipment

Shift duration, hours	Decrease in labor productivity, % in protective equipment	
	Gas mask	Gas mask and Protective suit
1	5	10
2	10	20
3	15	30
4	20	40
5	25	45
6	30	50

TOPIC 4

METHODOLOGY FOR CALCULATING THE REQUIRED NUMBER OF VEHICLES AND WATERCRAFT FOR EVACUATION OF THE POPULATION FROM THE FLOOD ZONE

4.1. Individual tasks

Goal: to master the skills of calculating the *required number of vehicles and watercraft for the evacuation of the population from the flood zone*

According to the scenario, there was an accident at a hydraulic structure. As a result of damage to the dam, the area inhabited by civilians was flooded.

It is necessary to calculate the required number of vehicles and watercraft for the evacuation of the population from the flood zone in accordance with the provisions of this Convention.

Table 4. 1 The following abbreviations are adopted:

ПЗ – watercraft;

ТЗ – vehicle;

d – equipped with an engine;

V – on oars.

Attention! *When performing calculations, all final values must be rounded to the highest integer.*

Table 4. 1 – Task Options

Parametrs	Options									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
$T_{ЛПР}^{вр}$, hours	18	19	20	21	22	23	24	18	19	20
ПЗ №1	PTS-2	DL-10-d	NL-5-d	NL-8-d	PTS-2	DL-10-v	NL-5-v	NL-8-v	PTS-2	DL-10-d
ПЗ №2	DL-10-d	NL-5-d	NL-8-d	PTS-2	DL-10-v	NL-5-v	NL-8-v	PTS-2	DL-10-d	NL-5-d
$R_{ПЗ}$, м	500	300	350	400	280	500	350	350	400	280
$T_{ПЗ}^{евак}$, min.	100	110	120	130	140	150	160	180	100	110
$T_{ТЗ}^{евак}$, min.	120	130	140	150	160	180	100	110	100	110
$k_{ПЗ}$	1,1	1,15	1,2	1,25	1,1	1,15	1,2	1,25	1,1	1,15
$N_{ПЗ1}^{нас}$, people	500	250	100	90	220	230	110	95	210	115
$N_{ПЗ1}^{нас}$, people	250	100	90	220	230	110	95	210	260	115
ТЗ №1	Ruta 23	Ruta 18	"Etalon"	Bogdan – A091	Bogdan – A301	Bogdan – A069	"Etalon"	Bogdan – A091	Ruta 23	Ruta 18
ТЗ №2	Etalon"	Ruta 23	Bogdan – A091	Etalon"	Bogdan – A069	Bogdan – A301	Ruta 18	"Etalon"	Bogdan – A091	Bogdan – A069
$N_{ТЗ1}^{нас}$, people	180	190	200	210	220	180	190	200	210	220
$N_{ТЗ2}^{нас}$, people	250	240	230	220	225	250	240	230	220	225
$T_{ТЗ1}^{рейс}$, hours	2	2,5	3	3,5	2	2,5	3	3,5	3	3,5
$T_{ТЗ2}^{рейс}$, hours	2,2	3	3,5	2	2	3,5	2,5	2,5	3	2,2

4.2 Example of the task.

4.2.1 Data preparation

To prepare for the calculations, we form a table of output data (Table 4.2) according to its variant (Table 4.1). For example, the information already included in the table is the same for all variants.

Table 4. 2 – Table Form to Record Output Data

Parameter name, designation, and dimension	Value
Name of watercraft No. 1	PTS-2
Name of watercraft No. 2	DL-10-v
Length of the evacuation route by watercraft $R_{ПЗ}$, *m*	280
Water flow velocity **V** $\mathbf{V_{ВП}}$ = 1 m/s	1
Duration of evacuation by watercraft $T_{ПЗ}^{евак}$, *min*	140
Watercraft utilization rate $k_{ПЗ}$	1.1
Population for evacuation by the 1st type of watercraft $N_{ПЗ1}^{нас}$, *people*	220
Population for evacuation by the 2nd type of watercraft $N_{ПЗ2}^{нас}$, *чол, people*	230
Vehicle Name No. 1	Bogdan – A091
Vehicle Name No.2	Etalon"
Population for evacuation by the 1st type of vehicle $N_{ТЗ1}^{нас}$, *people*	180
Population for evacuation by the 2nd type of vehicle $N_{ТЗ2}^{нас}$, *people*	250
Duration of evacuation by vehicles $T_{ТЗ}^{евак}$, *min.*	160
Duration of the trip of the 1st type of vehicle $T_{ТЗ1}^{рейс}$, *hours*	2.5
Duration of the trip of the 2nd type of vehicle $T_{ТЗ2}^{рейс}$, *hours*	3.5
Time of day coefficient $\mathbf{k_{чд}}$ *д*	1.5
Coefficient of underwater conditions $\mathbf{k_{пу}}$ *у*	1.25

The following abbreviations are adopted:

ПЗ – watercraft; ТЗ – vehicle; d – equipped with an engine; V – on oars.

4.2.2 Settlement procedure.

1. For the 1st type of watercraft according to Table 4.3 determine:

Table 4. 3 – Characteristics of watercraft of rescue formations

№ Salary	**Name of characteristics**	**Boats**			
		PTS-2	*DL-10*	*NL-5*	*NL-8*
1.	Capacity, people	**75**	25	5	8
2.	Speed, m/min.: with outboard engine Paddleboarding:	**283** -	200 83	133 67	116 50
3.	Time required for loading and unloading, minutes	**30**	22	13	16

1.1 Watercraft velocity $V_{П31}$, $m \cdot min^{-1}$. **$V_{П31}$ = 283** m/min

1.2 Time for loading (unloading) the watercraft $t_{П31}$, *min.* **$t_{П31}$** = ***30*** *min*

1.3 Watercraft capacity $M_{П31}$, *· people.* **$M_{П31}$** = ***75*** *people*

2. Determine the duration of the voyage of the 1st watercraft:

$$Т_{П31}^{рейс} = \frac{2 * R_{П3}}{V_{П31}}(1 + 0,3 * V_{ВП}) + t_{П31} =$$

$$= \frac{2 * 280}{283}(1 + 0,3 * 1) + 30 = 32,57\ min$$

3. Determine the number of watercraft of the 1st type for evacuation of the population from the flood zone:

$$N_{П31} = \frac{N_{П31}^{нас} * Т_{П31}^{рейс}}{M_{П31} * Т_{П3}^{евак}} * k_{П3} * k_{чд} * k_{пу} =$$

$$= \frac{220 * 32{,}57}{75 * 140} * 1{,}1 \; * 1{,}5 \quad * 1{,}25 \quad = 1{,}4$$

thus we accept a number of vehicles = **2 units**

4. For the 2nd type of watercraft according to Table 4.3 determine:

Table 4. 3 – Characteristics of watercraft of rescue formations

№ Salary	Name of characteristics	Boats			
		PTS-2	***DL-10***	*NL-5*	*NL-8*
1.	Capacity, people	75	**25**	5	8
2.	Speed, m/min.: with outboard engine Paddleboarding:	283 -	 **200** 83	 133 67	 116 50
3.	Time required for loading and unloading, minutes	30	**22**	13	16

4.1 Watercraft velocity $V_{П32}$, $m \cdot^{min-1}$. $\boldsymbol{V_{П32}} = \boldsymbol{200}$ m/min

4.2 Time for loading (unloading) the watercraft $t_{П31}$, *min.* $\boldsymbol{t_{П32}} = \boldsymbol{22}$ *min*

4.3 Watercraft capacity $M_{П32}$, · *people.* $\boldsymbol{M_{П32}} = \boldsymbol{25}$ *people*

5. Determine the duration of the voyage of the 2nd watercraft:

$$T_{П32}^{рейс} = \frac{2 * R_{П3}}{V_{П32}}(1 + 0{,}3 * V_{ВП}) + t_{П32} =$$

$$= \frac{2 * 280}{200}(1 + 0{,}3 * 1) + 22 = 25{,}64 \, min$$

6. Determine the number of watercraft of the 2nd type for evacuation of the population from the flood zone:

$$N_{П32} = \frac{N_{П32}^{нас} * Т_{П32}^{рейс}}{M_{П32} * Т_{П3}^{евак}} * k_{П3} * k_{чд} * k_{пу} =$$

$$= \frac{220 * 25{,}64}{25 * 140} * 1{,}1 * 1{,}5 * 1{,}25 = 3{,}32$$

thus we accept a number of vehicles = **4 units**

7. Determine the total number of watercraft for evacuation of the population from the flood zone:

$$N_{П3} = N_{П31} + N_{П32} = 2 + 4 = 6 \textbf{ units}$$

8. For the 1st type of vehicle according to Table 4.4 determine its m capacity M_{T31}, *people.*

Table 4.4 – Vehicle Characteristics

№ Salary	Vehicle	Capacity, people
1.	Ruta 23	23
2.	Ruta 18	18
3.	BAZ – A091 "Etalon"	26
4.	**Bogdan – A091**	**45**
5.	Bogdan – A301	41
6.	Bogdan – A069	19

$$M_{T31} = 45 \textit{ people}$$

9. Determine the required number of vehicles of the 1st type for the transportation of the affected population from the flood line to the areas of settlement:

$$N_{Т31} = \frac{N^{нас}_{Т31} * T^{рейс}_{Т31}}{M_{Т31} * T^{евак}_{ТЗ}} * k_{ПЗ} * k_{чд} * k_{пу} =$$

$$= \frac{180 * 2,5 * 60\ min}{45 * 160} * 1,1 * 1,5 * 1,25 = 7,73$$

thus we accept a number of vehicles = **8 units**

10. For the 2nd type of vehicle according to Table 4.4 determine its m capacity M_{T32}, *people.*

Table 4. 4 – Vehicle Characteristics

№ Salary	Vehicle	Capacity, people
1.	Ruta 23	23
2.	Ruta 18	18
3.	**BAZ – A091 "Etalon"**	**26**
4.	Bogdan – A091	45
5.	Bogdan – A301	41
6.	Bogdan – A069	19

$$\boldsymbol{M_{T32} = 25\ people}$$

11. Determine the required number of vehicles of the 2nd type for transportation of the affected population from the flood line to the areas of settlement:

$$N_{Т32} = \frac{N^{нас}_{Т32} * T^{рейс}_{Т32}}{M_{Т32} * T^{евак}_{ТЗ}} * k_{ПЗ} * k_{чд} * k_{пу} =$$

$$= \frac{250 * 3,5 * 60\ min}{45 * 160} * 1,1 * 1,5 * 1,25 = 15,0$$

thus we accept a number of vehicles = **15 units**

12. Determine the total number of vehicles for transportation of the affected population from the flood line to the areas of settlement:

$$N_{T3} = N_{T31} + N_{T32} = 8 + 15 = 23 \textbf{ units}$$

4.3 Reference tables required for calculations

Table 4. 3 – Characteristics of watercraft of rescue formations

№ Salary	**Name of characteristics**	**Boats**			
		PTS-2	***DL-10***	***NL-5***	***NL-8***
1.	Capacity, people	75	25	5	8
2.	Speed, m/min.: with outboard engine Paddleboarding:	283 -	200 83	133 67	116 50
3.	Time required for loading and unloading, minutes	30	22	13	16

Table 4. 4 – Vehicle Characteristics

№ Salary	**Vehicle**	**Capacity, people**
1.	Ruta 23	23
2.	Ruta 18	18
3.	BAZ – A091 "Etalon"	26
4.	Bogdan – A091	45
5.	Bogdan – A301	41
6.	Bogdan – A069	19

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