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ENVIRONMENTAL IMPACT ASSESSMENT REPORT

of the planned activity “Construction of power units 5 and 6 with AP1000 reactor unit at the Khmelnytskyi NPP site”

P.46.02/23-01-EIAR

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ACRONYMS LIST

AMS	–	aeronautical meteorological station (civil)
BDBA	–	beyond design basis accident
BDPP	–	backup diesel power plant
CA	–	controlled area
CAW	–	construction and assembly works
CDF	–	core damage frequency
ChNPP	–	Chernobyl Nuclear Power Plant
CMU	–	The Cabinet of Ministers of Ukraine
CP	–	cooling pond
CRDM	–	control rod drive mechanism
CST	–	condensate storage tank
CV	–	containment vessel
CWT	–	chemical water treatment
DE	–	design earthquake
DS	–	dead storage
DSL	–	dead storage level
Dnipro PS	–	Dnipro Power System
ECG	–	emergency crews and groups
EGP	–	exogenous geological process
EIA	–	environmental impact assessment
EPRS	–	emergency preparedness and response systems
FA	–	fuel assembly
Gy	–	Gray – unit of absorbed dose
HRO	–	high-risk object
HVL	–	high-voltage lines
I&C	–	instrumentation and control
IPS of Ukraine	–	integrated power system PS of Ukraine
JSC “NNEGC” “Energoatom”	–	Joint Stock Company National Nuclear Energy Generating Company Energoatom
KhNPP	–	Khmelnytskyi Nuclear Power Plant
LRW	–	liquid radioactive waste
MCP	–	main coolant pump
MCR	–	main control room
MDA	–	maximum design basis accident
MDE	–	maximum design basis earthquake
MEDF	–	maximum emergency discharge frequency
MPC	–	maximum permissible concentration
NF	–	nuclear fuel
NI	–	nuclear installation
NHL	–	normal headwater level
NPP	–	nuclear power plant

NPP SS	–	NPP shift supervisor
NRC	–	nuclear reactor core
NRF	–	natural reserve fund
OS	–	open switchgear
PD	–	permissible discharges
PPE	–	personal protective equipment
PR	–	permissible releases
PS	–	power system
PSA	–	probabilistic safety analysis
PSH	–	pumped-storage hydroelectricity
RF	–	reactor facility
RIG	–	radioactive inert gas
RM	–	radiation monitoring
RMG	–	radiation monitoring group
RNG	–	radioactive noble gases
RSS	–	radiation safety shop
RSSU	–	radiation safety standards of Ukraine
RW	–	radioactive waste
SA	–	supervised area
SBH	–	start-up boiler house
SERS	–	site emergency response supervisor
SG	–	steam generator
SHDA	–	seismic hazard deterministic analysis
SNF	–	spent nuclear fuel
SP	–	spray pool
SPZ	–	sanitary protection zone
SRW	–	solid radioactive waste
SRWS	–	solid radioactive waste system
SS	–	separate subdivision
Sta	–	stake (marking measure, distance between stakes is of 100 m)
SUNPP	–	South Ukrainian Nuclear Power Plant
Sv	–	Sievert – unit of equivalent and effective dose
US	–	The United States of America
WCR	–	water and chemical regime

INTRODUCTION

The necessity of new nuclear power units' construction to replace NPP capacity that will be decommissioned after 2030 was determined by the Energy Strategy [1, 2].

On August 31, 2021, in Washington, D.C., with the participation of President of Ukraine Volodymyr Zelenskyy, Energoatom CEO Petro Kotin and Westinghouse CEO Patrick Fragman signed a Memorandum of Understanding (hereinafter referred to as the Memorandum) [3], which provides for the construction of five new nuclear power units using AP1000 technology in Ukraine.

The pilot project is the construction of two new AP1000 power units at the Khmelnytskyi NPP site. On June 2, 2022, an Agreement was signed at the KhNPP site to start the practical implementation of a joint project between NNEGC Energoatom and Westinghouse Electric Company for the construction of AP1000 power units at the KhNPP site.

In accordance with the Law of Ukraine "On Environmental Impact Assessment" [4], the environmental impact assessment is mandatory in the decision-making process for the implementation of planned activity. The construction of NPPs is subject to the EIA procedure along with the assessment of transboundary environmental impacts, including the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention).

The EIA is conducted to identify and describe environmental factors that are likely to be affected by the planned activity, including public health, socio-economic conditions, fauna, flora, biodiversity, soil, water, etc., and to assess all possible significant environmental and social impacts of the proposed project.

The main methodological approach and content of the study were determined by Ukrainian legislation, primarily the Law of Ukraine "On Environmental Impact Assessment" [4], which establishes the legal and organizational framework for the EIA, as well as the Order of the Ministry of Environment [5].

In preparing the EIA report, scientific literature, official reports and Internet information have been also used.

The measures to prevent, avoid, reduce, eliminate a significant adverse environmental impact, including (if possible) compensatory measures are developed in case of significant potential impacts. These measures are also aimed at enhancing the potentially favorable effects of the project implementation.

The EIA also includes monitoring and control activities regarding the environmental impacts during the implementation of the planned activity.

1 THE PLANNED ACTIVITY DESCRIPTION

The Environmental Impact Assessment Report has been developed in accordance with the requirements of paragraph 2 of Article 6 of the Law of Ukraine "On Environmental Impact Assessment" [4] in compliance with environmental, sanitary and hygienic, fire protection, urban planning and territorial restrictions in accordance with current regulatory documents.

According to paragraph 2 of part 2 of Article 3 of the Law of Ukraine "On Environmental Impact Assessment", the project object - "Construction of power units 5, 6 with the AP1000 reactor unit at the KhNPP site" – belongs to the first category of planned activity and facilities that may have a significant impact on the environment and are subject to environmental impact assessment.

The planned activity is the construction of power units No. 5 and No. 6 at the KhNPP site using the technical characteristics of the AP1000 reactor unit of the Westinghouse Electric Company for further operation and electricity generation. The AP1000 is a proven Generation III+ reactor with passive safety systems, modular standard design, high availability and load monitoring capability licensed by the U.S. Nuclear Regulatory Commission (NRC).

1.1 Description of the location of the planned activity

New construction of power units No. 5, 6 with AP1000 reactor at the KhNPP site in Netishyn, Netishyn City Territorial Community, Shepetivka District, and Khmelnytskyy Region.

[redacted]

The KhNPP site is located in the northwest of Slavuta district of Khmelnytskyy region of Ukraine, 18 km west of the district center of Slavuta, 100 km north of the regional center of Khmelnytskyy, near Netishyn (NPP town).

The KhNPP site and the boundaries of its observation area are shown in Fig. 1.1.

The KhNPP supervised area includes the territories of Khmelnytskyy region (lands of Izyaslav, Slavuta, Bilohirsk and Shepetivka districts) and Rivne region (lands of Ostroh, Hoshcha and Zdolbuniv districts).

Currently, power units 1 and 2 are in operation at the plant. The planned activity envisages the placement of power units No. 5 and No. 6 on the territory of the operating KhNPP (preliminary designated location).

The area of the main industrial site of the NPP (fenced) is 90.2 hectares. The area of the land plot allocated for the main site, ISP-110, ISP-330, ISP-750 and the supply and discharge canals between the main site and the ISP territory is 147.0804 hectares. The site is located within the lands of Netishyn City Council and Slavuta State Forestry. [redacted]

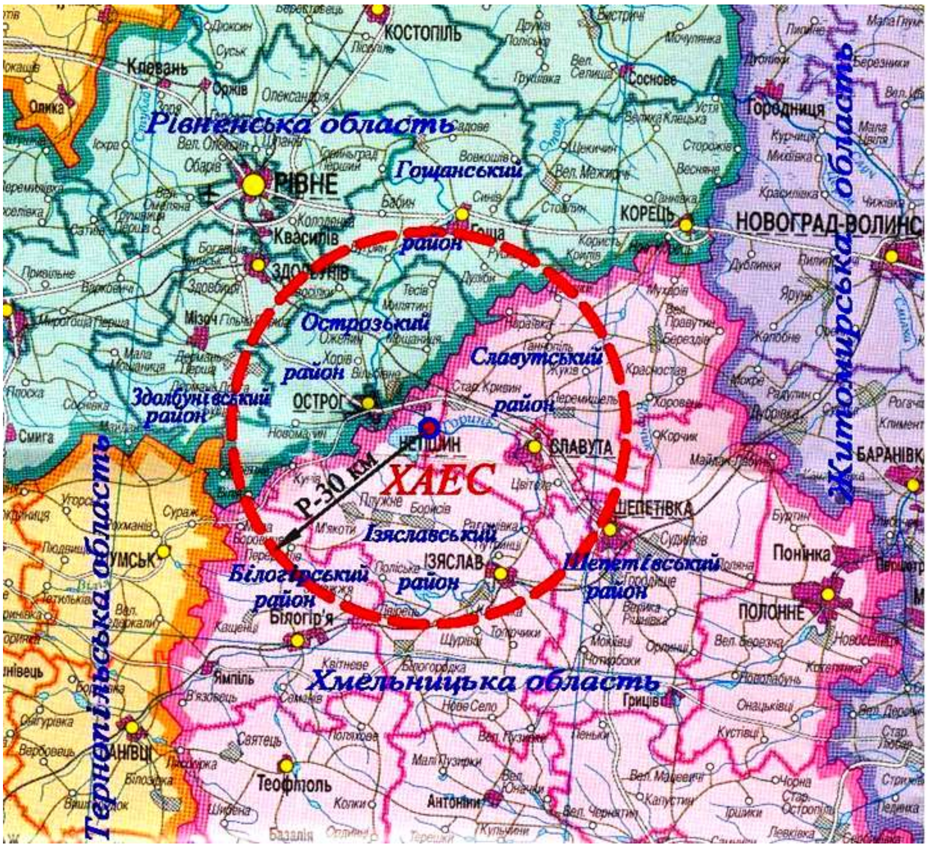


Figure 1.1 – Khmelnytskyi NPP location

Measures related to the disposal, reclamation and compensation of land acquisition costs were implemented during the commissioning of Unit 1. It should be noted that the previously allocated lands were characterized as low-productive for agricultural production.

The sufficiency of the land allocated for the placement of power units 5 and 6 and a set of facilities for their maintenance will be determined during the development of the working project "Construction of KhNPP Units 5 and 6".

The KhNPP site area has a well-developed network of roads and railways.

[redacted]

[redacted]

[redacted]

[redacted]

There is no water transport.

There are 47 protected areas of varying degrees of protection on the territory of KhNPP, with an area of more than 3000 hectares. Seven of the 47 protected areas have the status of national importance, and the other 40 are of local importance. According to the Decree of the President of Ukraine [6], the Small Polissia National Nature Park was established in Khmelnytskyy Oblast. River valleys and the Netishyn cooling pond conditionally lay out the boundaries of the national park (about 8762.7 hectares). In the north, there is the Goryn River and the cooling pond; in the east, the Goryn River; in the northwest, the Vilia River; in the south, the tributaries of the Goryn River and the Vilia River. Most of the southern and southeastern zone of the NPP is included in the territory of the mentioned national park.

1.2 Objectives of the planned activity

The objective of the planned activity is the construction of power units 5 and 6 with the AP1000 reactor unit at the KhNPP site.

The planned activity means the construction of power units No. 5 and No. 6 at the KhNPP site using the technical characteristics of the AP1000 type reactor plant of the Westinghouse Electric Company for the purpose of further operation and generation of electricity.

In accordance with the law, the decision to carry out this planned activity will be made after the Verkhovna Rada adopts the Law of Ukraine "On Siting, Design and Construction of Khmelnytskyy NPP Units 5 and 6".

1.3 Description of the characteristics of the activity during preparatory and construction works and implementation of the planned activity, including (if necessary) dismantling works, and the need (restrictions) on the use of land plots during preparatory and construction works and implementation of the planned activity

The preparatory and construction works were characterized in terms of the location, duration, content, fixed assets and work technologies, planned temporary structures, transport and utility networks, natural resource requirements, management of construction and other solid waste, as well as liquid waste, compliance with air quality standards (hygiene standards) and maximum permissible noise levels in relation to the nearest residential development [5], taking into account the relevant regulations [7, 8].

1.3.1 Worksite

The KhNPP site is located in Shepetivka district of Khmelnytskyy region on the left bank of the Goryn River. The town of Netishyn is located to the north of the site [redacted]. To the northwest of the site [redacted] is the city of Rivne (regional center of Rivne oblast). [redacted]

The construction site of KhNPP Units 5 and 6 was selected on the territory adjacent to the existing KhNPP industrial site. [redacted] The KhNPP site area and the boundaries of its supervised areas are shown in Figure 1.1.

1.3.2 Duration of work performance

The target period for the construction of power units 5, 6 [10, 11] with the selected set of drive machines before the startup of the second stage (power unit 5) is 108 months (9 years) based on the following operating mode: number of shifts – 2; shift duration - 8.0 hours; number of working days per month - 21.0.

The recommended construction duration is determined taking into account the combination of periods and stages, including:

- preparatory period – 12 months;
- construction of the first stage – 102 months (unit No 6);
- construction of the second stage – 102 months (unit No. 5).

The construction of the first stage is combined with the preparatory period and begins 6 months after its start.

The introduction of the second stage of construction – 6 months.

Units 6 and 5 will be commissioned after setting up and adjustment works that last 30 months.

1.3.3 Content, main assets and technologies of work performance

The following preparatory work must be completed before the start of the main construction and installation works [11]:

- restoration of the geodetic basis for the construction site;
- allocation of land plots that are not available;
- relocation of construction, installation and other specialized organizations, staffed with the required number of specialists of various profiles and construction equipment, to the place of work;
- ensuring that construction equipment can move and transport construction cargoes of maximum weight and dimensions on existing off-site and on-site roads and railways;
- construction of additional temporary on-site roads required for construction;

– providing construction with energy resources, water, heat, and communications (installation of temporary utility networks and their connection to the networks of the corresponding name after obtaining the necessary technical specifications);

– providing construction with temporary buildings and structures in the required quantity and placing them in specially designated areas.

Excavations for pits of individual buildings and structures, vertical layout, as well as backfilling of pit sinuses and vertical mounds, under roads and other structures represent earthworks.

Excavation of pits for buildings and structures should be carried out in accordance with [12, 13] using backhoe excavators with a bucket capacity of 0.50-1.50 m^3, loaded into dump trucks with a carrying capacity of 10-20 tons and transported to the worked quarries at a distance of up to 3 km and to a temporary dump at a distance of up to 1 km.

It is advisable to excavate trenches and swamps using backhoe excavators with a bucket capacity of 0.25-0.30 m^3.

Bulldozers are used for cutting, moving, unloading and placing soil in zero-cycle operations.

Various compaction methods are used, which can be used individually or in combination with each other during performing soil compaction. Similar operations are required when creating a sand cushion for the foundation and a crushed stone base for roads. Combined compaction methods include rolling with vibration or tamping with vibration. The choice of roller for the respective application depends on many factors, such as the required compaction ratio of the road mixture, compaction speed, quality and type of material used.

The list of machines and mechanisms for earthworks is given in Table 1.1.

Table 1.1 – List of main machines and mechanisms for earthworks and road construction

Item	**Model**	**Quantity**	**Note**
Backhoe excavator	EO-4121	8	Bucket capacity 1.0 m^3
Backhoe excavator	EO -4321	5	Bucket capacity 0,65 m^3
Universal excavator	EO -2621	4	Bucket capacity 0,25 m^3
Bulldozer	DZ-53 or DZ-54	5	Engine power 82 kW
Bulldozer	DZ 3-9 or DZ -33	4	Engine power 129 kW
Bulldozer	DZ -34	2	Engine power 228 kW
Front loader	TO-18A	1	Payload capacity 3.0 tons
Trailed roller on pneumatic tires	DU-30	1	Weight 12.5 t
Static pneumatic wheeled roller	DU -55	1	Weight 20,0 t
Sidewalk roller	BV-76	2	
Scraper	DZ-33	2	Bucket capacity 3.0 m^3
Motor grader	DZ-143	1	
Motor grader	DZ-122A	1	
Motor grader	DZ-180	1	
Asphalt paver	DS-143	1	

Item	Model	Quantity	Note
Asphalt paver	DS-195	1	
Asphalt sprayer	DS-39Б	2	
Bitumen truck	DS-138	2	
Bitumen truck	DS-39Б	2	
Hinged rammers		3	Weight 1,3 t
Tractor-trailer	T-100	2	

All main buildings and structures are made of monolithic and precast reinforced concrete. Reinforcement frames and grids are manufactured in the reinforcement shop located on the construction base. Delivery is carried out by motor vehicle.

Concreting of foundation slabs, walls, and floors is carried out using concrete pumping equipment and tubs.

The main large processes in the construction of the KhNPP units 5 and 6 buildings are the assembly and concreting of the containment and shield building structural modules.

Concreting is carried out mainly [14] with the use of modern concrete pumping equipment with concrete spreading booms, which ensures the intensity of concrete mix placement of 80-100 m^3/hour at a feeding height of up to 100 m.

To produce extra-heavy concrete with an average density of 2950, 3350 and 4000 kg/m3, aggregates from magnetite or hematite iron ores are used. Sand made from metallurgical scale, a waste product of the steel industry, can also be used as a fine aggregate.

The concrete mix is placed by gravity feeding from the hopper through a vertical pipe (concrete pipe) extending above the formwork surface to the bottom of the structure. As the concrete flows out of the bottom of the pipe, more concrete is added to the hopper, so that the pipe is constantly filled with new mix. The main purpose of this method of concreting is to place the mixture in its final position with as little interference as possible. A concrete mix with sufficient mobility is required to be easily fed from a pipe whose end is immersed in the mass. Gradually, the mixture flows to the edges, filling the molds, and as the concrete accumulates, the pipe is raised so that its outlet end is recessed by about 1 meter.

Extra heavy concrete is compacted with flexible shaft vibrators.

Specialized vehicles based on truck chassis - concrete mixer trucks - are used to transport ready-mixed concrete at a distance of more than 1 km from mixing plants and factories to the construction site, equipped with technological equipment to prevent losses and maintain the quality of the mixtures on the road.

The construction of the steel cylindrical containment vessel and the shield building is carried out using assembly blocks [15] (bottom, rings, and dome part). The assembly of the blocks is carried out on special stands, after which they are transported to the area of the assembly crane by multi-axis heavy-duty conveyors.

Before lifting and installing the blocks in the design position, transition platforms (in the area of horizontal joints), hinged ladders (in the area of vertical joints), fencing and formwork guides are attached to them, reducing the main and secondary work operations performed directly at height as much as possible. The choice of the size and weight of the assembly units is related to the adopted mechanization scheme and transportation capabilities.

The finished tier of the shield building is concreted after completion of the installation and welding work around the entire perimeter of the shell. The installation of elements or blocks of the next tier is started after a technological break to gain concrete strength.

A large lift capacity LTL 3000 Transi-lift crane will carry out the installation of the main building modules CA, CB, CH (Table 1.2).

Table 1.2 – Dimensions and weights of AP1000 components

Module / Item	**Weight, t**	**Required workspace (length/width/height), m**
CA-01	1069,353	30,5x21,4x21,4
CA-02	49,885	9,2x6x12
CA-03	213,145	9,2x19x12
CA-05	75,281	15,3x15,3x7,7
CA-20	887,953	30,5x21,4x21,4
CA-22	16,326	17x5x0,6
CA-31	34,466	8x7,5x0,6
CA-32	2,721	3,5x2,5x2
CA-33	22,675	12,5x6,7x1,2
CA-34	10,884	4,8x7,6x0,9
CA-35	31,745	6,7x6,7x0,9
CA-36	9,07	3,7x3x1,2
CA-37	39,001	10,7x10,7x1,2
CA-41	11,791	4,8x11,6x0,6
CA-42	10,884	4,8x11,6x0,6
CA-44	11,791	4,8x11,6x0,6
CA-45	11,791	4,8x11,6x0,6
CA-51	27,21	10,4x11,3x0,6
CA-52	19,047	7x12,8x0,6
CA-55	76,188	12,2x12,2x0,6
CA-56	13,605	11x5,5x0,6
CA-57	19,954	10,7x9,2x0,9
CA-58	13,605	9,2x9,2x0,9
CB-11	1,814	6x2,5x0,9
CB-12	1,814	6x2,2x0,9
CB-20	294,775	21,4x21,4x10,7
CH-80	362,8	16,2x10,4x24
CH-81A	145,12	16,2x0,6x24
CH-81B	145,12	16,2x0,6x24
CH-81C	145,12	16,2x0,6x24
CH-82	390,01	16,2x12,2x24

Module / Item	Weight, t	Required workspace (length/width/height), m
Schield Building Roof	1121,052	Diameter 44,2
Shield Building Steel Panel Assemblies	19,95 – 48,97	12 panels / rings
Condenser Lower Bodies	580,48	14,3x9,2x12,2
Condenser Upper Bodies	126,98	14,3x9,5x7
TG Roof 1-CH-85	263,03	36,5x32,9x5,8
TG Roof 2-CH-86	176,865	36,5x19,5x5,8
TG Pedestal Deck-CA-81	268,472	16,2x36x4,6
Steam generator	680,25	24x6,4x5,5
CV Ring 1	703,832	Diameter 48,8
CV Ring 2	675,715	Diameter 48,8
CV Ring 3	694,762	Diameter 48,8
CVTH (Top Head)	585,922	Diameter 48,8
CVBH (Bottom Head)	601,341	Diameter 48,8
Gen Stator 60 Hz	410,871	11x4,3x4,5
Reactor cover assembly (IHP)	235,82	7,6x7,6x15,3
Deaerator	273,007	44,2x5,2x5,5
CR-10	390,01	Diameter 48,8
Reactor Vessel	331,055	10x6,4x6,4
Moisture Separator	260,309	13,7x1,5x1,5
Pressurizer (MV20)	107,026	13,7x2,7x3,3
Main transformer 230 Kv	175,051	7,9x4,2x5,8
Polar crane	107,026	37,8x12,8x8,5

Pre-assembly of the modules is carried out from steel structures of submodules (of the original grades) in a temporary building equipped with three overhead cranes with a lifting capacity of 50 tons (2 pcs.) and 30 tons (1 pc.). For the consolidation assembly, a cantilever lift is used to bring the submodules into a vertical position before placing them on the assembly platform, which is a:

– a template to ensure proper alignment of the submodules with the required tolerances during the assembly process;

– a means of interaction with multi-axis heavy-duty conveyors when the module assembly is completed.

The assembled modules are transported to the crane platform area by heavy-duty transporters via a special road for cargo weighing 1500 tons with a width of 50 meters, after which the lifting loops are connected to the rigging, which is a traverse beam (crossbeams).

The structural modules are precisely positioned in the containment on the base plates (embedded parts) using guide pins and hydraulic jacks.

The structural modules installation is completed by making the connections to the base plates.

Two heavy-lifting cranes are required for the construction of the reactor and turbine islands [16]. The heavy components include the containment vessel cover and rings, large steel modular structures, large building frame modules, equipment modules, primary circuit components, and turbine generator components.

The heavy-duty cranes will have T-platforms or ring rails on the west side of the containment building from which they will be able to deliver heavy loads to the reactor building and turbine building.

The number and the leading cranes capacity required to support construction work on the critical path is determined based on research and is shown in Table 1.3. The list of auxiliary machines and mechanisms is given in Table 1.4 [16].

Table 1.3 – List of the main lifting mechanisms

Vendor	Quantity (Units)	Model	Location	Lift capacity	Notes
Lampson	2	LTL 3000 Transi-lift	Heavy components of units 5 and 6	3000 t	Heavy lift crane
Demag	1	CC-2800 Superlift	North end of turbine building	660 t	Crawler crane serving both units
Manitowoc	2	4100 Crawler	MAB, CV, shield wall assembly	230 t	Crawler crane
Demag	1	Truck crane AC 100	Workshops, warehouse	100 t	Crawler crane - site-specific (additional cranes may be required)
Liebherr	8	280 EC H12 Litronics (70 model)	Cooling towers, CV, special building, turbine compartment	3 t with a max. outreach of 70 m	Tower Crane – Max lift 13 t: six 60 m reach, two 70 m reach
Liebherr	3	Telescopic truck crane LTM series	As needed	75 – 100 t	Mobile Crane
Sarens	6	Goldhofer SPMT	Various	15000 t per axle	Self-propelled Modular Transporter (SPMT)

Table 1.4 – List of main vehicles and specialized vehicles

Item	Title	Quantity	Note
Dump trucks		50	Load capacity 8,0 - 27 t
Flatbed vehicles		40	Load capacity 5,0 - 12 t
Tractor truck		1	Load capacity 130 t
Trailer		1	Load capacity 130 t
Tractor truck		10	Load capacity 8,0 - 70 t
Trailer		10	Load capacity 8,0 - 70 t
Fuel truck		3	
Tanker trucks		22	
Drilling and crane machine	BM-305A	2	Tractor-based ДТ-75
Cement trucks			Load capacity 8,0 - 20 t
Concrete mixers		15	Capacity 4,0-6,0 м3
Concrete pumps		4	Productivity 80 м3/ч

Diesel shunting locomotive		4	Railway transportation
Platforms		14	Rail transport, load capacity 60.0 to 200.0 t
Multi-axle heavy-duty conveyor			Load capacity 1000 t
Buses		30	For transportation of employees, with 60 seats

1.3.4 Supply chain for the planned activities

1.3.4.1 Hydraulic facilities

The service water supply scheme of the designed power units No. 5 and 6 is reversed with the cooling towers as radiators. The KhNPP cooling pond in the adopted cooling and process water supply scheme for power units 5 and 6 is a source of water intake for cooling tower feeding, blowdown, and the other process system needs; it is also used for blowdown water discharge. The water supply scheme is unified and separate for each power unit.

The designed systems involved in the transportation and cooling of equipment at power units 5 and 6 using AP 1000 technology include SWS, CWS, and RWS systems:

– the pumps of the power units 5 and 6 pumping station of the Raw Water System (RWS) are used to intake and transport water for blowdown and makeup of the SWS and CWS systems, as well as for the needs of other systems;

– the Service Water System (SWS) removes heat energy from the primary circuit equipment and selected secondary plant circuit equipment, which is transferred from the heat exchangers of the Component Cooling Water system (CCS) to the atmosphere through fan cooling towers;

– the Circulation Water System (CWS) supplies water to the main condenser, the heat exchangers of the Turbine Building Closed Cooling Water System (TCS), and the sealing water heat exchangers of the Condenser Air Removal System (CMS) vacuum pump under various plant power load conditions and design weather conditions.

Hydraulic facilities that can be used during the power unit operation with AP 1000:

– a cooling pond;

– an earthen water retention dam with a flood spillway;

– drainage channel for filtration water discharge and filtration water return pumping station (FWRPS);

– cooling water supply and discharge canals;

– water intake canal from the Goryn River and supplementary water pumping station (SWPS).

A cooling pond

The KhNPP cooling pond is a combined type pond – a flood pond from the Goryn River and a channel pond on the Hnylyi Rih River. It is 5 km south of Netishyn, Netishyn Territorial Community, and Khmelnytskyy Oblast. The dam is located three kilometers from the mouth of the Hnylyi Rih River. [redacted]

[redacted]

To ensure the design temperature in the cooling pond and to increase the efficiency of cooling the circulating water, the construction of a 1.300 m jet-directing dam is planned, which should be carried out at the stage of construction of units No. 3, 4 according to a separate project.

Enclosure dam

Enclosure dam of the cooling pond - sand, soil, alluvial, trapezoidal profile. The dam is located three kilometers from the mouth of the Hnylyi Rih River. The dam is 7124.0 meters long, 8.0 meters wide along the crest, and the crest elevation is 206.0 meters. Monolithic reinforced concrete slabs 200 mm thick support the upstream slope of the dam, while the downstream slope is sown with perennial grasses. The dam's downstream slope is protected by a 600 mm thick sloping drainage made of stone rubble. A drainage channel is installed in the downstream area to intercept and organize the water drainage that filters through the dam body and base.

A flood spillway is on the Sta 14+00 to purge the reservoir and water discharge through the bottom outlet. The water is partially released during floods of exceptional recurrence, coinciding with periods of full reservoir filling. The flood spillway consists of two shafts, three spillway tunnels with a cross-section of 3.0×3.0 m, a spillway in the lower reaches, and a breakwater in the upper reaches. The flow rate of the flood spillway at 0.01% of the capacity is 110.0 m^3/s.

A piezometric network consisting of 15 piezometric shafts with 72 piezometers controls the filtration regime in the body and base of the dam.

During the EIA report development, the observation materials presented in the letter No. 4292 dated 09.10.2023 to the Khmelnytskyi NPP subdivision (see Appendix J) were used to analyze the filtration process in the body and base of the cooling pond enclosure dam. The reservoir operation is completely safe if the dam's operational condition is assessed as normal (reliable), i.e. the value of the water level marks in the piezometer does not exceed the maximum operational level. When comparing the provided actual water levels values in piezometers in 2021 and 2022 with the maximum permissible values determined in the work "Clarification of permissible operational values of the depression curve position in the earthen dam of Khmelnytskyi NPP UDC 626.862.3:532.001", performed by the National University of Water and Environmental Engineering (NUWEE), Khmelnytskyy, Ukraine. Rivne in 2014, it can be noted that water levels are increased:

– in piezometers No. 46, No. 50, No. 51 located on the downstream slope of the dam;
– in piezometers No. 5, No. 40, No. 69 located behind the drainage channel.

There is partial siltation of the drainage channel and damage to the dam's sloping drainage. The cause of this damage is the shrub root system spread and the digging animals activities.

To recover the dam's filtration capacity, it is necessary to repair the reinforced concrete screen of the dam's upstream slope, clear the drainage channel, and periodically cut down shrubs.

The soil dam filtration regime monitoring and its sole should be carried out according to the Operating Manual "System VU". Hydraulic facilities of the circulating water supply system of KhNPP. The flow rates and filtration volumes are recorded based on the flow meters of the filtration water pumping station. In general, the dam's condition is satisfactory.

Supply and discharge open channel

The water supply channel delivers water for cooling from the reservoir to the unit pumping station (UPS). The trapezoidal channel with a capacity of 266.1 m^3/s is 2.8 km long, 10.0 to 30.0 m wide along the bottom, 9.0 m deep, and has a 1:3 slope; monolithic reinforced concrete slabs support the slopes. The supply water channel bottom is 194.0 m.

The discharge canal with facilities has a trapezoidal cross-sectional shape. The channel's capacity is 266.1 m^3/s. The length of the canal is 3.3 km, the width along the bottom is from 9.0 m to 23.0 m, the depth is from 5.5 to 6.5 m, and the slopes are 1:3. The discharge channel bottom is 199.5 m.

Drainage channel and filtration water pumping station (FWPS)

The drainage channel intercepts the reservoir filtration water that passes through the dam body in depression curves. Part of the drainage channel's filtration water is intercepted by the filtration water pumping station (FWPS) and directed back to the reservoir. The inclined drainage is used to support the drainage channel and berm.

The filtration water pumping station (FWPS) is a reinforced concrete submersible. The main four pumps are D2000-21-2 for pumping filtration water into the reservoir with a flow rate of 2000 m^3/h.

Water supply channel from the Goryn River

The water supply channel from the Goryn River delivers the water to the Supplemental Water Pumping Station. The channel length is 2.4 km, the width is 16.0÷40.0 m, and the maximum water velocity is 0.32 m/s.

Supplemental water pumping station (SWPS)

It recharges the cooling pond to replenish irrecoverable losses in the service water consumption system. It is located in the lower pool near the dam at Sta 65. The maximum design flow rate is 30.0 m^3/s.

The supplemental water pumping station (SWPS) is equipped with pumps:

– OV2-110K (ОВ2-110К) with a flow rate of 18000.0 m^3/h, 5 pcs;
– D5000-32A (Д5000-32А)with a flow rate of 3200.0 m^3/h, 2 pcs;
– 550D-22 (550Д-22) with a flow rate of 2000.0 m^3/h, 2 pcs.

1.3.4.2 Transport network

The territory of the KhNPP's industrial area and the construction site is densely covered with roads and railways, which will be partially used during the commissioning and construction of units 5 and 6 using the AP1000 technology.

[redacted]

The width of the roads is 6-8 meters. The project provides for the further use of approximately 40% of the existing road transport network of the KhNPP construction site. Roads on the territory of the industrial site of power units 1-4 are not used in the operation of power 5-6, their route is not disturbed. The proposed roads are mostly in satisfactory condition with minor defects: crumbling edges, potholes, and pits in the places of concrete joints.

Rail transport is represented by railway lines serving the industrial area of power units 1-4 and those used for loading and unloading operations at the construction yard.

The lines related to the industrial area are mostly in satisfactory condition and require minor repairs. In general, these lines are not used in the operation of units 5 and 6, but they are preserved and continue to maintain units 1-4.

The loading and unloading of the construction yard lines are in poor condition. There is no direct connection with the external railroad network due to the dismantling of the connecting line. Significant sections of tracks, signaling, and switching equipment are missing. Wooden sleepers are destroyed or affected by natural decomposition. The railroad network is not expected to be used, and its restoration is economically unviable due to the dismantling of the warehouses they served.

1.3.5 Planned temporary structures, transportation and utility networks

An indicative list of temporary buildings and structures required for the construction of power units 5 and 6 is given below [16].

1.3.5.1 Building materials laydown areas

Building materials laydown areas include the following buildings:

– *Warehouse.* Three buildings measuring 40 x 20-meter. They provide storage of ready-to-use materials. Depending on the purpose, they can be prefabricated metal or metal-frame awning sheds;
– *Enclosed shop for concreting tools and devices.* The 40 x20-meter building. This building is used for storage, repair and modernization of equipment. Power, lighting, water, sewerage and compressed air must be provided;
– *Carpentry laydown area.* A 60 x 20-meter site, along with a carpentry shop for storing the manufactured structures;
– *Formwork laydown area.* A 60 x 40-meter site area to store formwork elements and equipment for its assembly;
– *Rigging storage.* A 28 x 20-meter warehouse building for storing, testing and calibrating equipment;
– *Small equipment and tools storage.* A 28 x 20-meter warehouse building for storing, testing and calibrating equipment;
– *Laydown Areas.* A complex of 16 sites made of compacted gravel with a slope towards the reservoir with a total area of 51.63 hectares for storing any equipment.

1.3.5.2 Fabrication shops

The fabrication shops will include the following ones:

– *Carpentry shop.* A 30 x 20-meter carpentry shop is set up at the construction site to manufacture additional scaffolding and building structures;
– *Formwork wash area.* A 15 x 10-meter site area for cleaning the formwork elements after use;
– *Paint shop.* A 26 x 13-meter building for storing, mixing and calibrating equipment;
– *Duct fabrication shop.* A building measuring 26 x 13-meter for the manufacture of air ducts for construction;
– *Insulation fabrication shop.* A building measuring 26 x 13-meter;
– *Small diameter piping shop.* A building measuring 50 x 25-meter for the manufacture of pipelines for construction;
– *Large diameter piping shop.* A 50 x 25-meter building for the manufacture of pipelines supporting the construction;
– *Maintenance shop.* A building measuring 18x12-meter for equipment maintenance;
– *Fab and storage.* A 26 x 13-meter building for the manufacture and storage of air and pipelines for construction;
– *Precast concrete panel fabrication area. A*n area measuring 63x25-meter, where reinforcement, concrete placement, vibration and temporary storage take place;
– *Weld test facility.* A 27 x 25-meter site area where welded joints are tested.

1.3.5.3 Sanitary and administrative rooms

Sanitary and administrative rooms will include:

– *Subcontractors' offices.* A 40 x 24-meter building, where contractors place their engineering and technical staff;

– *Subcontractors' field offices.* Six buildings measuring 49x13 meters, in which contractors place their engineering and technical staff and construction management;

– *Craft training.* The 24 x 23-meter building and is used for occupational safety and health briefings, ongoing training of construction workers and organizational meetings;

– *New hire training building.* A 29 x 14-meter building housing administrative staff responsible for hiring and training new employees;

– *Construction orientation building.* A 29 x 14-meter building, where new employees are trained with an emphasis on industrial safety, compliance with procedures, and the principles of a safe working environment specific to the facility;

– *First aid / Medical Facility.* The 29 x 14-meter building and is used for medical examinations of employees and first aid;

– *Canteen for construction workers.* The 50 x 25-meter building and is equipped with kitchen accessories, places for eating and a sanitary unit;

– *Craft Change / Lunch Facilities.* The 50 x 25-meter building to provide a place for gathering the workforce, receiving daily work instructions before work, changing into work clothes and personal protective equipment, and can also serve as a place for lunch breaks and heating (protection from solar radiation) for workers;

– The 50x25-meter shower building includes a room for women's personal hygiene and a drying room for clothes and shoes;

– *Craft toilet trailer (men) is* a complex of 6-10 portable restrooms measuring 13 x 6 meters. Such complexes are located on the site territory, taking into account the saturation of each zone with workers;

– *Craft toilet trailer (women)* is a complex of 6-10 portable toilets measuring 13 x 6 meters

– *Construction administration office.* The 40x24-meter building and houses the construction administration, offices of the general contractor and general designer;

– Time alley. A 29×14-meter building that houses turnstiles, an access control point and time readers;

– Refueling station in the construction zone. The 21 x 16-meter building is designed to refuel construction vehicles. It contains two 55,000-liter tanks with gasoline and diesel fuel. The filling station is to be provided with power supply, fire protection systems, lighting, ventilation, sewerage and water supply. Upon completion of construction, the gas station will be completely dismantled;

– *Truck parking.* The 138x64-meter site is intended for the storage of construction vehicles. It is located next to a maintenance station and a wash facility;

– *Truck wash facility.* A 24x15-meter area designed to wash construction vehicles after completion of work. It is located next to the maintenance facility site and truck parking;

– *Construction site maintenance facility.* The 29 x 14-meter building is intended for the maintenance of construction vehicles and equipment;

– *Heavy maintenance vehicle parking.* A 29x30-meter area designed for the parking of construction vehicles being repaired at the maintenance facility site. It is located adjacent to the maintenance facility site.

1.3.5.4 Batch plant

Production area of 3.3 hectares. It needs to be provided with power, sewerage, water supply and communications. The batch plant includes the following buildings:

– test laboratories for testing concrete and reinforcement;
– rock breaker;
– concrete plant water tanks;
– concrete installation site;
– concrete plant sump;
– unit to produce ice for concrete;
– quality control building.

1.3.5.5 Assembly pads sites

Assembly pads include:

– Containment Vessel (CV) module assembly pad. The main site is located next to the road for heavy vehicles, that is a complex of five round sites with a total size of 325x82 meters;
– CV plate laydown area. The covered-with-compacted gravel site size is 325x75 meters. It is placed near the containment assembly area;
– CA Sub-assembly Storage Area. Two compacted gravel sites measuring 80x46 m and 97x56 m are located next to the MAB and are the main storage/preparation area for submodules arriving on site awaiting final assembly inside the MAB or at the external final assembly area;
– CA20 Assembly area. The site measures 66x25 meters. It will be covered with compacted gravel. It is located next to the module assembly building. It is used for assembly and storage of finished CA20 modules;
– Module Assembly building - MAB. The building measures 101x47 meters and its height is 32 meters. The floor is to be covered with a 1.2 m thick concrete slab. It is used for the final assembly of large structural modules. It is located near the module assembly site;
– CA01 Assembly area. The site is 80x58 meters in size. The site is located next to the MAB module assembly building. The site is intended for pre-assembly/preparation of the CA01 module before its delivery to the module assembly building;
– Shield building fabrication / assembly. The site is 277x92 meters in size. It is located next to the main heavy hault road;
– Turbine building module assembly. The building measures 151x75 m. It is located next to the main heavy hault road. This building is used for assembling the turbine building components and preparing them for installation;
– CR10 laydown. The site measures 70x60 meters. It is located next to the main heavy hault road. This site is used to assemble the CR-10, CA-03 modules, the roof of the shield building and prepare for their installation. The site is to be covered with concrete;

– condenser laydown;
– gas industry (sector).

A special 50-meter-wide road for 1,500-ton loads is being built to supply goods for installation by multi-axle heavy-duty transporters, adjacent to the industrial site.

1.3.6 Natural resource needs for preparatory and construction works and sources of these needs

The demand for structures, semi-finished products and materials can be satisfied from geographically close areas, taking into account the transportation schemes of the following enterprises:

– prefabricated concrete structures - local reinforced concrete plants, Kyiv reinforced concrete plants, Svitlovodsk Reinforced-Concrete Wares Plant LLC, and Pivdenoukrainskyi HBC;
– metal-rolled products - Zaporizhstal PJSC, Zaporizhzhia; Dnipro Metallurgical Plant PJSC; Spetssplav LLC, Kryvyi Rih.
– Rebar – ArcelorMittal Kryvyi Rih Public Joint Stock Company (ArcelorMittal Kryvyi Rih PJSC ArcelorMittal Kryvyi Rih) KAMET STEEL, Kamianske town.
– special reinforced concrete and special steel structures - production facilities for the manufacture of non-standard products, enlargement of heavy equipment and structures at Khmelnytskyy NPP (after their reconstruction);
– PrJSC Dickergoff Cement Ukraine (Volyn-Cement branch office, Zdolbuniv; Yugcement branch office, Olshanske); Cemark Ukraine (JSC Podilsky Cement, Humentsi, Khmelnytskyy region, LLC Cement, Odesa; PrJSC Mykolaivcement, Mykolaiv, Lviv region);
– crushed stone and granite - Shepetivka Granite Quarry PRONEX LLC (Sudylkove village, Shepetivka district, Khmelnytskyy region), Shepetivka Granite Quarry LLC (Rudnia-Novenka village, Shepetivka district, Khmelnytskyy region), Polonne Mining Plant LLC (Polonne, Khmelnytskyy region), Korosten Crushed Stone Plant ALC, Zhytomyr region, JSC Malynskyi Stone Crushing Plant (Zhytomyr region), LLC Hnivanskyi Granite Quarry (Vinnytsia region);
– sand for concrete, backfill and quality fill – Slavutskyi Sand Quarry, Khmelnytskyy region, Khmelnytskyy NPP Construction Management PJSC, Starytsia-2 quarry (Netishyn, Khmelnytskyy region), quarries in Kyiv region, Ukrtransbud Corporation, Kyiv and Chernihiv regions;
– concrete and mortars - it is planned to build a temporary concrete plant for the construction period, located at the construction and assembly base.

The construction energy and water needs are shown in Table 1.5.

Table 1.5 - List of energy and water needs for the construction of KhNPP Units 5 and 6

Name	Value
Electricity (installed capacity of current collectors), kVA	6400
Hot water supply, Gcal/hour	37
Technical steam, t/h	11,5
Potable water, m $^{3/h}$	48
Service water, m $^{3/h}$	24
Oxygen, m $^{3/hour}$	130
Acetylene, m $^{3/h}$	16
Propane-butane, m $^{3/hour}$	32
Argon,m^3 / unit	80000
Carbon dioxide,^{m3} / unit	94000
Freon,^{m3} / unit	Freon,m^3 / unit
Compressed air, m $^{3/min}$	71,0

1.3.7 Management of construction and other solid waste, as well as liquid waste (wastewater and sewage sludge) generated during preparatory and construction activities

The project provides for the following measures to reduce the negative impact of construction production on the environment [17].

Cutting and uprooting of trees falling into the construction zone must be compensated by planting new trees in the same number in the adjacent areas. During assembly, the movement of goods must be performed at a distance of at least 0.5 m from the crown and trunks of trees. The destruction of tree and shrub vegetation and the filling of root necks and tree trunks with soil not provided for by the project are not allowed on the territory of the construction site.

Waste concrete, bricks, insulation, polymeric materials, asphalt, etc. must be separated by type and disposed of after crushing and fractionation.

Regularly remove construction waste from the construction site to a specially designated landfill – solid domestic waste landfill of the public utility Netishyn City Council “Housing and Utility Community”.

Soil dumping shall be arranged exclusively in specially designated areas.

Drain fuel and lubricants in specially designated and equipped areas.

During construction and assembly activities, it is prohibited to discharge wastewater, as well as untreated household or industrial wastewater generated at or near the construction site. It is envisaged to transfer the wastewater for further treatment to the existing wastewater treatment facilities.

Use mobile toilet cabins (MTC) with a storage capacity of no more than 250 liters. In the case of pumping at the construction site, the locations of liquid waste removal must be established in the work performance plan before the start of work. The distance between the bottom of the watertight tank of the MTC and the groundwater level should be at least 0.5 m.

Serviceable technical means are used to transport concrete and mortar, that prevent their loss on the road.

1.3.8 Compliance with air quality standards (hygienic standards) and maximum permissible noise levels in relation to the nearest residential buildings

All construction work will be carried out in compliance with the requirements for the prevention of dust formation and air basin pollution [17]:

– construction waste will be loaded into closed containers with preliminary irrigation, preventing dusting of the territory;
– loading, transportation and storage of bulk dusting materials to be carried out using special mechanisms, machines and closed containers;
– in summer, all roads and road-type sites will be regularly watered;
– at the exit from the construction site, set up a wheel washing station and build a paved area to clean the wheels of vehicles and construction machines from dirt.

The following actions are envisaged to reduce the noise level during construction and assembly activities:

– ensure that vehicle engines are turned off while on the construction site;
– exclude loudspeaker communication;
– to exclude the performance of works accompanied by noise over the permissible norm;
– to exclude the operation of equipment that has a noise and vibration level exceeding the permissible standards;
– to soundproof construction machinery engines, use protective covers and hoods with multilayer coating;
– to isolate local sources, use temporary noise protection screens, noise curtains, and tents (for example, place compressors in a sound-absorbing tent).

1.4 Description of the main characteristics of the planned activity (including manufacturing processes), e.g., the type and quantity of materials and natural resources (water, land, soil, biodiversity) to be used

The planned activity is characterized in terms of the presence of hazardous substances that may be used or manufactured, processed, stored, or transported, the need for raw materials, fuel, and other materials, water in appropriate units of measurement, etc.

1.4.1 Characteristics of the NPP site area

The NPP site and off-site facilities are located in the Shepetivka district of Khmelnytskyy region of Ukraine.

Within the 30-kilometer zone of the KhNPP site are the 157-kilometer-long Goryn River and its tributaries with a total length of 450 kilometers. The main ones are the Vilia River, the upper reaches of the Ustia River, and the Hnylyi Rih River. There are many reservoirs, ponds, and canals within the 30-kilometer observation zone of the KhNPP. These artificial reservoirs were created under conditions of uneven flow to regulate it and provide water for the needs of the national economy and population.

In total, there are 216 ponds within the 30-kilometer zone of the KhNPP,

Three reservoirs (Myslyatyn, Izyaslav and KhNPP cooling pond) and 1290 canals. The sources of service water supply for the NPP are the Goryn and Hnylyi Rih rivers. An artificial cooling pond is directly adjacent to the industrial site and is used to cool the main process equipment of the NPP.

Groundwater is widespread on the territory.

The territory taken up for NPP includes the following facilities:

– industrial site;
– construction yard.

Cooling towers and water intake facilities are located on the western side of the site. The NPP site is connected to off-site facilities by a network of paved roads.

Key indicators for the master plan (for the built-up area of the industrial site):

– land plot area 51.1 ha;
– building area 10.26 hectares;
– building density 30%;
– road area 18.06 hectares.

According to the technical report on engineering and geological surveys at the facility "Construction of power units 5, 6 with AP1000 reactor unit at the KhNPP site." No. 1509/4254 dated 2024, performed by Geobest Engineering Center LLC, the works site based on the set of factors specified in SBC A.2.1-1-2008 belongs to the III category of complexity of engineering and geological conditions. Soil strata are represented by siltstone-argillite strata covered with loams. Alluvial sands represent topsoil.

Karst phenomena and landslides do not characterize the design activity area.

In addition, during the preparation of the territories and the construction of power units No. 1 and No. 2, peat-containing soils were replaced with alluvial sand throughout the territory.

The planned activity will provide additional stabilization and site protection from water and wind erosion by installing coverings, sowing soil areas with lawn grasses, organizing surface water drainage into a closed sewerage network, and planting trees. After finishing the landscaping works, no unstable slopes are expected within the direct impact area.

There are no existing buildings on the territory for the KhNPP units 5&6, therefore, the report of existing buildings survey is not attached.

Maps are provided in Appendix H.

1.4.2 Technological characteristics of the planned activity

The AP1000 is a double-circuit pressurized water reactor (PWR) that uses a simplified, innovative and efficient approach to safety. The AP1000 design provides clear benefits, including high safety, economic competitiveness, and improved and more efficient operation. See also Figure 1.2.

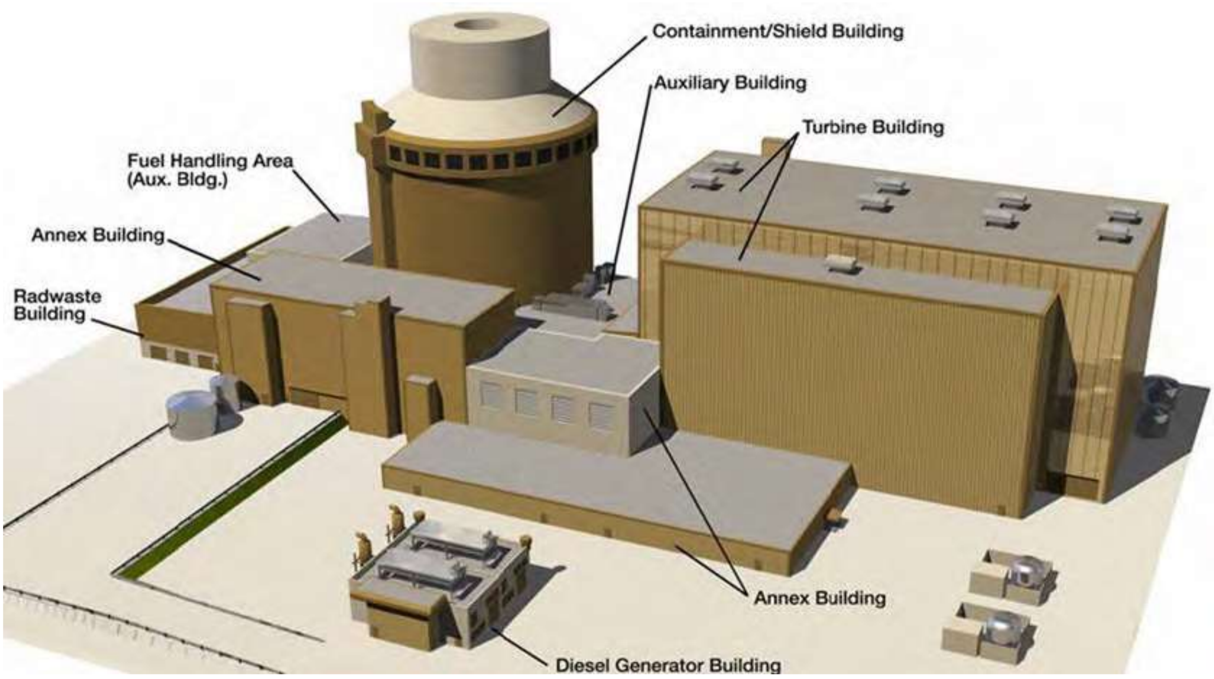


Figure 1.2 – AP1000 power unit

The AP1000 power unit site consists of five main building structures:

– nuclear island (containment, shield building and auxiliary building);
– turbine island (turbine building, the first bay);
– radioactive waste management building;
– diesel generator building;
– annex building (divided into four zones, 1-3 zones are technological premises, 4 zone is an office building).

1.4.2.1 Technological characteristics of the nuclear island

The layout of the main facilities and components of the AP1000 power unit is shown in Figure 1.3.

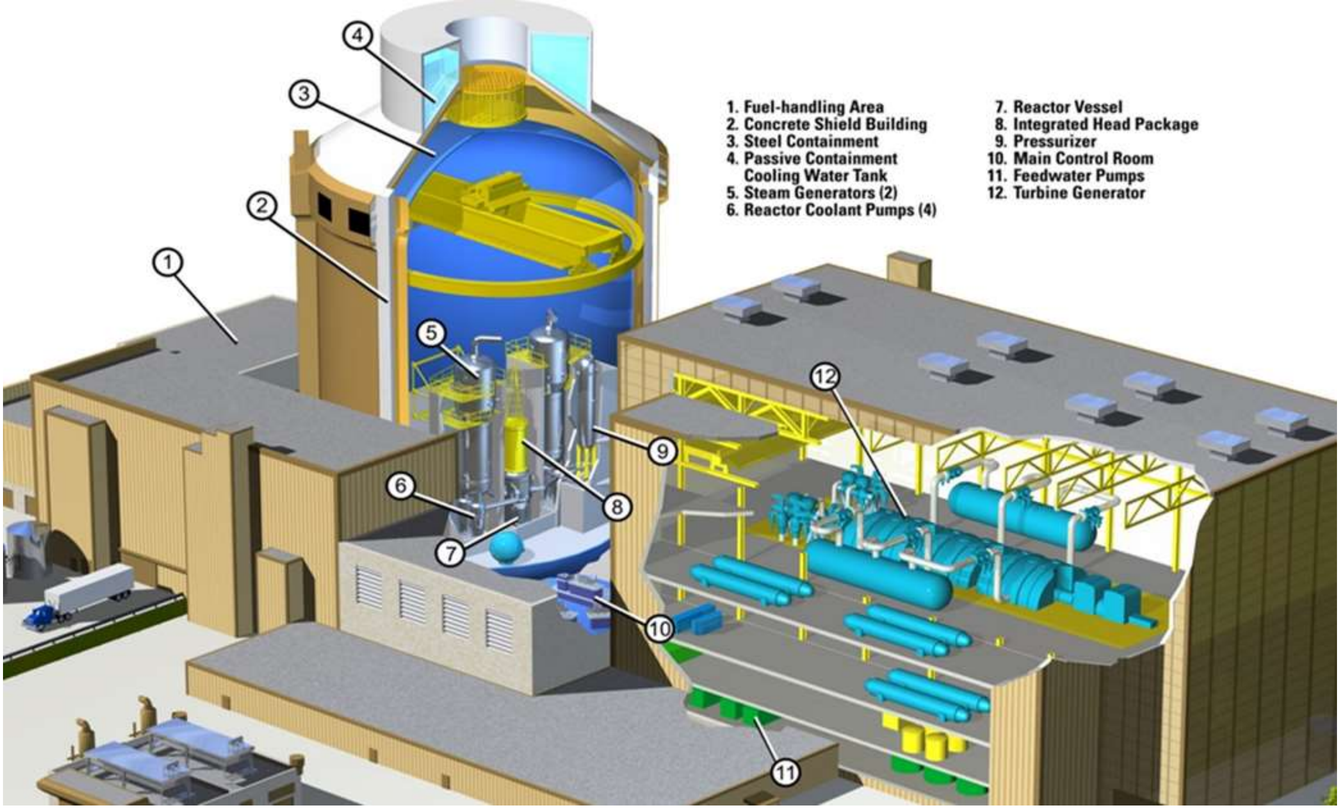


Figure 1.3 – The layout of the AP1000 unit main facilities and components

The reactor coolant system (RCS) consists of:

- Reactor;
- Steam Generator;
- Pressurizer;
- Main Coolant Pumps;
- Primary Coolant Pipelines.

The AP1000 RCS is designed to circulate the coolant to transfer heat generated in the reactor core to the secondary side.

The AP1000 RCS provides heat removal by the coolant from the core in all operating modes of the reactor unit.

The AP1000 RCS has two circuits with a single hot and two cold legs for each circuit, two steam generators (SG), to both of which 2 main coolant pumps (MCP) are directly connected (See Figure 1.4).

A cooling water reservoir is planned to be used as a source of service water for KhNPP Units 5 and 6.

The SWS and CWS equipment cooling at the KhNPP units 5&6 is planned with the construction of cooling towers – one tower-type cooling tower for the CWS and one two-section fan cooling tower for each power unit.

The nuclear island systems of the AP1000 unit include the following:

1) Reactor coolant system (RCS)

2) Nuclear island process systems:
- Chemical and Volume Control System (CVS)
- Primary Sampling System (PSS)
- Radio-chemistry Laboratory System (RLS)
- Spent Fuel Pool Cooling System (SFS)
- Normal Residual Heat Removal System (RNS)
- Containment Leak Rate Test System (VUS)
- Steam Generator Blowdown System (BDS)
- Component Cooling Water System (CCS)
- Service Water System (SWS)
- Special Process Heat Tracing System (EHS)

3) Safety systems
- Passive Containment Cooling System (PCS)
- Passive Core Cooling System (PXS)
- Containment Hydrogen Control System (VLS)
- Emergency Habitability System (VES)
- Containment Isolation System (CNS)
- Spent fuel pool cooling system (SFS)

4) Protection and Safety Monitoring System (PMS)
5) Class 1E DC system (IDS)

The main characteristics of the AP1000 power unit are shown in Table 1.6.

Table 1.6 – Main characteristics of the AP1000 power unit

Option	Values for the AP1000 power unit
Rated electric power	1117 - 1145 MW (the value is variable for each site, depending on the turbine unit used, cooling configuration, planned load, etc.)
Design operating lifetime of the power unit	60 years
Rated thermal power	3400 MW
Operating pressure in the reactor unit RU	15,51 MPa
Hot loop temperature	321,11 °C
Calculated pressure in the steam generator	8,27 MPa
Temperature of the main feedwater	226,67 °C
Core	
The number of fuel assemblies (FA), units.	157
Core height	4,267 mm
Fuel assembly (FA) array	17 x 17
Number of test assemblies	53
Number of rods with a burnup absorber in the FA	16

1.4.2.2 Reactor coolant system (RCS)

Safety-Related Functions

The RCS performs and/or supports the following safety-related functions: maintaining the reactor coolant pressure boundary, core cooling and reactivity control, process monitoring, automatic depressurization, and reactor vessel head emergency letdown/venting. These are described below:

- Reactor coolant pressure boundary (RCPB) – serves as a pressure boundary for containing the reactor coolant, soluble boron, limiting radiation releases (by limiting coolant leakage) to the containment and between the primary and non-radioactive secondary circuit except for plant conditions that postulate a failure of the RCPB. The RCS provides relief capability to prevent the reactor coolant system from overpressure during all plant operating conditions.
- Core cooling and reactivity control – circulates the coolant to remove the generated and decay heat produced in the reactor after it is shutdown, provide an adequately-uniform temperature distribution, and maintain the chemical homogeneity of the reactor coolant when chemical adjustments occur. The RCS provides the coolant circulation and decay heat removal required during the transition from forced circulation to natural circulation. The RCS, in conjunction with the reactor system (RXS), and the passive/active core cooling systems (PXS) contain the soluble neutron poison, which supplements the negative reactivity inserted by the control rods to provide the reactor shutdown subcriticality margin.
- Process monitoring – monitoring of the process parameters within the reactor coolant pressure boundary. The RCS supplies the signals required by the Protection and Safety Monitoring System (PMS) to provide automatic reactor trip and actuation of the passive safety systems.
- Automatic depressurization – the safety-related automatic depressurization system (ADS) function is to automatically depressurize the RCS so that the Passive Core Cooling System can adequately cool the core during small-break loss of coolant accidents (LOCAs).
- Emergency letdown – an emergency letdown system alows to control pressurizer level during accident events associated with an increase in pressurizer water level.
- The RCS provides the capability to vent non-condensable gases that might collect in the pressurizer and reactor vessel head in order to support core cooling capability in accident scenarios in accordance with the United States Nuclear Regulatory Commission (NRC) guidance.
- The RCS provides the capability to depressurize the system to an extent necessary to support the PXS during a non-design basis external event.
- Any of the six ADS 1-3 subsystem flow paths in the RCS provides a manually-opened vent path large enough, 27.8 cm^2 (4.15 in^2), to relieve water from the RCS to prevent reactor vessel low temperature over-pressurization in the event that the RNS relief valves are not operable when the reactor coolant is less than 135°C (275°F).

RCS Description and Design Data

The RCS consists of two heat transfer circuits, each with a steam generator, two reactor coolant pumps (RCPs), a single hot leg and two cold legs, for circulating reactor coolant between the reactor and the steam generators. In addition, the system includes a pressurizer, interconnecting piping, and valves and instrumentation necessary for operational control and safeguards actuation. All system equipment is located in the reactor containment.

The RCPs circulate pressurized water through the reactor vessel and the steam generators. The pressurized water, which serves as coolant, moderator, and solvent for boric acid (used for chemical shim control), is heated as it passes through the core. The coolant then flows to the steam generators where the heat is transferred to the secondary side, and then is returned to the reactor by the reactor coolant pumps to repeat the process.

The steam generators have a vertical shell and u-tube configuration with integral moisture separating equipment. The reactor coolant pumps are enhanced-inertia, high-reliability, lowmaintenance, canned-motor pumps and are integrated into the steam generator channel heads in an inverted position. Instrumentation is provided to monitor the following primary loop process parameters as required by the Plant Control System (PLS) and the PMS:

- Loop flow, wide range temperature, and narrow range temperature for each RCS cold leg.
- Level, wide range pressure, wide range temperature, and narrow range temperature for each RCS hot leg.

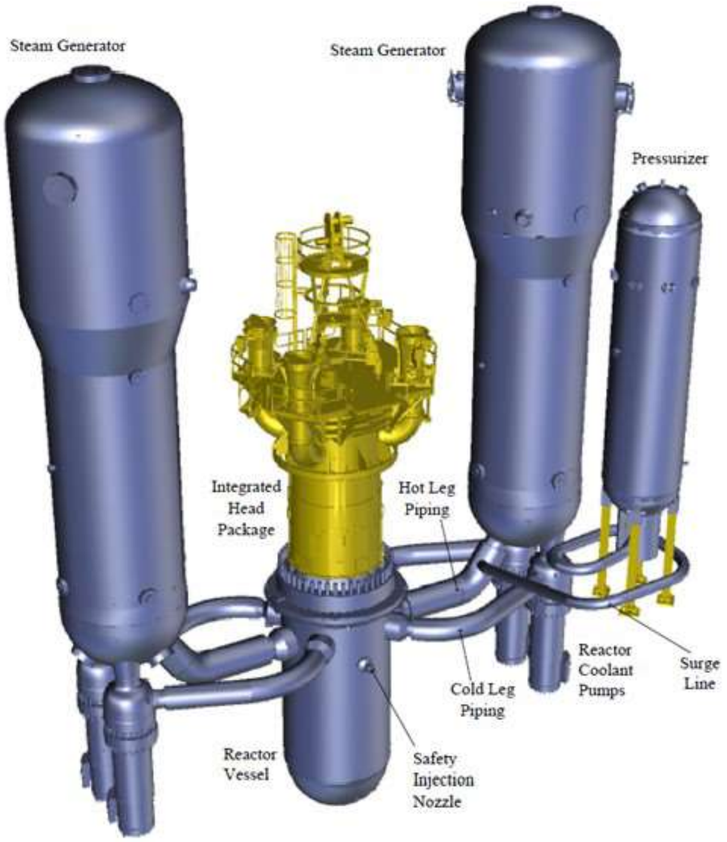


Figure 1.4 – RCS View

The reactor vessel has two direct vessel injection nozzles entering the downcomer below the level of the hot leg nozzles and cold leg nozzles. Each nozzle is connected to an accumulator tank, a core makeup tank, and to one of the two branch lines from the common discharge of the RNS.

The reactor coolant loop has connections to the Passive Residual Heat Removal Heat Exchanger, which is part of the PXS. This connection, along with the two core makeup tanks results in three safetyrelated, natural circulation flow paths to the reactor core through the RCS loop piping and PXS components.

Natural circulation would be expected to continue through until plant or equipment conditions change (such as depletion of safety-related batteries) and require actuation of the ADS valves and transition from natural circulation core cooling to safety injection and containment sump recirculation core cooling.

1.4.2.3 Technological characteristics of the turbine island

The final choice of the turbine unit and generator, their manufacturer and supplier will be determined at the project stage.

Currently, the use of a complete turbine island equipment package for KhNPP Units 5 and 6 is envisaged to use the previously obtained initial data of the complete turbine island equipment supply for General Electric. However, this information will be specified at the design stage.

The main equipment of the turbine building for KhNPP Units 5 and 6 is a steam turbine unit of the ARABELLE 1000 type manufactured by General Electric. The turbine unit and generator are assembled on a common foundation.

The main process equipment and systems of the second circuit of the power unit with the AP1000 reactor:

1) Turbine unit:
   - Complete Turbine Generator;
   - Gland Seal system (GSS);
   - Generator Hydrogen and CO2 Systems (HCS);
   - Hydrogen Seal Oil System (HSS);
   - Main Turbine and Generator Lub Oil System (LOS);
   - Main Turbine System (MTS);
   - Main Turbine Control and Diagnostic System (TOS);
   - Main Steam System (MSS);
   - Main and Sturtup Feedwater System (FWS).
2) Auxiliary systems of the turbine unit:
   - Auxiliary Steam Supply system (ASS);
   - Condensate System (CDS);
   - Condenser Tube Cleaning System (CES);
   - Turbine Island Chemical Feed System (CFS);
   - Condenser Air Removal System (CMS);
   - Condenser Polishing System (CPS);
   - Circulating Water System (CWS);
   - Demineralized Water Treatment System (DTS);
   - Heater Drain system (HDS);

– Secondary Sampling System (SSS);
– Turbine Building Closed Cooling Water System (TCS);
– Turbine Island Vents, Drains and Relief System (TDS);
– Turbine Building Ventilation System (VTS).

1.4.3 Water and energy supply of the construction performance

Quantitative data on the energy and water needs for construction are shown in Table 1.7, are preliminary, and will be refined at the "project" stage.

Table 1.7 – Energy and water needs for the construction of KhNPP Units 5 and 6

Name	Value
Electricity (current collectors installed capacity), kVA	6400
Hot water supply, Gcal/hour	37
Technical steam, t/h	11,5
Potable water, m 3 /h	48
Service water, m 3 /h	24
Oxygen, m 3 /hour	130
Acetylene, m 3 /h	16
Propane-butane, m 3 /h	32
Argon,m3 / unit	80000
Carbon dioxide,m3 / unit	94000
Freon,m3 / unit	23600
Compressed air, m 3 /min	71,0*

**Notes. ***The specified amount of compressed air corresponds to the compressed air demand at the construction site of power units 5 and 6

The KhNPP industrial site (construction of Units 5 and 6), industrial site (construction yard), and construction site will be supplied with electricity via 10 kV networks from the 10 kV outdoor switchgear at Substation 35/10/6.

The existing utility networks will provide heat supply, water supply and sewage of the KhNPP industrial site, industrial site (construction yard) and construction site.

The demand for oxygen, acetylene, propane-butane and compressed air will be covered by the respective temporary construction site facilities.

1.4.3.1 Preliminary water treatment

The main technological solution for the water pretreatment system is the technology of membrane ultrafiltration; it means that lime is not used. This technology is used to remove suspended solids, colloidal impurities, some organic contaminants from the treated water, as well as to remove bacteria, algae and other microorganisms. The ultrafiltration pretreatment technology has the following advantages compared to the coagulation method with liming in clarifiers and treatment of treated water using mechanical filters:

- High quality of clarified water: suspended solids less than 0.1 mg/l; turbidity less than 0.2 NTU; iron less than 0.1 mg/l; manganese less than 0.1 mg/l;
- No need for lime farming - when operating ultrafiltration plants, only periodic hypochlorite and acid flushing of membrane modules is required;

- No need for precise observance of technological parameters (pH, water flow), as required by the operation of clarifiers - whereas, the quality of water treatment remains consistently high;
- Absence of sludge;
- Purification efficiency is 95.0 ÷ 96.0%, that is comparable to the existing lighting technology;
- Significant reduction of production space for the main and auxiliary equipment;
- Easy operation, high degree of automation of the water treatment process;
- Lifetime of ultrafiltration membrane modules is 8-10 years.

1.4.4 Provision of resources during operation

This section provides information on the provision of power units No. 5 and 6 with the main resources for operation, including water, power and fuel.

1.4.4.1 Provision of service water

The existing KhNPP units 1 and 2 service water supply plan is recirculated with a combined type cooling pond: bulk water from the Goryn River and channel water for the Hnylyi Rih River. The service water supply plan for corresponding consumers is a recirculating one with spray ponds. The main facilities include: a cooling pond, supply and discharge canals, block pumping stations, circulation water pipelines and a supplementary water pumping station.

The cooling pond was created by constructing a water retention dam in the valley of the Hnylyi Rih River. The Khmelnytskyy NPP service water reservoir was designed based on the permissible cooling water temperature (no more than 33°C) to replenish losses and remove heat from NPP equipment, taking into account repair schedules.

Units 1 and 2 are currently in operation. In the existing KhNPP service water supply system, fresh water is used to cool the main and auxiliary equipment, as well as to replenish irrecoverable losses in the plant's process cycles. It is discharged to the reservoir:

– from domestic wastewater treatment plants;
– from the neutralization unit (NU);
– from the oily wastewater treatment plant (OWTP);
– from the sludge pond;
– from spray ponds;
– stormwater;
– from the wash water tank;
– drainage water from the industrial site.

The service water supply system of power units No. 5 and 6 is reversed with the use of cooling towers as radiators and is designed using existing hydraulic facilities. The KhNPP cooling pond is the source of water intake for cooling tower feeding and blowdown and for the needs of other process systems in the adopted cooling and service water supply system for KhNPP Units 5 and 6. The water supply system is unified and separate for each power unit.

The designed systems involved in the transportation and cooling of equipment at Units 5 and 6 using AP1000 technology include the SWS, CWS and RWS systems. The SWS and CWS are used to supply cooling water to the components of the AP1000 reactor and turbine units. The intake from the cooling pond and transportation to the SWS, CWS and technological processes of the Westinghouse Electric Company AP1000 plant is performed using the RWS pumping station pumps of Units 5&6.

To assess the availability and possibility of using the water resources of the Goryn River and the pond under different conditions of water availability, the affiliate SS "Atomprojectengineering", JSC "NNEGC "Energoatom", in 2024, performed a water management calculation to determine the need for service water for cooling the main and auxiliary equipment of units 1-4 and feeding the circulation system of two designed units 5 and 6 with AP1000 reactors [83].

Water management balances have been developed for average and low-water years of 50%, 95% and 97% supply at the current level of manufacturing development with the prospective commissioning of units 3&4 with VVER 1000 reactors and units 5&6 with AP1000 reactors.

As a result of calculations of the water balance of the KhNPP cooling pond in a low-water year at 95% supply, it was found:

- The annual intake of circulating water for units 1-6 from the cooling pond is 5514.633 million m^3, including:
  - for cooling the main and auxiliary equipment of units 1-4 and replenishment of irrecoverable losses - 5467.34 million m^3;
  - for feeding the CWS and chemical treatment system of the AP1000 units 5 and 6 - 47.23 million m^3;
- The total annual cooling pond losses are 5607.60 million m^3;
- The annual water inflow to the cooling pond is 5559.60 million m^3;
- There is a need for additional water intake from the Goryn River for the years of 95% supply in the amount of 30.95 million m^3 according to the authorized limit for water intake from the Goryn River for the KhNPP needs – 33.72 mln.m^3.

To substantiate the possibility of meeting the needs of KhNPP for service water supply during the operation of units 5 and 6 under design, in view of the hydrological state and surface water bodies regime located in the area of influence of the planned activity, Vinnytsia National University performed a research work in 2024: "Construction and forecasting of the water balance of the water management site M5.1.4.45 of the Goryn River from the source to the border of Khmelnytskyi and Rivne regions" [84]. The main purpose of this work is to assess the amount of the inflow and release parts of the Goryn River water balance at the current level and at the perspective levels of the KhNPP production activity during the operation of units 1-6, as well as to draw up the water balance of the studied water management area for 50%, 75%, 95% of supply, using the initial data provided by the State Agency of Water Resources of Ukraine, the Central Geophysical Observatory, the Ukrainian Hydrometeorological Center, and the Khmelnytskyi NPP.

Based on the results of these two calculations, we can conclude that the availability of water reserves is sufficient to meet the needs of KhNPP Units 5 and 6 for service additional water from the Goryn River. In a year of 95% availability, the pond is operated according to the scheme of filling the cooling pond in winter and spring with operation in summer months.

To prevent the impact of the planned activities of power units 5 and 6 on the hydrological regime of the Goryn River, it is proposed to use cooling towers with optimal cooling water evaporation losses, regulate water intake from the Goryn River, including the rational operation of the KhNPP units 5 and 6 main equipment, discharge treated industrial, rain and domestic wastewater from power units 5 and 6 into the supply channel for reuse in the NPP cycle, which will reduce the need for additional fresh service water.

1.4.4.2 Provision of potable water

The city of Netishyn and KhNPP are supplied with water through a centralized potable water supply system that also meets the city's firefighting needs. Water is supplied from a water intake located in the northeastern suburb of the town. The source of water intake is non-pressure groundwater. Centrifugal well pumps are used to lift water from artesian wells. Raw water is supplied from artesian wells with a depth of 200-240 meters to the water demineralization station via four collectors. Each artesian well is connected to the main water supply system using water pipes.

The water intake capacity, according to the approved reserves and data provided by the KhNPP utility, is 18 000 m^3/day. The actual average load is from 8000 to 10000m^3/day. According to the Feasibility Study "Construction of Units 3&4", water consumption for the household and potable needs of Units 3&4 is 317.25 m^3/day. According to preliminary calculations, the water consumption for the household and potable needs of units 5&6 is 126.58 m^3/day.

The total water consumption for the household and potable needs of the designed KhNPP Units 3-6 is 444.64m^3/day.

Thus, the design water intake capacity is sufficient to meet the needs of existing and projected consumers.

Commercial accounting of potable water supply is carried out at the off-site demineralization station, which supplies water to the city of Netishyn and through separate water pipelines to the KhNPP site.

Water meters are installed in the designed buildings and structures of power units 5 and 6 at each building inlet where household and potable water supply is provided.

Netishyn is located within the eastern part of the Volyn-Podilskyi artesian basin, in the area of its connection with the Ukrainian crystalline massif.

The existing water intake in Netishyn exploits the Olchedayivska aquifer of the Upper Proterozoic, which is confined to the sandstones of the Horbashivska Formation of the Volynian Series and to the sandstones of the Polissia Series of the Upper Proterozoic.

The closest water intake that uses the same aquifer for centralized water supply is the water intake of Slavutych.

In the area of the wells' location, the Horbashivska Formation aquifer lies at a depth of 150 meters. The thickness of the aquifer is about 35 meters.

Three sanitary protection zones are planned around the wells: Zone I is a "strict" zone; Zones II and III are restricted zones.

Water intake wells are located on the floodplain of the Goryn River. The geological structure of the floodplain consists of modern fourth-quarter alluvial deposits, represented by sands of various sizes, underlain by clays of the Sarmatian layer of the Lower Neogene. The waters of the Gorbashivska Formation aquifer meet the requirements [20] for groundwater sources by the key indicators.

The degree of participation of surface waters in the formation of operational reserves of the water intake aquifer is less than 20%. Thus, as a result of natural filtration (the Horbashivska Formation aquifer is reliably protected by a thick tuff layer of overlying sediments), surface water from the Goryn River does not affect groundwater quality. Operational reserves of 18,000m3/day are secured. Thus, there will be no changes in the surrounding hydrological environment with the increase in water intake.

The aquifers feeding the mine water intakes of the surrounding villages are hydraulically distant from the main aquifer of the Horbashivska Formation feeding the water intake in Netishyn. Therefore, the increase in the flow rate of the water intake in Netishyn will not have an impact on the groundwater and surface water of the surrounding villages.

1.4.4.3 Provision of demineralized water

A chemical water treatment system was designed, which includes a water pretreatment system and the Demineralized Water Treatment System (DTS), to replenish the losses of water, steam and condensate in the steam-water cycle of Khmelnytskyy NPP Units 5 and 6.

Membrane ultrafiltration technology was chosen as the main technological solution for the water pretreatment system. This technology is used to remove suspended solids, colloidal impurities, some organic contaminants from the treated water, as well as to remove bacteria, algae and other microorganisms. The membrane ultrafiltration unit was chosen as a common unit for the two power units. The maximum water flow rate to the pretreatment system is 400.0 m^3/hour. After pretreatment, the water is supplied to a separate demineralized water treatment system (DTS) for each power unit with a flow rate of 125.0 m3/h per unit.

The DTS system receives the prepared water after pretreatment, treats it to reduce ionic impurities and sends it to the Demineralized Water Transfer or Storage System (DWS) for further distribution. The quality of the demineralized water is brought in line with industry standards.

After water treatment in the DTS system, the water is transported to the demineralized water storage tank (DWST) of the Demineralized Water Transfer and

Storage System (DWS), which provides supply and distribution of demineralized water throughout the plant. Water is supplied to demineralized water consumers in the containment, containment building, auxiliary systems building, turbine building, radwaste storage facility, diesel generator building, as well as in the condensate storage tank (CST) in all plant operating modes.

To ensure normal operation of the power units and meet the needs for the demineralized water of the Chemical Feed System (CFS), the Condensate Polishing System (CPS), the Chemical and Volume Control System (CVS), the Rheochemical Laboratory System (RLS), the following are installed: the Demineralized Water Storage Tank (DWST) with a capacity of 477.0m^3 and the Condensate Storage Tank (CST) with a capacity of 2483m^3.

The amount and reserve of demineralized water is sufficient to ensure the plant in all operating modes, including: startup, hot shutdown, shutdown and operation at capacity.

1.4.4.4 Provision of energy resources for NPP operation

To provide power units No. 5 and 6 with the main necessary resources, the following are in operation:

Diesel oil storage tanks (DOS-MT-01-A and DOS-MT-01-B). The Diesel Oil Storage tanks of the DOS system are steel. Each tank has a useful working capacity of approximately 279.0 m^3 of diesel oil for seven days of continuous operation of the diesel generator. The useful working capacity includes an additional 18.9 m^3. The nominal oil consumption of the diesel generator (Caterpillar C280-16) at 5903 kW is 1.54 m^3/hour. Based on the expected load sequence and fuel consumption at demand, the total fuel consumption for a period of seven days is less than 208.0 m^3.

Boric Acid Tank. The Boric Acid Storage Tank (BAST) is designed to store up to 302.8 m^3 of boric acid solution with a concentration of 2.5 weight percent.

Plant gas storage tanks (PGS). The liquid nitrogen storage tank has a volume of 11.36 m^3. It is used to clean the gaseous radioactive waste disposal system, liquid radioactive waste system, and central chilled water system; consumption is 0.46 m^3/hour. Three liquid hydrogen storage tanks with a total capacity of 5.68 m^3 are used to reserve accumulative tanks for liquid radioactive waste treatment.

The main reagents required for the normal power units operation, namely, for pretreatment, as well as for the chemical water treatment system of power units 5 and 6, consisting of a pretreatment system, the Demineralized Water Treatment System (DTS, DWS), a Chemical Feed System for the turbine hall (CFS),the Condensate Purification System (CPS), the Chemical and Volume Control System (CVS), to maintain the water-chemical regimes of the first and second circuits of the power units, there are chemicals that maintain the pH in the system, control dissolved oxygen, control dissolved carbon dioxide, chlorine, biological fouling, disperse trapped sludge, limit scale formation and control corrosion.

Chemicals used for the operation of AP1000 units 5 and 6 are stored in the nuclear island, turbine hall, and NPP site.

The reagent storage facility is designed for receiving, storing and dispensing reagents. The reagent storage building is combined with a pretreatment unit (one for two blocks) with dimensions of 61.0 × 109.0 m. According to the general plan, the reagent storage facility is located at a distance of 22.0 m from the checkpoint and 45.0 m from the control room. According to the master plan, there is a railroad and road access to the storage facility with an unloading area.

The Chemical and Volume Control System (CVS), and the radiochemical laboratory (RLS) add the reagents of the required concentration to maintain the water-chemical regime of the primary circuit. The CVS system provides control of the reactor cooling system (removal of fission products and undesirable impurities, control of hydrogen, lithium hydroxide, hydrazine, hydrogen peroxide, and zinc acetate concentration), provides control of boron concentration (both for adding boric acid and for removing boron to introduce the gray control rod and T_{avg}/T_{cep}). The main components of the CVS system are located in the Auxiliary Building, the Annex, inside the containment, and inside the Containment Vessel. The chemicals used in the extended nuclear island are shown in Table 1.8.

Preparation of reagents for the needs of the Demineralized Water Treatment System (DTS, DWS) is carried out in the reagent farm of the chemical feed system for the turbine island (CFS). The functions of the CFS system using the main reagents are shown in Table 1.9.

Table 1.8 – Chemical reagents used in the expanded nuclear island

Tank	Volume, м^3	Chemical reagents	Form and concentration	System/function	Location
Boric acid solution tank (BAST)	302,8	Boric acid	Liquid solution (2.5 wt. %)	CVS / Neutron absorber and pH buffer for the first circuit coolant	BAST is on the site, at the east end of the annex. The boric acid solution preparation tank is located in the annex.
Hydrogen (liquid)	5,7	Hydrogen	Liquid (100%)	CVS / Oxygen absorber in the first circuit coolant system	Plant gas storage system (PGS) - on the site to the west of the northern end of the turbine building
Lithium hydroxide tank	0,019	Lithium hydroxide 7	Liquid solution (12 wt. %)	CVS / Monitoring the pH of the first circuit coolant system	Annexe building
Hydrazine tank	0,019	Hydrazine	Liquid solution (35 wt. %)	CVS / Oxygen absorber in the first circuit coolant system / AVT	Annexe building, (100 kg), and turbine building, (1 t)
Zinc injection kit	0,76	Zinc acetate	Liquid solution	CVS / injection of zinc acetate into the RCS	Turbine building room

Table 1.9 – The water-chemical regime parameters for systems supplied by the Turbine Island Chemical Feed System (CFS)

System	Chemical agent	Normal values during operation at capacity
Condensate System (CDS)	Oxygen absorber	≤ 0,01 mg/L oxygen
	Chemical for pH control	> 9,0
Main and Startup and Feedwater System (FWS)	Oxygen absorber	≤ 0,002 mg/L oxygen
	Chemical for pH control	> 9,5
Steam Generator Blowdown System (BDS)	Oxygen absorber	< 0.1 mg/L oxygen (cold shutdown / moist parking mode)
	Chemical for pH control	9.8 - 10.5 (cold shutdown / moist parking mode)
Auxiliary Steam Supply System (ASS)	Oxygen absorber	≤ 0,002 mg/L oxygen
	Chemical for pH control	> 9,5
Service water system (SWS)	Chemical for pH control	6,0 – 8,5
	Scale inhibitor	Langelier index 0.0 - 1.0
	Sludge disperser	150 mg/l of suspended solids
	Biocide	0.0005 - 0.001 mg/l residual chlorine
	Non-oxidizing biocide	< 10 CFU/ml Legionella
Demineralized Water Treatment System (DTS)	Caustic (CO_2 control)	> pH 9,0
	Chlorine control	<0.001 mg/l residual chlorine
	Scale inhibitor	Langellier index 0.0 - 1.0

Reagents for maintaining the water-chemical regime of the second circuit are prepared at each power unit in a separate building.

Each demineralization unit uses a mixture of lithiated cationic and anionic resin. Both forms of resin remove fission and corrosion products.

The quality of the filter materials (ion exchange resins) used to maintain the water-chemical regime (WCR) must meet the requirements of ISO-NNEGC 1.013:2014 [21].

All the necessary reagents in the form of concentrated solutions or dry form are supplied to the CWT reagent storage and then sent to the reagent preparation unit. Table 1.10 shows the consumption of basic reagents for one power unit.

Table 1.10 – List of basic reagent needs for one power unit (indicative)

Chemical reagent	Annual demand for one power unit	Type of delivery/transportation
Boric acid H3BO3 grade A	20,0	By railroad cars
Aqueous ammonia technical NH_3 grade A, high grade, 25%	29,5	By railroad tankers or special vehicles in glass bottles
Carbohydrazide, 10%	15,5	By rail or road in barrels made of corrosion-resistant steel
Hydrazine hydrate N_2H_4, 35 %	2,0	By rail or road in barrels made of corrosion-resistant steel
Sodium hydroxide 20%	10,0 ÷ 25,0	By rail tankers with boilers made of corrosion-resistant steel, by rail or road in tall or polyethylene barrels, in 15 kg canisters
Sodium hypochlorite	20,0 ÷ 60,0	By rail in special rubberized tanks
Hydrochloric acid solution 14%	5,0 ÷ 15,0	By rail or road in steel "sulfuric acid" tanks, barrels or glass bottles
Sulfuric acid contact technical H2SO4, 92%	250,0	By rail or road in steel "sulfuric acid" tanks, barrels or glass bottles

Chemical reagent	Annual demand for one power unit	Type of delivery/transportation
Morpholine, 41%	2,5	By rail or road in barrels or canisters of 200 kg
Coagulant	60,0	By road or rail in tanks with a corrosion-resistant coating

1.4.4.5 Fuel provision

The AP1000 core consists of 157 Class C fuel assemblies, 53 Class B rod cluster control assemblies (RCCAs), 16 gray rod cluster assemblies (GRCAs), and 4 (2 primary and 2 secondary) neutron source assemblies. Neutron sources are usually required only for the initial cycle. Burnup absorbers are typically used to compensate for some installed excess reactivity and to ensure that the moderator temperature coefficient is maintained at a negative value.

Fuel rod. The rods consist of ceramic uranium dioxide pellets contained in tubes of ZIRLO™ alloy, which are plugged and welded at the ends to seal the fuel. [redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Fuel cycle duration and fuel batch size. The standard fuel cycle duration of the AP1000 project is 18 months, which is optimal in terms of fuel efficiency. The requirements for the cycle 1 fuel loading batch size are 157 new assemblies. The cycle 1 reactor load is designed to provide full capacity during 465 effective days.

New nuclear fuel storage. The fuel storage facility provides on-site storage of a sufficient number of new fuel assemblies to be replaced at each outage for fuel cycles up to 18 months. This is usually about 40% of the fuel assemblies.

1.5 Assessment of the expected wastes, emissions (discharges), water, air, soil and subsoil pollution, noise, vibration, light, heat and radiation pollution by type and amount, as well as radiation caused by the preparatory and construction activities and the planned activity

The operation of any large industrial facility involves certain environmental impacts. NPP is a source of radiation, chemical, thermal, electromagnetic and noise impacts.

The key component of NPP environmental impact is related to the specifics of electricity generation using energy released as a result of nuclear reactions – radiation impact. The NPP radiation environmental impact is determined by releases and discharges of radioactive substances both during normal NPP operation and in the event of accidents. The main sources of radioactive substances at NPP with VVER reactors are uranium-235 fission products during core fuel neutron irradiation, neutron activation of structural materials, primary coolant impurities and air in the reactor space.

The amount of radioactive substances released to the environment, under other equivalent conditions, during normal operation directly depends on the primary circuit activity and during accidents on the fuel activity, the activity under fuel cladding and the primary circuit activity.

KhNPP under operation may have the following impact on the air environment and microclimate:

- radioactive gaseous discharge;
- non-radioactive releases;
- heat and moisture releases from the cooling system ponds (cooling and spray ponds);
- noise, electromagnetic radiation.

1.5.1 Contamination assessment

The construction of power units using the Westinghouse's AP1000 technology at KhNPP is carried out in compliance with the current regulations on environmental protection against radioactive contamination in Ukraine, as well as radiological protection and radiation safety of personnel and the public [22, 23, 24].

In accordance with the requirements of [22], radiation safety and protection in relation to practical activities are based on the following basic principles:

– any practical activity that involves exposure of people shall not be carried out unless it brings greater benefit to the exposed persons or society as a whole compared to the harm it causes (the principle of justification);
– exposure levels from all significant practical activities shall not exceed the established dose limits (the principle of non-exceedance);
– individual dose levels and/or the number of exposed persons in relation to each radiation source shall be as low as reasonably achievable including economic and social factors (optimization principle).

In accordance with the provisions of regulatory documents, the limits are set with the following criteria:

– internal and external exposure of personnel and the public;
– maximum permissible emissions and discharges of radioactive substances into the environment.

According to the Ukrainian legislation on radiation safety, critical groups are divided into the principle of direct work with radiation sources, by gender and reference age.

In accordance with the provisions of [22] the following categories of persons exposed to radiation are established:

– Category A (personnel) – persons who permanently or temporarily work directly with sources of ionizing radiation.
– Category B (personnel) – persons who are not directly involved in work with sources of ionizing radiation, but due to the workplace location in the facility rooms and industrial sites with radiation and nuclear technologies may receive additional exposure.
– Category V – the entire population.

In terms of gender, Ukrainian NPPs have established restrictions on the exposure of pregnant women and women of reproductive age.

In addition, by reference age, the distribution is divided into the following age groups: 3 months, 1 year, 5 years, 10 years, 15 years, and “Adult”.

The numerical values of the received dose limits are set at levels that exclude the possibility of deterministic exposure effects and at the same time guarantee such a low probability of stochastic exposure effects that it is acceptable for both individuals and society as a whole. Dose limits are given in Table 1.12.

Table 1.12 – Radiation dose limits (mSv/year)

	Category of the exposed persons		
	A [a) b)]	**B** [a)]	**V** [a)]
DL_E (effective dose limit)	20 [в)]	2	1
Equivalent external dose limits:			
DL_{lens} (for the eye lens)	150	15	15
DL_{skin} (for the skin)	500	50	50
DL_{extrim} (for the hands and feet)	500	50	-

Notes:
a) radiation dose distribution during a calendar year is not regulated;

b) for the childbearing age women (up to 45 years) and for pregnant women, the restrictions of Clause 5.6, NRBU-97 apply;
c) on average for any consecutive 5 years, but not more than 50 mSv in a single year (DL_{max}).

Public exposure is limited through regulation and monitoring:

– radionuclide intake through the respiratory system (ALI_{inhal} V) and digestion (ALI_{ingest});
– radionuclide concentration in air (PC_{inhal} V) and drinking water (PC_{ingest});
– permissible environmental discharge and release.

1.5.1.1 Radiation exposure during construction

No additional radiation impact is expected during the construction of AP1000 units, given the low values of the construction site contamination (within the background contamination values of the adjacent territory).

The AP1000 construction is carried out at the existing plant site, which has been in operation since the start of KhNPP construction, so no compensation measures are required.

The data on the radiation situation give the following grounds:

– not to limit the time spent by personnel at workplaces;
– construction wastes are not be classified as radioactive waste.

1.5.1.2 Radiation exposure during normal AP1000 units operation

For the relevant radiation and nuclear facilities, a dose limit quota is set for exposure of category V persons due to radioactive releases and discharges [22]. Dose limit quotas are given in Table 1.13.

Table 1.13 – Annual dose limit quotas used to set permissible discharges and permissible emissions

Source	**DL quota due to all dose formation pathways from releases**		**Discharges: DL quota due to critical water use**		**Total DL quota for an individual enterprise**	
	%	**µSv**	**%**	**µSv**	**%**	**µSv**
NPP, NCP, NHP	4	40	1	10	8	80

The permissible discharges and releases are set based on the dose limits quota for each individual NPP. The development and approval of permissible discharges and releases values are performed in accordance with the procedure established by the Ministry of Health of Ukraine.

When establishing the permissible discharges and releases values, the migration of radionuclides in the environment and in food chains are considered, as well as land use structure and actual water bodies use (recreation, fishing and fish farming, irrigated agriculture, water bodies for livestock, presence of flooded meadows, etc.)

Exceeding the permissible releases and discharges under normal NPP operation is not allowed.

The release limit is set for the entire NPP, regardless of the operating units number.

The radiation impact from units 5 and 6 is additional to the operating NPP impact.

Liquid, solid and gaseous radioactive waste is inevitably generated during NPP operation. The sources of radioactive waste generation are NPP equipment and systems containing gaseous, liquid, and solid media.

GRW – volatile emissions (aerosols) of the primary coolant that occur during maintenance, small leaks, and fugitive coolant leaks.

LRW – generated during operation and maintenance of the reactor main and auxiliary equipment, balance of plant containing radioactive media or that is contaminated.

SRW includes spent reactor internals, pump parts, pipelines, valves, thermal insulation, ventilation system filters, wiping materials, cotton and film overalls, used PPE, various construction waste, etc.

The AP1000 unit provides a radioactive waste treatment and management system to support the expected waste generation from plant operation, and provides the flexibility and space to install mobile systems during emergency situations and special waste treatment systems that may be required in the event of such situations. Below is a list of the AP1000 radioactive waste treatment systems:

– Gaseous Radwaste System (WGS);
– off-site Liquid Radwaste System (WLS);
– Radioactive Waste Drain System (WRS);
– Solid Radwaste System (WSS).

1.5.1.3 Gaseous radwaste sources

The AP1000 reactor is designed to accept all potentially hydrogen-containing and radioactive gases generated during plant operation. The largest amount of gaseous waste is generated during plant operation at the end of the fuel cycle. Gaseous radioactive waste includes:

– gas blowdowns, non-condensable gases and volatile aerosols from equipment operating on radioactive media;
– air that is removed from workspaces.

Gases that accumulate in the primary circuit during operation are removed from it. This leads to the formation of a gaseous radwaste flow. Gaseous emissions can also be generated as a result of ventilation of volatile emissions of the primary coolant arising from small leaks, controlled and fugitive leaks. Gaseous waste is treated before being released to the atmosphere.

Expected radionuclide releases during normal and abnormal operation modeled on the basis of input data obtained from PWR NPP operation experience are presented in Table 1.14 and are conservative.

Table 1.14 – Expected iodine release during normal and abnormal operation

Nuclide	Activity Release (GBq/yr) of Airborne Gases					
	Fuel Handling Area	**Containment Building**	**Auxiliary Building**	**Turbine Building**	**Condenser Air Removal System**	**Total Release**
I-131	7.4E-03	1.9E-02	1.8E-01	2.4E-03	9.6E-04	2.1E-01
I-133	1.1E-02	7.4E-02	2.6E-01	7.4E-04	3.0E-03	3.5E-01
Total Airborne Radioiodine						5.6E-01

Note: Values less than 3.7E-5 GBq/yr are considered to be negligible.

At the design stage, such data will be revised using the baseline data for Ukraine and recalculated using software tools (calculation codes) to substantiate the safety of nuclear power plants approved in accordance with the Company's procedure. The expected radioactive noble gases emissions under normal and abnormal operation are shown in Table 1.15.

Table 1.15 – Expected discharges of radioactive noble gases under normal and abnormal operation

Nuclide	Activity Release (GBq/yr) of Airborne Gases					
	Waste Gas System	**Containment Building**	**Auxiliary Building**	**Turbine Building**	**Condenser Air Removal System**	**Total Release**
Kr-85m	4.6E-01	1.4E-01	1.6E+01	8.5E-04	7.8E+00	2.4E+01
Kr-85	3.0E+03	1.1E+01	5.2E+01	2.9E-03	2.6E+01	3.1E+03
Kr-87	negligible	4.4E-02	1.7E+01	2.6E-04	2.2E+00	1.9E+01
Kr-88	6.7E-03	1.0E-01	1.8E+01	9.6E-04	8.5E+00	2.7E+01
Xe-131m	1.1E+03	3.1E+01	1.8E+02	9.3E-03	8.1E+01	1.4E+03
Xe-133m	3.6E-02	6.7E+00	7.4E+01	4.1E-03	3.5E+01	1.1E+02
Xe-133	2.4E+02	8.9E+01	6.3E+02	3.3E-02	2.9E+02	1.3E+03
Xe-135m	negligible	6.7E-02	1.3E+02	7.0E-03	5.9E+01	1.9E+02
Xe-135	negligible	3.1E+00	1.7E+02	2.9E-02	2.6E+02	4.4E+02
Xe-137	negligible	negligible	3.4E+01	1.8E-03	1.6E+01	4.8E+01
Xe-138	negligible	2.9E-02	5.9E+01	3.3E-03	2.9E+01	8.9E+01
Total Noble Gas						6.7E+03

Note: Values less than 3.7E-5 GBq/yr are considered to be negligible.

The expected aerosol emissions under normal and abnormal operation are shown in Table 1.16.

Table 1.16 – Gaseous discharge of particulates during normal and abnormal operation

Nuclide	Activity Release (GBq/yr)				
	Waste Gas System	Containment Building	Auxiliary Building	Fuel Handling Area	Total Release
Cr-51	negligible	negligible	1.2E-04	6.7E-05	2.3E-04
Mn-54	negligible	negligible	negligible	1.1E-04	1.6E-04
Co-57	negligible	negligible	negligible	negligible	negligible
Co-58	negligible	9.3E-05	7.0E-04	7.8E-03	8.5E-03
Co-60	negligible	negligible	1.9E-04	3.0E-03	3.2E-03
Fe-59	negligible	negligible	negligible	negligible	negligible
Sr-89	negligible	4.8E-05	2.8E-04	7.8E-04	1.1E-03
Sr-90	negligible	negligible	1.1E-04	3.0E-04	4.4E-04
Zr-95	negligible	negligible	3.7E-04	negligible	3.7E-04
Nb-95	negligible	negligible	negligible	8.9E-04	9.3E-04
Ru-103	negligible	negligible	negligible	negligible	negligible
Ru-106	negligible	negligible	negligible	negligible	negligible
Sb-125	negligible	negligible	negligible	negligible	negligible
Cs-134	negligible	negligible	2.0E-04	6.3E-04	8.5E-04
Cs-136	negligible	negligible	negligible	negligible	negligible
Cs-137	negligible	negligible	2.7E-04	1.0E-03	1.3E-03
Ba-140	negligible	negligible	1.5E-04	negligible	1.6E-04
Ce-141	negligible	negligible	negligible	negligible	negligible
Total Particulates					1.7E-02

Note: Values less than 3.7E-5 GBq/yr are considered to be negligible.

1.5.1.4 Liquid radwaste sources

The system for handling liquid contaminated media includes subsystems that can be used to treat and dispose of liquids containing radioactive material.

The main sources of liquid radioactive waste generation at the AP1000 facilities are:

– the primary coolant;
– decontamination water generated during decontamination activities at NPP equipment;
– controlled and fugitive leaks from equipment containing liquid radioactive media;
– steam generator blowdown water;
– drainage water coming from the Radioactive Waste Drain System (WRS);
– others.

Before liquid waste is discharged and throughout its management, it is mandatory to monitor and control the compliance of radiation parameters of the process environment.

The AP1000 plant is designed to provide adequate capacity to treat the anticipated wastes. The AP1000 plant also includes provisions for a connection to mobile equipment in the event that liquid radwaste production exceeds the anticipated volume, or for other situations such as unusual impurity content or prolonged equipment unavailability.

The projected radwaste flows in the WLS system under normal operation are shown in Table 1.17.

Table 1.17 – The projected liquid radwaste flows for the radwaste management system under normal operation conditions

Collection Tank and Sources	**Expected Input Rate**	**Activity**	**Treatment Strategy**
Effluent Holdup Tanks			
CVS Letdown	601.9 m^3 /yr	100% of Reactor Coolant	Degassed, filtered, demineralized, monitored, and discharged.
Leakage Inside Containment (to Reactor Coolant Drain Tank)	0.04 m^3 /day	167% of Reactor Coolant	
Leakage Outside Containment (Relief Valve Leakoffs Piped to Effluent Holdup Tanks)	0.30 m^3 /day	100% of Reactor Coolant	
Sampling Drains	0.76 m^3 /day	100% of Reactor Coolant	
Waste Holdup Tanks			
Reactor Containment Cooling	1.89 m^3 /day	0.1% of Reactor Coolant	Degassed, filtered, demineralized as required, monitored, and discharged.
Spent Fuel Pool Liner Leakage	0.10 m^3 /day	0.1% of Reactor Coolant	
Floor Drains	2.56 m^3 /day	0.1% of Reactor Coolant	
Chemical Wastes (Detergent Waste)			
Hot Shower	0 m^3 /day	10^{-7} μCi/g	Filtered, monitored, and discharged. If necessary, processed with mobile equipment.
Hand Wash	0.76 m^3 /day	10^{-7} μCi/g	
Equipment and Area Decontamination	0.15 m^3 /day	0.1% of Reactor Coolant	
Laundry	Laundry waste is treated offsite		
Chemical wastes	0.01 m^3 /day	≤ reactor coolant	

1.5.1.5 Solid radwaste sources

The main solid radioactive wastes from the AP1000 reactors for which the system is designed can be identified as follows:

– spent ion exchange resins;
– spent filter cartridges;
– dry active wastes and mixed wastes generated as a result of plant equipment operation, containing contamination;
– other.

The Solid Radwaste System collects spent ion exchange media and filters from the Chemical and Volume Control System, the Spent Fuel Pool Cooling System, and the Liquid Radioactive waste System. The spent ion exchange media is stored within two spent resin tanks in the Auxiliary Building. See Table 1.18 for details on the spent resin tank. The data on solid radwaste during normal operation and anticipated operational occurrences are presented in Table 1.19.

Table 1.18 – Spent Resin Tanks

Tank Name	Tag Number	Building and Location	Usable Volume
Spent Resin Tank A	WSS-MV-01A	Auxiliary Building Room 12373	7.0 m^3 (250 ft^3)
Spent Resin Tank B	WSS-MV-01B	Auxiliary Building Room 12373	7.0 m^3 (250 ft^3)

Table 1.19 – The forecasted SRW flows at the AP1000 plant

RAW Description	RAW Classification	Frequency	Average volume per unit (m^3)	Maximum volume per unit (m^3)	Emissions for the entire period of operation (m^3)
Ion exchange resins	intermediate level	40%/18 months	7,8	15,6	561
Gray rod clusters	intermediate level	Annually	1,7	-	5,1
Control rod clusters	intermediate level	1 time/20 years	5,6	1,1	16,9
Wet granular carbon sorbent	intermediate level	1 time/20 years	0,6	0,4	41
Metal filter element cartridge	intermediate level	Annually	0,2	206	13,7
Pressed paper, films, clothing, plastics, elastomers	low level	Annually	135	1,06	8924
Non-sealed metal objects, glass, wood	low level	Annually	6,6		455
HVAC filters - unsealed fiberglass/metal	low level	Miscellaneous		7,7	761
Spent ion exchange resins from the condensate treatment system	low level	Annually	3,9	3,3	69,3
Dry granular carbon sorbent	low level	Annually	0,3	-	54,3
HVAC system filters - granular coal	low level	1 time/10 years	4,9	-	29,1
Compressed rigid plastic - gaskets, valve seals, insulation	low level	Miscellaneous	-	-	7,6
Electrodeionization unit - resin/membrane module	low level	1 time/12 years	1,7	-	10,8
Heat exchanger insulation	low level	1 time/60 years	8,4	-	8,4

1.5.2 Assessment of non-radiation pollution

According to the Constitution of Ukraine [25], the state policy of Ukraine is aimed at ensuring environmental safety and maintaining the ecological balance in the territory of Ukraine. For that purpose Ukraine pursues an environmental policy on its territory aimed at preserving a safe habitat for wildlife and inorganic nature, protecting the life and health of the population from the negative impact caused by environmental pollution, achieving harmonious interaction between society and nature, and protecting, rationally using and restoring natural resources [25, 26].

1.5.2.1 Air emissions assessment

The assessment of air pollutant emissions is carried out both during the preparatory and construction activities and during operation. When operating mobile and stationary fugitive emission sources, the assessment is carried out in accordance with the methodology for calculating air pollutant concentrations from emissions (according to OND-86) for surface emission sources. At the same time, the emission capacity of a mobile source is determined by the calculation method in accordance with the calculation methodologies.

Environmental impact assessment during preparatory and construction activities During the preparatory and construction activities, some air pollution will be associated with the operation of construction and transport equipment (exhaust emissions from internal combustion engines). Prior to the start of the main construction and installation activities, the preparatory activities specified in clause 1.3.3 shall be performed.

The following works cause the negative environmental impact during the construction of power units:

- soil development to install the technological equipment, structures, pipelines, and other engineering networks;
- road surface arrangement;
- installation works.

The need for construction and transport equipment for the construction and installation works is given in clause 1.3.3 in the Tables 1.1, 1.3, 1.4.

Construction and transport equipment that operates simultaneously during the facility construction is shown in Table 1.20.

Table 1.20 – List of equipment operating simultaneously

Name	Model	Quantity	Notes
Backhoe excavator	EO-4121	1	A bucket capacity of 1.0 m^3
Backhoe excavator	EO-4321	2	A bucket capacity of 0.65 m^3
Universal excavator	EO-2621	2	A bucket capacity of 0.25 m^3
Bulldozer	DZ-53 or DZ-54	2	Engine power 82 kW
Bulldozer	DZ-9 or DZ-33	1	Engine power 129 kW
Autocrane	LTM series telescopic autocrane	3	Load capacity 75 – 100 tons
Self-propelled modular transporter	Goldhofer SPMT	2	Load capacity 15000 tons per axle
Dump truck		5	Load capacity 8.0 - 27 tons
Drop-side truck		5	Load capacity 5.0 - 12 tons
Tractor truck		2	Load capacity 8.0 - 70 tons
Truck mixer		5	Capacity 4.0-6.0 m^3
Truck mounted concrete pump		2	Capacity 80 m^3/h
Total		32	

The calculation of pollutant emissions from transport and construction equipment during the construction was performed in accordance with the Methodology for Calculating Pollutant Emissions from Mobile Sources, 1999, published by UkrNTEK OJSC.

The average diesel fuel consumption of 8 liters per hour was used in the calculation. The density of diesel fuel – 0.85 kg/l.

The calculation results of pollutant emissions from machinery are shown in Table 1.21.

Table 1.21 – Pollutant emissions from transport and construction equipment

Pollutant	Specific emissions, kg/t	Coefficient of equipment technical condition	Fuel consumption*, t/h	Pollutant emissions, g/s*
	Diesel fuel			
301 Nitrogen dioxide	32.8	0.95	0.007	0.061
328 Soot	3.85	1.8	0.007	0.013
330 Sulfur dioxide	5.0	1.0	0.007	0.010
337 Carbonic oxide	32.0	1.5	0.007	0.093
2754 Hydrocarbons C12-C19	5.65	1.4	0.007	0.015

Note*: fuel consumption and pollutant emissions are given for one piece of equipment (excavator, bulldozer, crane, dump truck, etc.).

Gross emissions of pollutants from all equipment used during the facility construction (tons/construction period) will be calculated at the project development stage.

The calculation of pollutant dispersion in the surface air layer for the facility construction period was performed according to the OND-86 methodology, using the EOL 2000 [h] software package for all simultaneously operating construction and transport equipment.

Ground-level pollutant concentrations were determined in a calculated square with a side size of 8000 m and a step of 250 m. The control points were selected as the points of the sanitary protection area boundary and on the border of the nearest city of Netishyn.

The calculation was performed for the warm season, including the background concentrations in Netishyn, issued by the Khmelnytskyy Regional State Administration on June 02, 2023.

The records for calculating the airborne pollutant dispersion for the construction period is in Appendix C.1.

The calculation analysis of the surface pollutant emission concentrations shows that during construction activities the pollutant emission impact is limited to the KhNPP industrial site.

Assessment of the airborne pollutant emissions for the facility operation period

The main KhNPP operating units for the existing power units 1 and 2, which have sources of air pollutants, are as follows:

- a hydroengineering shop, consisting of a start-up and backup boiler house, an oil, fuel oil and diesel facility, and repair workshops;
- a power repair unit with repair and mechanical workshops and shops;
- a turbine shop – turbine halls of units 1 and 2.

During the operation of units 5 and 6, the air will be polluted by the releases from the designed diesel fuel tanks, buildings: turbine building, diesel generators, repair and mechanical workshop, internal passage of vehicles (during arrival and departure from the parking lot).

The calculations of the polluted releases rate from the designed sources (No. 1001-1051) with referenced methods are in Appendix L. The location of the designed pollutant sources is shown on the general plan of units 5 and 6 in Appendix H.6.

The calculation of the pollutant dispersion in the surface air layer for the period of the facility's operation was performed using the EOL 2000h v 4.0 program, which implements the OND-86 methodology.

The calculation was performed for the designed equipment of units 5 and 6, including the existing main pollutant sources of emissions from units 1 and 2, the designed pollutany sources from units 3 and 4, as well as background pollutant concentrations in the facility impact area (Netishyn). The calculation includes the simultaneous operation of power and technological equipment.

The values of background pollutant concentrations in the facility impact area (Netishyn), issued by the Khmelnytskyi Regional State Administration dd 02.06.2023, are given in Appendix E.

The pollutant parameters are given in Appendix M.

During the calculation, the ground-level air pollutant concentrations were determined at two control points selected in the direction of Netishyn - on the SPZ border and the settlement.

The calculation results of the air pollutant dispersion for the period of facility operation are presented in Appendix C.2.

Based on the dispersion calculation, no exceedances of pollutant concentrations are expected on the SPZ border and the nearest settlement (Netishyn) during the KhNPP operation.

1.5.2.2 Assessment of discharges and water pollution

The preparatory and construction activities. No additional negative impact sources on the hydrosphere are expected during the construction of units No. 5 and 6. Temporary residential and storage facilities at the construction site have water supply and sewerage systems. Domestic drinking water for these temporary facilities is provided through existing utilities. Wastewater is discharged into existing sewage systems. No wastewater is expected to be generated or discharged into the environment.

Operation. Production activities may have an impact on surface and groundwater.

Surface water. The impact of KhNPP production activities on surface water is in places of direct contact of NPP process components and facilities with surface water bodies of public use, i.e. with the cooling pond.

The KhNPP cooling pond was built for the plant process needs based on the permissible water cooling temperature of 33 °C [27], to remove heat from the 4000 MW NPP equipment (4 power units), including outage schedule. Under the most unfavorable "hot" climatic conditions and the most unfavorable wind situations, the thermal calculation of the KhNPP cooling pond, including the construction of AP1000 units 5 and 6, performed by the affiliate SS "Atomprojectengineering" in 2023, showed the following:

– during the operation of two units in summer, the water temperature in the underwater channel (at the turbine condenser inlet) is 24.4-25.5 °C;
– during the operation of three units in summer, it is 30.0-30.8 °C, which is less than the regulatory temperature value of 33.0 °C [27];
– during the operation of four units in summer, the water temperature is 33.0-33.2 °C and will already reach the critical temperature under process conditions of 33,0°C [27];
– during the operation of units 5 and 6 – according to the AP1000 process flow diagram, developed by Westinghouse, the purge water from the tower cooling basin of the CWS system is combined with the purge flow from the SWS system, taken from the pump discharge header and sent to the purge sump of the wastewater collection and disposal system for further discharge into the KhNPP cooling pond. Based on the operating conditions of the cooling and blowdown water removal scheme, it can be concluded that the cooling pond receives water already cooled to ambient temperature. That is, the operation of power units 5 and 6 will not affect the value of additional evaporation from the reservoir and the temperature regime in the reservoir as a whole.

When units 3 and 4 are commissioned at the permissible cooled water limit temperature of 33.0 °C, the cooling pond can provide NPP capacity of no more than 3240 MW. Additional cooling of the circulating water is required to ensure NPP capacity of 4000 MW. To ensure NPP capacity of 4000 MW or more, additional cooling of the circulating water is required. When developing the feasibility study of units 3 and 4 [28], the UkrNIIEP Institute designed a 1300.0 m long flow control dam.

The dam height is from 5.0 m to 9.0 m, depending on the depth, with the crest mark at 205.00 m. The width of the dam crest is 12.0 meters. The slope of the dam to the 203.00 m mark is 1:3. The slope of the dam in the underwater part is 1:5. To avoid washing away of the alluvial soil, it is planned to fix the alluvial slopes with 1.0 m thick stone riprap.

The length of the flow control dam of 1300.0 m is minimal to ensure full utilization of the reservoir area and cooling of the circulating water. Cooling efficiency is increased in this case by redistributing water flows and increasing the core of the transit flow and whirlpool. This allows cooling the circulating water during the operation of three units to 27.7 °C in the conditions of hot decade meteorological factors and to 29.6 °C during the operation of four units.

The dam will be constructed under the units 3&4 construction project implementation and will allow to improve the efficiency of cooling the recycled water in the pond and guarantee the necessary temperature conditions for the operation of six units even in the most unfavorable "hot" hydrometeorological conditions.

Groundwater. The stationary groundwater monitoring network includes 189 wells. The purpose of hydrogeological monitoring is to control the stability of groundwater regime criteria (level, temperature, chemical composition) and assess the impact of technogenic factors on groundwater.

During the operation of units 1 and 2, the NPP technogenic impact had almost no effect on the groundwater level, but affected its chemical composition and temperature as a result of the industrial water infiltration into the soil due to leaks from water supply lines. It should be emphasized that, according to the monitoring data, chemical and thermal contamination of groundwater and hydraulically connected in the upper part of the Upper Proterozoic horizon is localized only within the NPP site; the background (i.e., unaffected by technogenesis) values of groundwater chemical composition and temperature were recorded on the site periphery. At the same time, within the industrial site, there is not a continuous field of technogenically polluted groundwater, but rather disconnected local areas where groundwater is characterized by increased mineralization and temperature.

Seasonal fluctuations in the groundwater level averaged 0.5m in 2017, 0.56m in 2016, 0.7m in 2015, 0.52m in 2014, 0.72m in 2013, and 0.73m in 2012. Groundwater levels are stable and respond only to seasonal climate changes.

The difference in groundwater temperature within the industrial site is 10.0 °C. The background temperature is between 9.0 °C and 10.0 °C. The water temperature of the Upper Proterozoic aquifer, as well as the groundwater temperature, is also higher than the background temperature in some areas. The background temperature is 10 °C.

The range of temperature fluctuations within the industrial site is 10.5 °C, with a maximum of 20.5 °C.

The chemical composition of groundwater has been gradually changing in recent years. The mineralization changing during recent years is shown in Table 1.22:

Table 1.22 – The mineralization changing during recent years

	2012	2013	2014	2015	2016	2017	2019	2020	2021	2022	2023
Ground water, mg/l	342.36	406.42	423.72	552.91	541.19	605.26	676.98	-	996.40	901.71	869.11
Upper Proterozoic aquifer, mg/l	401.11	475.4	487.38	564.97	620.99	586.68	624.84	644.78	724.84	717.92	610.37

It is not possible to fully predict quantitative changes in the chemical composition and temperature of groundwater associated with the technogenic impact of NPP facilities, as there are no input data for such a quantitative forecast (possible losses of chemically contaminated and hot water are unpredictable).

1.5.2.3 Assessment of the expected wastes

In the course of ***production activities***, certain non-radioactive wastes may be generated (see also Table 1.23), namely:

- saturated ion exchange resins (damaged or spent);
- waste materials used for water disinfection and purification (anthracite chips, sulfonated carbon);
- activated carbon (faulty or spent);
- waste materials used in water extraction, treatment and distribution (waste slaked lime);
- process waste and waste from distribution of electricity, gas, steam and hot water, not otherwise designated (waste heat insulation);
- mixed waste from the construction and demolition of buildings and structures (roofing material waste, broken concrete, broken bricks, glass, etc;)
- fragments of porcelain and semi-porcelain;
- waste from the wastewater treatment plants operation, not otherwise designated (sand);
- other industrial and process waste, not otherwise designated, or waste from combined processes of drinking or service water preparation;
- lumpy wood waste;
- crushed artificial sand from volcanic slag (perlite sand);
- crushed stone and sand from industrial waste.

Table 1.23 – List of the expected wastes

Waste Code as per the National Waste List	Waste Name as per the National Waste List	Production Waste Name	Amount of Waste per year, tons
20 01 21*	Fluorescent lamps and other mercury-containing waste	Fluorescent lamps	2.220 (7398 pcs)
06 04 04*	Mercury-containing waste	Instruments containing mercury (manometers, oscilloscopes, normalizers, thermometers, etc.)	0.007
16 06 01*	Lead batteries	Spent lead batteries and lead waste	39.276
13 02 05*	Mineral oils, non-chlorinated motor, transmission and lubricating oils	Used mineral turbine oils	4.031

Waste Code as per the National Waste List	**Waste Name as per the National Waste List**	**Production Waste Name**	**Amount of Waste per year, tons**
20 01 35*	Electrical and electronic equipment waste other than those specified in codes 20 01 21 and 20 01 23 containing hazardous components	Spent paper insulation polluted with oil products	3.241
17 06 03*	Other insulating materials consisting of or containing hazardous substances	Spent silica gel polluted with oil products	2.070
06 05 02*	Sediments (sludges) from wastewater treatment at an enterprise containing hazardous substances	Sediment, sludges polluted with oil products	29.253
05 01 03*	Bottom sludge (sediment, silt) at the tank bottom	Sludge from tank cleaning polluted with oil products	8.000
20 01 34	Batteries and accumulators other than those specified in code 20 01 33	Used batteries	0.185
13 07 03*	Other fuels (including mixtures)	Spent blends (ethanol-gasoline, gasoline, diesel fuel, oils, etc.)	1.871
16 01 07*	Oil filters	Used automotive fuel and oil filters	1.000
15 02 02*	Absorbents, filter media (including oil filters not otherwise specified), wiping rags and protective clothing polluted with hazardous substances	Wiping materials and overalls polluted with oil products	5.750
2000.3.1.16 (DK 005-96)	Off grade ties for railway or tram tracks	–	20.977
16 02 14	Equipment waste other than specified in codes from 16 02 09 to 16 02 13	Waste electronic equipment: monitors, laptops, printers, servers, keyboards, mice, telephones, etc.	0.423
16 01 03	Used tires	Used tires	13.454
03 01 04*	Sawdust, shavings, scraps, wood, chipboard and veneer containing hazardous substances	Oiled sawdust, filters from car wash treatment facilities	0.728
16 02 09*	Transformers and condensers containing polychlorinated biphenyls (PCBs) or polychlorinated terephthalates (PCTs)	Used transformers and condensers	0.014
16 02 15*	Hazardous components removed from waste equipment	Spent cartridges and filters for cleaning cartridges	0.604
20 01 32	Medicines other than those specified in code 20 01 31	Drugs and medicinal substances expired	0.002

Waste Code as per the National Waste List	Waste Name as per the National Waste List	Production Waste Name	Amount of Waste per year, tons
16 02 12*	Waste equipment containing free asbestos	Used asbestos, ebonite, textolite, fiberglass, paronite parts or materials	2.817
10 01 26	Waste from cooling water treatment (purification)	Sludge from water desalination	195.328
19 08 06*	Saturated or used ion exchange resins	Used filtration material polluted with oil products: sipron, birch charcoal, ion exchange resins, anthracite chips, sulfonated carbon	35.625
17 06 04	Insulating materials other than those specified in codes 17 06 01 and 17 06 03	Waste thermal insulation material	26.000
17 09 04	Mixed construction and demolition waste other than that specified in codes 17 09 01, 17 09 02, 17 09 03	Construction waste	999.636
10 13 04	Burning and lime slaking waste	Waste slaked lime	70.000
19 08 05	Sludge from municipal wastewater treatment	Sludge from municipal wastewater treatment	75.468
19 08 02	Waste from sand removal	Spent sand from wastewater treatment	32.304
17 02 01	Wood	Lumpy wood waste	112.126
20 03 01	Mixed domestic waste	Domestic waste	1202.990
06 10 99	Other waste in this subgroup	Spent extinguishing powder	0.970
16 01 18	Non-ferrous metals	Non-ferrous scrap	30.705
16 01 17	Ferrous metals	Ferrous scrap including electrodes	515.297
15 01 04	Metal packaging	Polluted metal containers	0.293
08 02 99	Other waste in this subgroup	Spent porcelain insulators and fragments of porcelain, semi-porcelain	39.623
11 01 99	Other waste in this subgroup	Spent membranes and filter elements (osmosis elements, filters for water purification made of foamed polypropylene)	0.102
19 09 04	Spent activated carbon	Spent activated carbon	4.200
20 01 01	Paper and cardboard	Used paper and cardboard (waste paper)	29.056
20 01 10	Clothes	Worn overalls and footwear	4.313
07 02 13	Waste plastics	Polluted plastic and plastic containers	5.544
10 12 03	Small residues and dust	Waste perlite sand, zeolite, silica gel	1.500
19 09 99	Other waste in this subgroup	Crushed stone, waste sand from drinking water treatment	1.999
15 01 07	Glass containers (packaging)	–	2.091
17 02 02	Glass	Waste technical glass	8.089

Waste Code as per the National Waste List	Waste Name as per the National Waste List	Production Waste Name	Amount of Waste per year, tons
20 03 99	Other domestic waste of this subgroup	Polyethylene waste (clean)	0.102
16 02 16	Components removed from waste equipment other than that specified in 16 02 15	–	0.314
19 12 04	Plastics and rubber	Waste rubber	4.283
12 01 21	Spent abrasion bodies and abrasion materials other than those specified in code 12 01 20	Waste abrasives, grinding wheels, belts, sandpaper	0.022
07 02 13	Waste plastics	Polluted plastic and plastic containers	4.662

Waste generated ***during construction*** is mainly generated in buildings and structures of the site facilities and during welding operations. Wastes generated at site facilities include:

- unsorted ferrous metal scrap;
- concrete waste in lump form;
- scrap of reinforced concrete products;
- wiping material polluted with oil products;
- metal containers polluted with paint.

Welding operations generate the following types of waste:

- remnants and fragments of steel welding electrodes;
- cardboard containers for electrodes;
- welding slag;
- domestic waste.

During the construction of industrial facilities, the generated waste is stored at a specially designated construction waste dump territory.

All solid industrial and domestic waste unsuitable for further use will be disposed at the landfill of the Municipal Enterprise for Public Utilities and Housing in Netishyn as it accumulates and upon completion of construction. Metal containers are used for domestic waste collection.

1.5.2.4 Assessment of noise, vibration and ultrasonic pollution

Noise impact assessment. The assessment is carried out including:

- impact of additional noise sources that appear with the commissioning of units 5 and 6;
- absence of permanent workplaces for service personnel at the industrial site, outside of production buildings and structures, and noise impact assessment is appropriate only inside these buildings;

– absence of any buildings and structures within the sanitary and protection area with permanent presence of people who are not NPP personnel.

In the case of construction activities at units 3&4, the noise impact assessment shall include the noise of construction equipment.

At the industrial site, the noise sources are power transformers and backup diesel power unit. As for the turbine building, the noise sources are the turbine generator, feed pumps, control pumps, hydraulic lift pumps, ejectors, and as for the NPP buildings and structures – ventilation and air conditioning systems, pumping units.

Transformers are operated without the constant presence of personnel and, as a result, no noise requirements are imposed on transformers. Transformer operation is monitored periodically (1-2 times per shift) by operating personnel for 15-20 minutes.

The operating personnel who are constantly at their workplaces in the respective buildings maintain the turbine building equipment (turbine unit, pumping units, and ejectors) and the backup diesel power unit equipment (diesel generator, compressors, pumps) around the clock.

The noise level in the turbine hall and backup diesel power unit buildings may exceed the permissible sound pressure level [29] in the production facilities of the enterprises. In this regard, the project provides for acoustically protected rooms for the turbine shop and backup diesel power unit operating personnel in the turbine hall and backup diesel power unit buildings. When the operating personnel carry out mandatory visual inspection of the equipment at the place of its installation, it is assumed that the personnel use appropriate personal protective equipment (headphones, earplugs, antiphons).

The following measures are provided to reduce noise and vibrations from operating ventilation units to values that do not exceed the permissible sound pressure levels in the premises [29]:

- installation of fans on vibration isolators;
- connection of air handling units with air ducts through flexible inserts;
- limiting the air velocity in the air ducts, which ensures that the noise levels generated by the control and air distribution devices in the serviced premises are within the permissible limits;
- installation of air handling units with the lowest specific sound power levels;
- installation of sound attenuators in ventilation systems serving premises with a permanent presence of people;
- installation of sound-absorbing structures on the walls and ceilings of ventilation chambers.

Vibration impact assessment. No vibration impact exceeding the established standards is expected during the construction and operation of KhNPP units 5 and 6.

The main sources of vibration are fans of ventilation systems. Noise and vibration from ventilation and air conditioning equipment after the use of noise attenuators and measures against noise and vibration impact comply with sanitary and hygienic standards for the working area in accordance with regulatory documents [29, 30]. The fans of ventilation and air conditioning systems are isolated from the unit casing by means of spring-type vibration isolators.

Ultrasound exposure assessment. The ultrasound impact from operating thermal and mechanical equipment during the operation of KhNPP units is not envisaged.

A single, short-term, local, ultrasonic exposure is possible during ultrasonic quality control of welded butt joints performed under repair.

1.5.2.5 Electromagnetic radiation assessment

There are no sources of electromagnetic radiation exceeding the limit values established by regulatory documents at KhNPP units. New sources are not expected during the construction and operation of units 5 and 6.

Electrical equipment installed in NPP facilities is not a source of harmful emissions, radio interference and noise.

According to the sanitary standards [31], protection of the public from the electric field of aerial power lines with a voltage of 220 kV and below is not required.

330 kV and 750 kV aerial power lines from the KhNPP switchyard are designed in accordance with the sanitary standards requirements [31].

1.5.2.6 Thermal pollution assessment

A nuclear power plant is a source of significant heat emissions. Approximately two-thirds of the thermal energy generated by the reactor cannot be used to generate electricity and is discharged into the environment.

The service water supply scheme for units 5 and 6 was adopted as a reversed, using cooling towers as radiators. In the adopted scheme, the KhNPP cooling pond is a source of water intake for cooling tower basins feeding and blowdown and is used for the needs of other process systems, as well as for blowdown water discharge. The water supply scheme is unified, separate for each unit. In the NPP cooling systems, heat emissions are discharged into the atmosphere through cooling towers.

For the circulating water system (CWS), a naturally ventilated cooling tower is adopted to receive the heated circulating water from the main condensers and support the heat exchangers. The circulating water is cooled by evaporation and returned to the cooling tower basin.

The service water system (SWS) is cooled by a fan cooling tower. The cooling tower is a straight, counterflow tower with a suction fan and a clog-resistant film fill.

The total heat emissions to the atmosphere from the cooling towers according to [32, 33], are shown in Table 1.24.

Table 1.24 – Heat emissions to the atmosphere from units 5 and 6 cooling towers (at 7200 hours of units operation)

Cooling tower type		The amount of heat, maximum/minimum

	Cooling tower number, pcs.	Gcal/h	Gcal/day	Gcal/year
CWS cooling towers	2	3810.0/0	91440.0/0	27.4 x 10^6/0
SWS fan cooling towers	Two double-chamber cooling towers	174.6/37.74	4190.4/905.76	1.26 x 10^6/ 0.74 x 10^6
Total	4	3 984.6/37.74	95 630.4/905.76	28.66 x 10^6/ 1.74 10^6

2. DESCRIPTION OF THE REASONABLE ALTERNATIVES TO THE PLANNED ACTIVITY, THE MAIN REASONS FOR SELECTING THE PROPOSED OPTION, CONSIDERING THE ENVIRONMENTAL CONSEQUENCES

The main requirement for the selection of sites for new power units with the AP1000 reactor should ensure nuclear and radiation safety of the population and environmental protection according to the current legislation at all stages of the nuclear facility life cycle, as well as maximum efficiency of electricity generation for supplying electricity to consumers under the best conditions.

According to international practice, the most acceptable option for the deployment of new facilities is to build them at the sites of operating NPPs to efficiently use previously invested funds and reduce the construction cost of new units by using ready-made infrastructure and qualified personnel.

The Energy Strategy of Ukraine until 2050 envisages the construction of new power units at the sites of operating NPPs, including KhNPP. Favorable factors include:

– a developed road and railway networks;
– general plant facilities, including auxiliary facilities and water supply facilities;
– construction facilities, construction industry enterprises, and construction and installation organizations;
– staffing, etc.

This section provides information on the current status of the selected sites for the new power units construction (information according to the State Land Cadaster on ownership and property rights to the land plot) and construction conditions at these sites.

According to preliminary calculations, the following areas are required for the construction of two power units with an AP 1000 reactor:

– for the industrial site – 45 ha for power units with cooling towers
38 ha for power units without cooling towers;
– 100 ha for the construction site.

The cadastral information for each site is provided only for the area to be occupied by the NPP industrial site.

2.1 Construction conditions at the South Ukrainian NPP site

2.1.1 Brief site description

The South Ukrainian NPP site is located in the Voznesensk district of Mykolaiv region, on the left bank of the middle reaches of the Southern Bug River. The distance from the river shoreline to the NPP site is 3 km.

The South Ukrainian NPP is located in the central part of the IPS of Ukraine on the territory of the Dnipro power system. A complex closed network of 330 kV and 750 kV has been formed in this area.

There are three WWER-1000 power units in operation at the South Ukrainian NPP:

– power unit No.1 with the V-302 reactor;
– power unit No. 2 with the V-338 reactor;
– power unit No. 3 with the V-320 reactor.

The total capacity of the NPP is 3000 MW. Table 2.1 shows the general characteristics of the power units and their lifetime according to the licenses to carry out activities at the life cycle stage "operation of nuclear facilities of South Ukrainian NPP power units" issued to the operating organization, National Nuclear Energy Generating Company Energoatom JSC by the State Nuclear Regulatory Inspectorate of Ukraine.

Table 2.1 – General characteristics of SUNPP power units

Power Unit number	Reactor type	Commissioning	Estimated lifetime end	Installed capacity, MW
Power unit No. 1	WWER - 1000/V-302	31.12.1982	The lifetime is extended until 02.12.2033	1000
Power unit No. 2	WWER - 1000/V 338	09.01.1985	The lifetime is extended until 31.12.2025	1000
Power unit No. 3	WWER - 1000/V -320	20.09.1989	The lifetime is extended until 10.02.2030	1000

The site has the infrastructure to support NPP operations. Possibility of deploying operating, construction, and assembly specialists in the existing city of power engineers. There is a production of construction materials and a well-developed road and rail transportation network.

2.1.1.1 Demographic conditions

The South Ukraine NPP site is located in Mykolaiv Oblast, on the left bank of the Pivdennyi Buh River. The district center is Voznesensk town. [redacted]

2.1.2 Scheme of the NPP situational plan. A disposed land area

Currently, the 3 operating power units are located on a plot of 317.96 hectares. [redacted] The industrial site can be used for the construction of two new power units, the existing 43.2-hectare; and an additional 6.93 hectares of privately owned land for private farming can be used..

The site layout is shown in Figure 2.1.

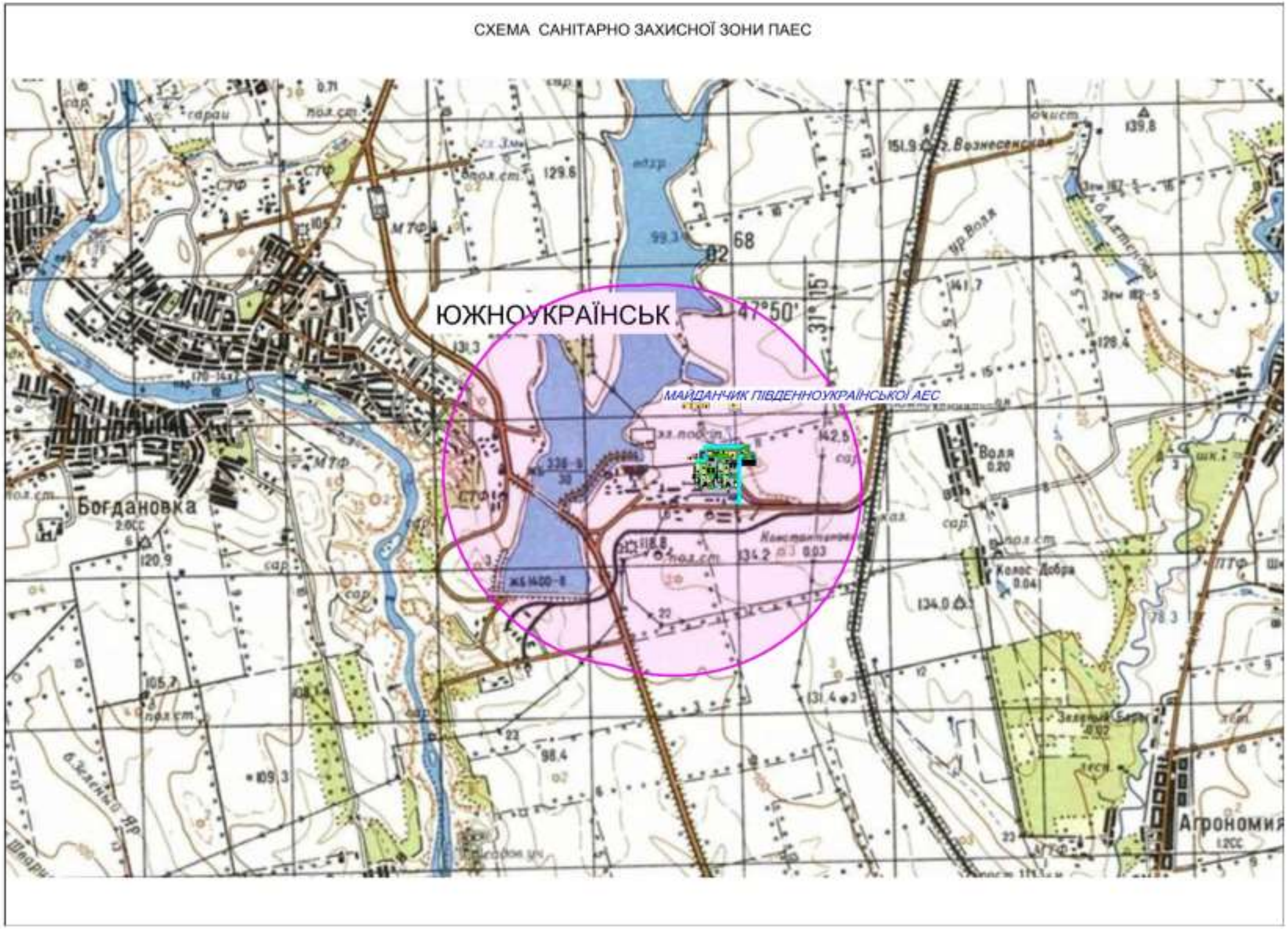


Figure 2.1 – Situation layout scheme of new power units at South Ukrainian NPP

2.1.3 Power output

South Ukrainian NPP together with Tashlyk PSP and Oleksandrivska HPP make up the entire South Ukrainian power complex.

[redacted]

[redacted]

2.1.4 Service water supply system

The operating South Ukrainian NPP is supplied with water using the specially created Tashlyk cooling reservoir in the Tashlyk Gully, which is fed from the Southern Bug River.

Due to the construction of the Tashlyk PSPP, a dam separates the deepest part of the cooling pond. This causes an additional burden on the rest of the reservoir used for the operation of existing SUNPP units.

The Tashlyk Reservoir provides for the operation of the NPP at a nominal capacity of 3000 MW only in the cold season. In the summer, as a result of the temperature increase in the circulating water, the plant's capacity is limited to 1800 MW, and on particularly hot days - to 1500 MW.

The commissioning of five spray pools will reduce the circulating water temperature by 7-8°C and allow the SUNPP to operate at its nominal capacity of 3000 MW.

It is necessary to envisage the recycled service water supply system for the new SUNPP units with water cooling at cooling towers and spray pools.

2.1.5 Transport connection

The new NPP units are to be supplied with road access from the existing access roads of the South Ukraine NPP.

The national highway Ulyanivka - Mykolaiv runs from south to north near the NPP industrial site and the city of Yuzhnoukrainsk. It connects the NPP with the network of other highways. The Oleksiivka-Arbuzynka-Yelanets highway runs in the eastern direction. Most settlements within the 30-kilometer zone have paved access roads.

The new NPP units are to be supplied with railroad service from the existing single-track access railroad that serves the South Ukrainian NPP.

2.1.6 Current condition of the land plot

The existing power units are located on the site [redacted] the area is 317.96 hectares, and the type of ownership is state-owned. The 43.2-hectare plot of this area can be used for the construction of a new power unit, but there is a shortage of 100 hectares of land at the SUNPP site for the construction of temporary buildings and facilities for the construction and assembly base.

2.2 Construction conditions at the Rivne NPP site

2.2.1 Brief site description

The Rivne NPP is located in the northern part of the Western region of the IPS of Ukraine. The 110, 220, 330, and 750 kV grids have been developed in this region.

Four power units are in operation at the Rivne NPP:

– Units 1 and 2 with the V-213 (WWER-440) reactor;
– Units 3 and 4 with the V-320 (WWER-1000) reactor.

The total capacity of the NPP is 2835 MW. Table 2.2 shows the general characteristics of power units and their lifetime according to the licenses to carry out activities at the life cycle stage "operation of nuclear facilities of Rivne NPP power units" issued to the operating organization - National Nuclear Energy Generating Company Energoatom JSC by the State Nuclear Regulatory Inspectorate of Ukraine.

Table 2.2 – General characteristics of the RNPP power units

Power Unit number	Reactor type	Commissioning	Estimated lifetime end	Installed capacity, MW
Power unit No 1	WWER- 400/ V-213	22.12.1980	The lifetime is extended until 22.12.2030	420
Power unit No 2	WWER -440/ V-213	22.12.1981	The lifetime is extended until 22.12.2031	415
Power unit No 3	WWER-1000/V -320	22.12.1986	The lifetime is extended until 11.12.2037	1000
Power unit No 4	WWER -1000/ V-320	10.10.2004	07.06.2035	1000

The site has the infrastructure to support NPP operations. There is a possibility of deploying operational and construction and assembly specialists in the existing satellite city and the availability of construction materials production. It is the developed road and rail transportation network.

2.2.1.1 Demographic conditions

[redacted]

[redacted]

The RNPP site supervised area (30 km) in administrative terms includes most of the Varash district of the Rivne region and part of the Kamen-Kashyr district of the Volyn region. The total area is 2826 km². There are 106 settlements with a total population of 130 thousand people on this territory.

2.2.2 Scheme of the NPP situational plan. A disposed land area

Currently, the four operating power units are located on a plot of about 218 hectares [redacted] of which 12 hectares can be used for new power units. To accommodate two new power units with a capacity of 1100 MW each at the Rivne NPP site, an additional area of about 138 hectares will be required near the NPP industrial site.

The site layout is shown in Figure 2.2.

2.2.3 Power output

The Rivne NPP connection scheme is aimed at supplying power to the backbone grid of the Western region of the IPS of Ukraine. [redacted]

[redacted]

2.2.4 Service water supply system

The main source of water for RNPP is the Styr River. Water intake is performed from the river itself without the use of any retaining structures. The service water supply system at RNPP is a reverse system with circulating water cooled by six tower cooling towers with a capacity of up to 100,000 m^3/h each, designed to provide cooling water for turbine condensers and other heat exchangers in the NPP's engine and reactor buildings.

A supplementary water pumping station with bucket intake is located on the Styr River to replenish water losses in the service water supply system.

Currently, the estimated consumption of additional water to the service water supply system and for the needs of other consumers is 10,660 m^3/h based on the following:

- evaporation losses in cooling towers and from the canals` water surface - 8,700 m^3/h; system blowdown - 1,715 m^3/h;
- removal and filtration - 655 m^3/h;
- for service water supply to other consumers - 690 m^3/h.

To analyze the current situation and prospective water supply for the new power unit construction, JSC KIEP (Kyiv Research and Design Institute Energoproject) performed the "Calculation of the water balance for the Styr River" 381817.216.001(4, 5).3T00

According to this calculation, if based on the sanitary water flow rate below the RNPP – 12.1m^3/s (sanitary flow rate determined by the minimum average annual flow rate of 95% availability at the Lutsk station), there is a small water shortage in the sections from the source to the Lutsk station, from the Lutsk station to RNPP, and from RNPP to the Mlynok station in low-water years. At the same time, given the approved sanitary flow rate of 8.8m^3/s and the maximum water intake limit for RNPP (2.86m^3/s), which correspond to the special water use permit No. 87/RV/49d-23 dated 14.07.2023, there are no water shortages. In any case, even under conditions of abnormally low water content of the Styr River, water supply to the new RNPP units will be guaranteed.

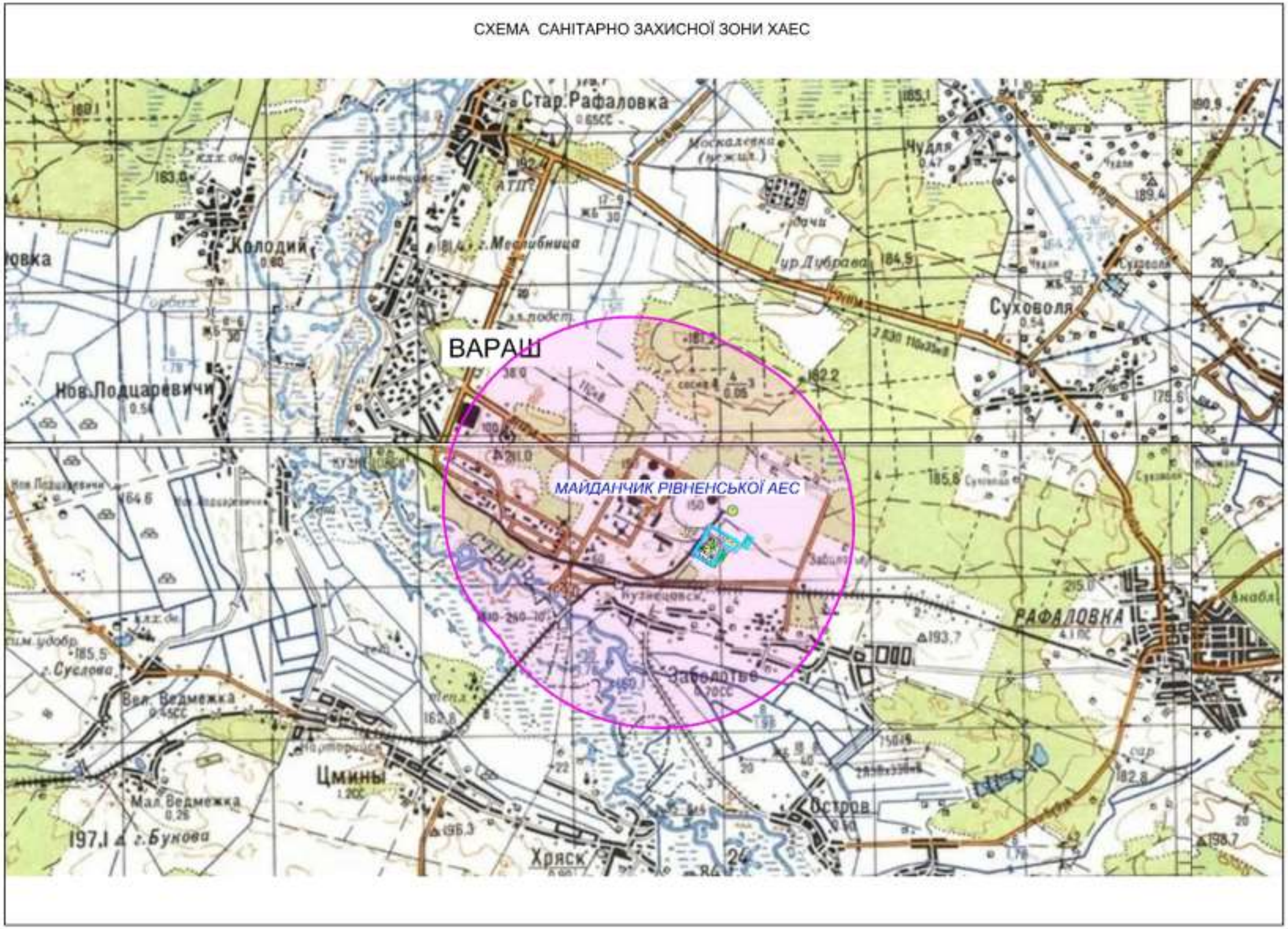


Figure 2.2 – Situation layout scheme of new power units at Rivne NPP

2.2.5 Transport connection

The new NPP unit is to be supplied with railroad service from the existing single-track access railroad that serves the RNPP.

[redacted]

The new NPP units are to be supplied with road access from the existing RNPP access roads.

The connection with the general road network is provided by the station access road. [redacted]

2.2.6 The current land plot state

The existing power units are located on the site [redacted] the type of ownership is state-owned, and the area is 217.895 hectares, of which 12 hectares can be used for the new power units placement.

This area is only sufficient to locate the main buildings of the nuclear and turbine sites, but not enough to site all buildings of the power unit technological complex and to locate temporary buildings and structures of the construction and assembly base. Therefore, the space shortage at the RNPP site is approximately 138 hectares. It is necessary to allocate additional land plots to implement the project for the new power units construction.

The soils in the Rivne NPP area are prone to sufosion and karst services. Rocks that are easily dissolved by water, such as gypsum and limestone; cover the area and there is a large amount of precipitation, which leads to soil leaching.

The RNPP site is located in unfavorable soil conditions, which can lead to instability of buildings and structures constructed on these soils, subsidence, and uneven settlement of buildings, which can cause cracks, deformations, and other damage. These conditions can be challenging for nuclear power plant construction due to possible risks of groundwater contamination.

To provide for RNPP safety, dams and other facilities have been built to protect the plant from floods, soil reinforcement has been performed; and the soil condition and RNPP buildings are constantly monitored. Despite these measures, sufosion and karst services remain a serious threat to NPPs, which is a serious problem for the new power unit construction and requires further technical measures.

2.3 Construction conditions at the KhNPP site

2.3.1 Brief site description

KhNPP is located in the northern part of the South-Western region of the IPS of Ukraine. [redacted]

KhNPP operates two power units (No. 1 and No. 2) with a V-320 (WWER-1000) reactor. The total capacity of the NPP is 2000 MW. Basic information about the power units, including their lifetime, according to the licenses to carry out activities at the life cycle stage "operation of nuclear facilities of Khmelnytskyy NPP" issued to the operating organization, JSC National Nuclear Energy Generating Company Energoatom by the State Nuclear Regulatory Inspectorate of Ukraine, is presented in Table 2.3.

Table 2.3 – General characteristics of the KhNPP units

Power Unit number	Reactor type	Commissioning	Estimated lifetime end	Installed capacity, MW
Power unit No 1	WWER -1000/ V-320	22.12.1987	The lifetime is extended until 13.12.2028	1000
Power unit No 2	WWER -1000/ V-320	07.08.2004	07.09.2035	1000

The site already has a well-developed infrastructure to support NPP operations. There is a possibility of deploying operating and construction and assembly specialists in the existing satellite town. Besides, there is a production of construction materials and a developed road and rail transportation network.

2.3.1.1 Demographic conditions

[redacted]

The KhNPP supervised area includes a part of Khmelnytskyy (Shepetivka district) and Rivne regions (Rivne district).

The supervised area is 2826 km^2, with 1024 km^2 being the territory of the Rivne region and 1802 km^2 of the Khmelnytskyy region.

The area includes 207 settlements with a population of over 195 thousand people. [redacted] The majority of the population lives in the Khmelnytskyy region - about 136 thousand people.

2.3.2 Scheme of the NPP situational plan. A disposed land area

Currently, two operating units 1 and 2, and the uncompleted units 3 and 4 are located on a site with a total area of 147.0804 hectares, and the new units 5 and 6 will be located on the same site. The area will be additionally required to construct the temporary construction and assembly facilities.

The site layout is shown in Figure 2.3.

Figure 2.3 – Situation layout scheme of the KhNPP Units 5 and 6

2.3.3 Power output

The connection scheme of KhNPP is focused on the power plant's output to the backbone grid of the South-Western region of the IPS of Ukraine. [redacted]

2.3.4 Service water supply system

The Khmelnytskyi NPP is fed by water from a cooling pond created on the Hnylyi Rih River, which is a tributary of the Vilia River, which in turn is a tributary of the Horyn River.

To fill the reservoir and recharge it during the spring flood (March-April), a pumping station was built to supply water from the Horyn River. According to the permit for special water use, the cooler reservoir water recharge regime is carried out only during the spring flood (March-April). Otherwise, KhNPP service water supply is supposed to be provided by using the useful volume of the reservoir. The amount of water recharge to the KhNPP service water supply system at the 4000 MW plant capacity will be 54.2 million m^3/year.

The designed service water supply plan for power units 5 and 6 is reverse with cooling towers as radiators and is designed using existing hydraulic structures. The KhNPP cooling pond is a source of water intake for cooling tower feeding and purging and for the needs of other technological systems in the adopted cooling and process water supply plan for power units 5 and 6. The water supply scheme is unified and separate for each power unit.

In 2023, affiliate Atomprojectengineering performed a thermal calculation of the KhNPP cooling pond [34], considering the construction of power units 5 and 6 with the AP1000 reactor unit, which resulted in determining the temperature of the cooled water in the pond during operation of one, two, three, four and six power units with a capacity of 1000 MW each:

– during the operation of two power units in summer, the water temperature in the underwater channel (at the inlet to the turbine condensers) is 24.4-25.5 °C;
– during the operation of three power units in summer, the water temperature is 30.0-30.8 °C, which is less than the standard temperature value of 33.0 °C;
– during operation of four power units, the water temperature in summer months is 33.0-33.20 °C and will already reach the critical temperature of 33.0 °C under technological conditions [27];
– during the operation of power units 5 and 6 – in accordance with the AP1000 process flow diagram, developed by Westinghouse, the purge water of the cooling tower basin of the CWS system is combined with the purge flow from the SWS system, taken

from the pump discharge header and directed to the purge sump of the wastewater collection and disposal system for further discharge into the KhNPP cooling pond. Based on the operating conditions of this cooling and blowdown water discharge plan, it can be concluded that the cooling pond receives water already cooled to ambient temperature. Thus, the operation of power units 5 and 6 will not affect the value of additional evaporation from the pond and the temperature in the pond as a whole;

It is envisaged to construct a flow control dam for the operation of units 3 and 4.

The cooling system for KhNPP units 5 and 6 involves the use of cooling towers:

– for the CWS system of units 5 and 6, a naturally ventilated cooling tower is adopted to receive heated circulating water from the main condensers and support the heat exchangers. The circulating water is cooled by evaporation and returned to the cooling tower basin. One cooling tower is provided for each of power units 5 and 6.

– the SWS service water of power units 5 and 6 is cooled by a fan cooling tower. The cooling tower is a straight, counterflow tower with a suction fan and a clog-resistant film fill. The cooling tower is divided into two chambers. Each chamber utilizes a single propeller-type fan located at the top of the chamber to draw air upward through the fill against the downward water flow.

2.3.5 Transport connection

The new NPP units are to be supplied with road transport from the existing KhNPP access roads.

The KhNPP is located in an area with a developed road network. [redacted]

The railroad connection of the new NPP units is planned to be provided from the existing access railroad. [redacted]

2.3.6 Current condition of the land plot

Currently, two operating units 1 and 2, and uncompleted units 3 and 4 are located on a site with a total area of 147.0804 hectares; the new units 5 and 6 will be located on a site with an area of 56.8 hectares. The area will be additionally required to construct the temporary facilities for the construction and assembly base.

2.4 Conclusion on the selection of a site for the new power units construction

Hydrogeological conditions at the Rivne NPP site require special measures to prevent possible karst formation under the influence of natural and technogenic factors. The water supply of Rivne NPP is sufficient for the 6 units with installed capacity more than 5000 MWt.

The water supply of the South Ukrainian NPP is sufficient in the cold season for the capacity of 3000 MWt, which is exhausted by the power units 1-3 that are in operation. New units can be commissioned subject to the implementation of additional technical measures for a water supply, such as the use of tower cooling towers and spray pools, but it should be taken into account that these measures lead to an increase in the share of consumption for own needs up to 10-15%.

Following the site selection studies, construction of new power units at KhNPP is more optimal than at SUNPP and RNPP.

The Feasibility Study confirms the suitability of the KhNPP site for the construction of Units 5 and 6 following the requirements of the current regulatory documents.

Since new power units cannot be less reliable and safe compared to operating power units, the environmental impact is a conservative estimate of the possible new units impact. The actual impact of the RNPP, KhNPP, and NPP units during their normal operation is orders of magnitude less than the established threshold levels.

3 A DESCRIPTION OF THE CURRENT ENVIRONMENTAL STATE (BASE SCENARIO) AND A DESCRIPTION OF ITS POSSIBLE CHANGE WITHOUT THE PLANNED ACTIVITY TO THE EXTENT THAT NATURAL CHANGES FROM THE BASE SCENARIO CAN BE ESTIMATED BASED ON AVAILABLE ENVIRONMENTAL INFORMATION AND SCIENTIFIC KNOWLEDGE

The description of the current environmental state is an integral part of the EIA report, and provides an overview of the main environmental characteristics, such as water sources, atmospheric air, terrain, climate, soils, etc. Information from the KhNPP Unit 2 Final Safety Analysis Report was used in this section [35].

3.1 Geographical location of the site

The KhNPP site is located in Shepetivka district of Khmelnytskyi region on the left bank of the Horyn River, 30 km southwest of the district center – Shepetivka. The town of Netishyn is located 3 km north of the site. To the northwest of the site, at a distance of 50 km, is the city of Rivne (the regional center of Rivne region). The city of Slavuta is located 15 km to the east.

3.2 Terrain and landscapes

The territory and site of the KhNPP are located on the Volyn-Podolian plate, which is situated between the western slopes of the Ukrainian Shield and the Carpathian Alpine geosyncline. The plate consists of an Archean-Middle Proterozoic metamorphic basement and an Upper Proterozoic-Paleozoic sedimentary cover. The surface of the basement gently dips to the west and northwest. The basement dips in step faults of meridional and submeridional strike. The basement structure of the plate is divided into separate blocks by a system of faults. Due to tectonic movements, the blocks moved in relation to each other in vertical and horizontal directions, which led to uneven accumulation of sedimentary complexes.

Most of the KhNPP supervised area belongs to the Horyn River basin. The eastern spurs of the Volyn Upland (Goshcha Plateau) represent the right bank of the Horyn basin. In the left-bank part of the basin, there is an alternation of wavy and low-wavy plains of different levels: Podolian (in the south area) and Volyn Upland dissected by the valleys of the left tributaries of the Horyn. The Rivne Plateau in the north and the Ostroh Plateau in the southeast of the Upland represent the Volyn Upland on the left bank of the Horyn. The Podolian and Volyn Uplands are separated by the lower plains of Male Polissia, almost entirely located in the left-bank part of the 30-kilometer area, and the Mizotskyi Ridge.

The modern Volyn-Podolian terrain plate is represented by plains of different genesis and morphological design. Karst landforms are on the cretaceous deposits of the Slavuta Plain, within the Volyn Upland, on the second and third terraces of the Horyn

River. They are mainly represented by sinkholes located in separate groups or chains. The main karst blocks are located to the west of Slavuta, near the urban area of Radoshivka, in the upper reaches of the Hnylyi Rih River, and urban area of Storonyche. A network of ravines and gullies represents the gully terrain. This terrain is mostly within denudation and structural-denudation plains. The gully network reaches its greatest density in the southern part of the territory and is confined to the slopes of the Horyn River valley and Podolian Upland. The largest number of active ravines is observed within the Podolian Upland.

Dunes and ridges of various configurations are found in large quantities within the interfluves. Their relative height reaches from 5 to 25 m, and they are oriented in the western and southwestern directions.

The landscapes of the Volyn physical and geographical region are dominated by hilly forest plains with erosive terrain - gullies, ravines, and water galls - that affect the processes of redistribution of chemicals with water flows and lead to differentiation of vegetation and soil cover. The terrain fragmentation in the Volyn physiographic region contributes to intensive rain and meltwater runoff.

There are 15 physical and geographical (landscape) districts within the Volyn region: Novoselskyi, Novomalynskyi, Hoshchanskyi, Zavozovskyi, Mirotynskyi, Hremyachivskyi, Myliatynskyi, Bochanetskyi, Annopolskyi, Badovskyi, Prykorchytskyi, Ostrohskyi, Netishynskyi, Mizotskyi-Bushevskyi and Mynkovetskyi.

The NPP construction site is located in the Malopilska lowland, on the first floodplain terrace of the Horyn River. The NPP facilities occupy alienated lands of the Slavuta and Iziaslav State Forestry Funds, collective farms, and the territory of residential development in Dorohohoscha village. The NPP sanitary protection area includes the lands of Slavuta State Forestry, Izyaslav State Forestry, collective farms and the territory of Siltse village, whose population was settled out in accordance with the requirements for facilities that can be located in the sanitary protection area.

3.3 Soils

Most of the soil cover in the region around NPP consists of acidic sod-podzolic soils of light composition, which are highly acidic and permeable.

The absorption complex of these soils is unsaturated, which leads to the fact that colloidal complexes in the form of exchangeable state absorb some elements in the upper soil layer. To increase the fertility of these soils, reduce migration processes and increase resistance to anthropogenic impacts, it is necessary to liming and applying organic and mineral fertilizers.

A significant area of the controlled territory includes deep chernozems, dark gray, podzolized soils, and podzolized, meadow chernozem and meadow soils, which are highly resistant to anthropogenic loads [36]. This is facilitated by such soil properties as a close to neutral reaction of the environment, a much higher humus content, high absorption capacity, etc. These properties cause low mobility and almost complete fixation of heavy metals and radionuclides by the absorbing complex.

The development of exogenous geological processes is not expected at the KhNPP site, since the redeposited chalk was removed and replaced with sand at the location of the main structures (main buildings of power units 1-6), which created conditions for infiltration of precipitation and thus prevented waterlogging.

3.4 Climate

The KhNPP site is located in the northwestern part of Ukraine in the Volyn Polissya region, in a moderate continental climate area with a positive moisture balance. Relatively high temperatures and low relative humidity characterize this type of climate in summer and low temperatures, high humidity and snow cover in winter.

According to the climatic zoning [37], the territory under consideration is located in the second climatic region (sub-region I I-B).

The climate of the region is formed under the influence of both sea and continental air masses. The nature and intensity of the main climate-forming factors varies significantly by season.

Winter. Cyclonic activity is most pronounced. Short-term warming, intense snowfall, strong winds and blizzards often accompany the passage of western and northwestern cyclones. The coldest winter month is January (average monthly temperature is minus 5.2°C).

Spring. Given a significant fluctuation in heat and cold, the spring transition is characterized by an active rise in temperature, intense snowmelt, and increased evaporation from the soil and water surface. In April and May, there is often a return of cold weather caused by the intrusion of Arctic air, which causes sharp cold snaps and frosts.

Summer. A summer season is characterized by a significant increase in air temperature due to the warming of the earth's surface, a high frequency of clear days, rare fogs, increased precipitation and active thunderstorm. The summer season begins in mid-May. The highest temperature in summer is observed mainly in July, with an average temperature of +19.5°C, an average maximum of +25.4°C, and an average minimum of +14.1°C. In 35-40% of cases, the highest air temperatures are observed in August or June. Summer is characterized by heavy rainfall.

Autumn. Solar radiation decreases and the air begins to cool. The first half of autumn is characterized by mostly dry, warm weather without precipitation. The second half of autumn is characterized by a general deterioration of the weather, a large number of cloudy days, heavy precipitation and prolonged fog. The passage of western cyclones during this period is often accompanied by increased winds and ice. The atmospheric circulation in the second half of autumn is close to the winter season.

The average annual air temperature within the KhNPP supervised area is 7.1°C, the absolute maximum is 36.6°C, and the absolute minimum is minus 33.6°C.

The annual average monthly air temperatures in the KhNPP area is characterized by the highest values in July (18.4 °C) and the lowest in January (minus 5.2 °C).

The frost-free period lasts an average of 169 days.

The average annual relative humidity is 79%; the average annual partial pressure of water vapor is 8.9 hPa; the saturation deficit is 3.3 hPa.

The average annual cloudiness within the area under consideration is 6.7 points for total cloudiness and 4.9 points for partial cloudiness. In terms of precipitation, the area under consideration belongs to the area of sufficient moisture. The annual precipitation is 667 mm. About 70% of the annual precipitation falls during the warm season.

The average number of days with precipitation within the area is 163 days.

The number of days with snow cover averages 90 days. The average ten-day snow cover is 12 cm, the maximum is 52-53 cm.

The annual amount of evaporation from the land surface (total evaporation) is 538 mm, the highest monthly amount (106 mm) is in July. In the winter months, the total evaporation has the lowest values of 2-7 mm.

Prevailing wind direction:

– for the whole year: westerly direction 20.4%; a calm is 11.9%;
– in the warm period: westerly direction 19.9%; a calm is 13.9%;
– in the cold period: westerly direction 21.5%; a calm is 8.0%.

The average annual wind speed is 2.7 m/s. The lowest average monthly wind speed is observed in the summer months and ranges from 1.9 to 2.2 m/s. In winter, the average monthly wind speeds range from 3.1 to 3.4 m/s.

The maximum wind speeds recorded by the aeronautical meteorological stations closest to the KhNPP site (Shepetivka, Khmelnytskyy, Rivne and Lutsk) reached 28, 34, 38 and 40 m/s [38].

During the year, there are on average 62 days with fog and 31 days with thunderstorms in the KhNPP area.

Natural meteorological phenomena on the territory bordering the KhNPP site, within a radius of 200 km (Khmelnytskyi, Rivne, Volyn, Ternopil and partially Vinnytsia and Lviv regions) include: strong winds, squalls, hurricane winds, tornadoes (from zero to second intensity class), heavy rain, heavy blizzards, heavy snowfall, heavy ice. These natural meteorological phenomena are considered particularly dangerous. In some cases, these phenomena led to catastrophic consequences and caused significant damage to the agriculture. However, during KhNPP operation, natural meteorological phenomena that occurred in the territories adjacent to the plant did not create emergencies at NPP.

The aerometeorological conditions in the KhNPP area are characterized by an increased probability of a stably stratified atmosphere at surface and low elevated inversions and low-power mixing layers (especially in winter), which weakens the mechanism of natural self-purification of atmospheric air in this region.

3.5 Hydrological characteristics

Hydrological characterization is a key tool in understanding the water cycle and water resources. It provides comprehensive information on various aspects of the water environment. It is important to provide a hydrological characterization of surface and groundwater in the EIA report.

3.5.1 Surface water

The Horyn River basin, as well as lakes, ponds, reservoirs, and a reclamation network of canals represent the hydrographic network in the 30-kilometer area of KhNPP impact.

Within the 30-kilometer area of the KhNPP, 37 tributaries ranging in length from 10 to 80 km and approximately 220 tributaries less than 10 km long flow into the river.

The Horyn and Hnylyi Rih rivers are the sources of service water supply for KhNPP power units.

The Horyn River is one of the largest tributaries of the Pripyat River, which in turn is the largest tributary of the Dnipro River. According to the Hydrometeorological Service, the river is 659 km long, with a basin area of 27.7 thousand km^2 and an average slope of 29 cm/km.

The Horyn River catchment in the upstream is located within the Volyn-Podolian Upland and in the midstream and downstream within the Polissia Lowland. The Horyn River has its source in Ternopil Oblast, northwest of Volytsia village.

The largest left tributaries of the Horyn river are the Vilia (catchment area of 1815 km^2) and the Ustia (762 km^2), with the Vyrka (261 km^2) being much smaller. The largest right tributary of the Horyn River is the Sluch River, with a catchment area of 13.9 thousand km^2, or almost half of the entire Horyn catchment. These rivers merge a few tens of kilometers before the border with Belarus. The right tributaries include the Tsvitokha River with a catchment area of 368 km^2.

It is in the Vilia River basin that the KhNPP cooling pond was created, more precisely, on its right tributary, the Hnylyi Rih River. The length of this small river is 28 km and the catchment area is 201 km^2. The Hnylyi Rih River is a right-bank tributary of the Vilia River and flows into it one kilometer from the mouth. It originates in the north-east of Mokrets village at an altitude of 230 m above sea level and flows through the Volyn Upland. The river basin is swampy. The river valley and floodplain do not have distinct boundaries.

The reservoir was filled due to the flow of the Hnylyi Rih River and intake from the Horyn River. The inlet channel site from this river is located 204.0 km from the source (455.0 km from the mouth). The total annual water intake into the reservoir (including the volume supplied from the Horyn River) is determined in accordance with the current Special Water Use Permit. The main hydrological characteristics of the Hnylyi Rih River and the Horyn River are shown in Table 3.1. The dynamics of KhNPP water consumption during the operation of Units 1 and 2 is shown in Table 3.2.

Table 3.1 – Main hydrological characteristics of the Hnylyi Rih and Horyn rivers

Catchment basin	Area of the catchment basin up to the hydropower plant site, km²	Alimentation type	Annual runoff volume (mln. m³) with provision of		Flooding period
			50%	75%	
the Hnylyi Rih river	201.0	Surface runoff and groundwater	24.12	21.1	mid-March
the Horyn river	3830.0	Surface runoff and groundwater	501.4	400.0	mid-March

Supervisory control of the Hnylyi Rih river flow is not performed. The Hnylyi Rih river flow is completely accumulated in the reservoir. Flood releases from the Hnylyi Rih River after the reservoir is filled to the NWL level are carried out automatically through the flood spillway.

As a result of the reservoir measurements carried out by LvivODRES in 2007, the average reservoir depth was 6.1 m and the maximum depth was 18.2 m. On the non-pressure reservoir side (left bank), there is a shallow water area 100-300 meters wide and up to two meters deep. The water volume in the reservoir at the water level of 202.800 meters was 115.55 million m^3. This volume of water corresponds to the design data, which concludes that the reservoir is slightly silted up, despite its long operational period.

Table 3.2 – Dynamics of KhNPP water consumption during operation of units 1&2

№	Water supply source	Water used, thousand m^3				
		2023	2022	2021	2020	2019
1	Artesian	999.6	1060.6	1378.3	1277.7	1471.4
2	Service	29017.9	22882.8	39660.8	30664.0	14471.8
2.1	*the Hnylyi Rih river*	14901.1	15986.4	16253.1	7889.2	10909.2
2.2	*the Horyn river*	14116.8	6896.4	23407.7	22774.8	3562.6

Notes: The table shows water use values for KhNPP only (excluding losses and transfer of water resources to the population or other enterprises).

The total number of lakes in the KhNPP area (in river basins with a length of ≥ 10 km) is 111, with a total water surface area of 5.92 km^2. The largest number of lakes is located in the basins of the Vilia (28–1.55 km^2) and Tsvitoha (22–1.02 km^2) rivers.

The total number of reservoirs in the KhNPP supervised area is three. The largest is the NPP cooling pond.

3.5.2 Groundwater

The diversity of groundwater distribution and formation conditions, its chemical composition, feeding and discharge are determined by the geological structure, geomorphological and climatic factors.

In terms of hydrology, KhNPP units 5&6 are located within the Volyn-Podolian fractured water basin. The NPP area is characterized by predominantly planned groundwater flows with the general direction of movement to the regional drain – the Pripyat River, which is due to a significant predominance of their lateral extent compared to the power and relatively low hydrographic terrain.

Currently, two aquifers have been identified [39]:

1. The first groundwater aquifer from the surface was recorded at a depth of 1.40-3.50 meters. The water-bearing soils are medium-sized sands of anthropogenic origin and partially light and heavy loams. The conditional water-resistant layer is a thickness of siltstone and mudstone rocks, the roof of which lies at a depth of 3.00-7.90 m. The aquifer is recharged by losses from water supply systems and infiltration of precipitation, as well as by upward flow from the pressure aquifer. The aquifer is discharged in the southwestern direction towards the KhNPP cooling pond;

2. Lower Neogene pressure water horizon. The depth of the piezometric level of pressure water is 1.40 – 4.20 m. The appearance of water in the pressure aquifer was recorded at a depth of 11.30 – 15.90 m. The pressure water horizon is confined mainly to fractured sandstones. The upper and lower water-resistant layer is made up of siltstone and mudstone. The water masses migrate mainly through fractured sandstones and through the area of siltstone-argillite rocks.

The regime of the first aquifer from the surface is unstable and depends on climatic and anthropogenic factors. The level of the aquifer directly depends on the amount of infiltration losses and accidental leaks.

The pressure water regime is characterized as closed and not subject to seasonal fluctuations.

The level regime of the first groundwater aquifer from the surface is in a stable state.

The chemical composition of the groundwater of the first horizon is of the bicarbonate-calcium type and is not aggressive to all types of concrete.

The water of the pressure horizon is of the sulfate-chloride-natrium-magnesium type. They are highly aggressive to Portland cement concrete.

The main changes in hydrodynamic conditions are localized in the upper area of the superficially developed system of three aquifer complexes: sedimentary complex of Quaternary, Neogene, Paleogene and Upper Cretaceous rocks; Upper Proterozoic (Vendian) rocks of the Mohyla-Podilska and Kanylivska series; rocks of the Volynska series (Gorbashevska Formation) and Polissya series of the Upper Proterozoic.

The regional distribution of piezometric surfaces of the second and third aquifers is similar to the distribution of levels of the first aquifer (regional direction of movement, dynamics of slopes, etc.).

The radiation status of groundwater, including the Netishyn water intake, is satisfactory, i.e. below the limit level regulated by regulatory documents.

3.6 Generalized characteristics of flora and fauna

A generalized characterization of flora and fauna is an important step in the study of biological diversity and ecosystems of a particular territory and ecosystems of a territory.

3.6.1 Floristic complexes

The KhNPP supervised area is located at the intersection of three geobotanical districts. The northern part belongs to the southern edge of the Volyn Upland, the territory of which is heavily plowed. The natural vegetation consists of oak, hornbeam-oak forests and meadow steppes. Typical features of Polissya nature (Male Polissya) characterize the central and eastern parts, where oak-pine, hornbeam-oak-pine and pine forests prevail, with mesotrophic bogs interspersed in the lower parts. The southern part is similar to the terrain, soils and vegetation of the Volyn forest plateau and is located on the spurs of the Podolian Upland. All three areas are crossed by water streams (e.g., the Horyn river and its tributaries), where azonal hydrophilic vegetation (aquatic, marsh, meadow) is formed.

The anthropogenic factor has influenced the structure and distribution of vegetation cover. The diversity of the plant world is determined by the complexity of the terrain, uneven moisture supply and the diversity of quaternary sediments.

The supervised area flora belongs to the flora of the migratory type and consists of various species that have arisen as a result of the influence of different development centers. This area is dominated by forests, in particular pine forests, which occupy the upper parts of the slopes and peaks, and are replaced by oak-pine forests in the lowlands. The following main groups of associations characterize pine forests: lichen, green lichen, blueberry-green lichen, and molinia. Oak-pine forests are widespread throughout the territory and are the main subformation. Hornbeam-oak and hornbeam-pine-oak forests cover smaller areas, while alder and birch forests occur in relatively small areas.

In 2024, the National Museum of Natural History of the National Academy of Sciences of Ukraine assessed the impact of the planned activity on construction of new units at KhNPP on populations of rare plant species of international, national and regional protection status, rare plant communities, habitats of the Emerald Network and nature reserve sites [77].

The work was carried out to identify, inventory and characterize the rare phytodiversity of plant species of national, regional and international conservation status, rare plant communities and habitats of the Emerald Network in the KhNPP affected area.

The phytodiversity of vascular plants of summer vegetation within the KhNPP construction site, the dam of the KhNPP cooling pond and its natural coastline was studied in detail. Particular attention was paid to the study of rare species of state, regional and international protection, rare coenoses listed in the Green Book of Ukraine, habitats of the Emerald Network and objects of the nature reserve network of Ukraine.

In the KhNPP impact area and adjacent protected areas, 22 plant species from the Red Book of Ukraine grow, of which 4 species are included in Appendix I of the Bern Convention; 20 species, mostly of the LC category, are included in the World Red List.

During floristic surveys in the KhNPP construction site area, 133 species of higher vascular plants were identified, of which 96 were native species and 37 (27.8%) were adventitious.

Along the KhNPP cooling pond water pressure dam (10m from the road and on concrete slopes), 108 species of higher vascular plants were found, including 85 (78.7%) native species and 23 (21.3%) adventitious species.

Field studies are in progress, which will result in the establishment of population phytomonitoring for model rare species, rare plant communities, and invasive adventitious species.

Table 3.3 – List of state and internationally protected plant species predicted to be within the KhNPP impact area.

№	Ukrainian species name	Latin species name	Presence on the National Nature Park territory	Sozological status	Family	The authors of the article in the Red Book of Ukraine (RBU)
1.	Fir clubmoss	*Huperzia selago* (L.) Bernh. ex Schrank et Mart.	Male Polissia, Dermansko-Ostrozkyi	RBU(2009)-**Endangered** IUCN (2024) – (Global, EU) LC	Lycopsids – Huperziaceae	S.M. Panchenko, I.I. Chornei, N.M. Sychak, V.I. Melnyk (p. 19).
2.	Sword-leaved helleborine	*Cephalanthera longifolia* (L.) Fritsch.	Dermansko-Ostrozkyi	CITES(2015) RBU(2009)-**Rare** IUCN (2024) – (EU) LC	Orchid – Orchidaceae	I.A. Timchenko, V.I. Goncharenko, O.O. Orlov, S.M. Panchenko, (p. 159).
3.	Red helleborine	*Cephalanthera rubra* (L.) Rich.	Dermansko-Ostrozkyi	CITES(2015) RBU (2009)- **Rare** IUCN (2024) – (EU) LC	Orchid – Orchidaceae	I.A. Timchenko, V.I. Goncharenko, O.O. Orlov, S.M. Panchenko (p. 160).
4.	Swamp willow	*Salix myrtilloides* L.	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable**	Willow – Salicaceae	T.L. Andrienko, O.O. Kahalo (p. 586).
5.	Garland flower (spurge flax, cepe)	*Daphne cneorum* L.	Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable**	Flowering plants – Thymelaeaceae	Y.P. Didukh, (p. 608).
6.	Water caltrop	*Trapa natans* L. s.l.	–	RBU (2009)-**Endangered** BK (2002) IUCN (2024) – (Global) LC	Water chestnut – Trapaceae	D.V. Dubina, G.A. Chorna (p. 612).
7.	Bird's-nest orchid	*Neottia nidus-avis* (L.) Rich.	Dermansko-Ostrozkyi	RBU (2009)-**Endangered** CITES(2015) IUCN (2024) – (Global, EU) LC	Orchid – Orchidaceae	I.A. Timchenko, O.O. Orlov, S.M. Panchenko (p. 196).
8.	Yellow widelip orchid	*Liparis loeselii* (L.) Rich.	Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable** BK (2002) CITES(2015)	Orchid i – Orchidaceae	Orlov O.O., Chornei I.I., Goncharenko V.I. (p. 190).
9.	Eggleaf twayblade	*Listera ovata* (L.) R.Br.	Dermansko-Ostrozkyi	RBU (2009)-**Endangered** CITES(2015) IUCN (2024) –(EU) LC	Orchid – Orchidaceae	I.A. Timchenko, O.O. Orlov, O.T. Kuzyarin,

№	Ukrainian species name	Latin species name	Presence on the National Nature Park territory	Sozological status	Family	The authors of the article in the Red Book of Ukraine (RBU)
						S.M. Panchenko (p. 192)
10.	Early marsh-orchid	*Dactylorhiza incarnata* (L.) Soy s.l.	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)-**Vulnerable** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	O.T. Kuzyarin, M.S. Kozyr I.A. Timchenko, O.V. Lukash S.M. Panchenko, O.M. Bayrak (p. 168).
11.	Heath spotted-orchid (moorland spotted orchid)	*Dactylorhiza maculata* (L.) Soó s.l.	Male Polissia	RBU (2009)- **Vulnerable** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	I.A. Timchenko, O.O. Orlov, S.M. Panchenko (p. 169).
12.	Broad-leaved marsh orchid	*Dactylorhiza majalis* (Rchb.) P.F.Hunt et Summerhayes s.l.	Dermansko-Ostrozkyi	RBU (2009)- **Rare** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	V.V. Protopopova (c. 170).
13.	Marsh helleborine	*Epipactis palustris* (L.) Crantz	Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable** CITES(2015) IUCN (2024) – (Global, EU) LC	Orchid – Orchidaceae	I.A. Timchenko, O.T. Kuzyarin (p. 179).
14.	Dark-red helleborine	*Epipactis atrorubens* (Hoffm. ex Bernh.) Besser	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	I.A. Timchenko (p. 176).
15.	Broad-leaved helleborine	*Epipactis helleborine* (L.) Crantz	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)-**Endangered** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	I.A. Timchenko, O.O. Orlov, S.M. Panchenko, O.M. Bayrak (p. 177).
16.	Martagon lily	*Lilium martagon* L.	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)- **Endangered** IUCN (2024) – (EU) LC	Lily – Liliaceae	T.L. Andrienko (p. 141).

№	Ukrainian species name	Latin species name	Presence on the National Nature Park territory	Sozological status	Family	The authors of the article in the Red Book of Ukraine (RBU)
17.	Lesser butterfly-orchid	*Platanthera bifolia* (L.) Rich.	Dermansko-Ostrozkyi	RBU (2009)- **Endangered** CITES(2015) IUCN (2024) – (EU) LC	Orchid – Orchidaceae	V.V. Protopopova, O. Orlov (p. 212).
18.	Stiff clubmoss	*Lycopodium annotinum* L.	Male Polissia, Dermansko-Ostrozkyi	RBU (2009)- **Vulnerable** IUCN (2024) – (EU) LC	Vascular plants – Lycopodiaceae	T.L. Andrienko, O.I. Pryadko (p. 18).
19.	Marsh clubmoss	*Lycopodiella inundata* (L.) Holub	Male Polissia	RBU (2009)- **Vulnerable** IUCN (2024) –(Global, EU) LC	Vascular plants – Lycopodiaceae	O. Pryadko (p. 17).
20.	Floating watermoss	*Salvinia natans* (L.) All.	–	RBU (2009)- **Endangered** BK (2002) IUCN (2024) – (Global) – LC, (EU) – NT	Heterosporous ferns – Salviniaceae	D.V. Dubina (p. 38).
21.	Eastern pasqueflower (cutleaf anemone)	*Pulsatilla patens* (L.) Mill. s.l.	Dermansko-Ostrozkyi	RBU (2009)- **Endangered** BK (2002) IUCN (2024) – (EU) – DD	Buttercup – Ranunculaceae	O.O. Kagalo, I.A. Korotchenko, O.V. Lukash (p. 565).
22.	Wild garlic	*Allium ursinum* L.	Dermansko-Ostrozkyi	RBU (2009)- **Endangered** IUCN (2024) –(EU) LC	Herbaceous – Alliaceae	T.L. Andrienko (p. 60).

3.6.2 Faunal complexes

The fauna is characterized by a high level of species diversity and rare species for Ukraine and Europe.

In 2024, the I.I. Schmalhausen Institute of Zoology of the National Academy of Sciences of Ukraine assessed the impact of the planned activities for the construction of new power units at KhNPP on the species of animals listed in Resolution 6 (1998) of the Convention on the Conservation of Wild Flora and Fauna and Natural Habitats (Bern Convention) [78].

The available data on animals as per Resolution 6 were collected and analysed in the KhNPP 30-km area and field surveys were conducted.

The analysis of available data within KhNPP 30-km area revealed the presence of 84 animal species as per Resolution 6: 1 species of molluscs, 7 species of insects, 3 species of fish, 3 species of amphibians and reptiles, 66 species of birds, and 4 species of mammals.

3.6.2.1 Terrestrial and aquatic molluscs (Mollusca)

The analysis of the Resolution 6 species list revealed that out of 33 species of molluscs in Ukraine, 6 species are found in Ukraine, and only one of them, Vertigo angustior Jeffreys, 1830, has been identified in the KhNPP 30-km area.

3.6.2.2 Insects (Insecta)

Based on the analysis of the species list from the Annex to Resolution 6 of the Standing Committee of the Berne Convention and information from the National Biodiversity Information Network (UkrBIN), the Global Biodiversity Information System (GBIF), the iNaturalist network, as well as all available literature data, it was found that out of 99 insect species included in the Annex to Resolution 6, 51 species live in Ukraine, and 7 species occur in the KhNPP 30-km area, namely:

– Ophiogomphus cecilia (Fourcroy, 1785) - included in the Red Book of Ukraine;

– Lucanus cervus (Linnaeus, 1758) - included in the Red Book of Ukraine;

– Cucujus cinnaberinus (Scopoli, 1763) - included in the Red Book of Ukraine;

– Lycaena dispar (Haworth, 1802);

– Phengaris teleius (Bergsträsser, 1779);

– Phengaris nausithous (Bergsträsser, 1779);

– Euplagia quadripunctaria (Poda, 1761).

3.6.2.3 Lampreys and ray fishes (Petromyzonti and Actinopterygii)

There are about 30 species of lampreys and fish in Ukraine, and three species of fish from this international list have been reliably recorded within 30 kilometers around KhNPP, namely:

– Misgurnus fossilis (Linnaeus, 1758);

– Cobitis taenia (Linnaeus, 1758);

– Rhodeus amarus (Bloch, 1782).

3.6.2.4 Amphibians (Amphibia) and reptiles (Reptilia)

The analysis of the Resolution 6 species list showed that out of 4 reptile and 6 amphibian species listed in Resolution 6 for the territory of Ukraine, 1 and 2 species occur within KhNPP 30-km area, respectively, namely:

1. Reptiles – Emys orbicularis (Linnaeus, 1758)

2. Amphibians – Triturus cristatus (Laurenti, 1768), Bombina bombina (Linnaeus, 1761)

3.6.2.5 Birds (Aves)

Based on the analysis of available ornithological data, at least 66 species of birds listed in Annex 6 of the Bern Convention occur in the study area during all periods of the annual bird cycle, see Table 3.4.

Table 3.4 – List of birds predicted within the KhNPP impact zone.

Order	Species name
GAVIIFORMES	Gavia arctica
GAVIIFORMES	Gavia stellata
PODICIPEDIFORMES	Podiceps auritus
CICONIIF ORMES	Ardea purpurea
CICONIIF ORMES	Botaurus stellaris
CICONIIF ORMES	Casmerodius albus (Egretta alba)
CICONIIF ORMES	Egretta garzetta
CICONIIF ORMES	Ixobrychus minutus
CICONIIF ORMES	Nycticorax nycticorax
CICONIIF ORMES	Ciconia nigra
CICONIIF ORMES	Ciconia ciconia
CHARADRIIFORMES	Chlidonias hybridus
CHARADRIIFORMES	Chlidonias leucopterus
CHARADRIIFORMES	Chlidonias niger
CHARADRIIFORMES	Larus minutus
CHARADRIIFORMES	Sterna albifrons
CHARADRIIFORMES	Sterna caspia (Hydroprogne caspia)

Order	Species name
CHARADRIIFORMES	Sterna hirundo
STRIGIFORMES	Asio flammeus
STRIGIFORMES	Strix uralensis
CAPRIMULGIFORMES	Caprimulgus europaeus
CORACIIF ORMES	Alcedo atthis
PICIFORMES	Dendrocopos leucotos
PICIFORMES	Dendrocopos médius
PICIFORMES	Dendrocopos syriacus
PICIFORMES	Dryocopus martius
PICIFORMES	Picoides tridactylus
PICIFORMES	Picus canus
PASSERIFORMES	Lullula arborea
PASSERIFORMES	Anthus campestris
PASSERIFORMES	Lanius collurio
PASSERIFORMES	Lanius minor
PASSERIFORMES	Luscinia svecica (Cyanosylvia svecica)
PASSERIFORMES	Sylvia nisoria
PASSERIFORMES	Ficedula albicollis
PASSERIFORMES	Ficedula parva

3.6.2.6 Mammals (Mammalia)

The Ukrainian list of mammals of the fauna included in Resolution 6 of the Bern Convention includes 24 species from 6 orders. Based on the analysis of available data (prior to the field surveys), the species known to occur within the KhNPP 30-km study area were identified, namely:

1. Order Chiroptera. Chiropterans
   – Myotis dasycneme (Boie, 1825)
   – Barbastella barbastellus (Schreber, 1774)
2. Order Carnivora. Raptors
   – Lutra lutra (Linnaeus, 1758)
3. Order Rodentia. Rodents
   – Castor fiber (Linnaeus, 1758)

The field research is in progress, which will result in the development of recommendations for the conservation of animal species of Resolution 6 of the Bern Convention.

3.7 Characterization of the nature reserve fund objects

Two national nature parks are located in the KhNPP supervised area:

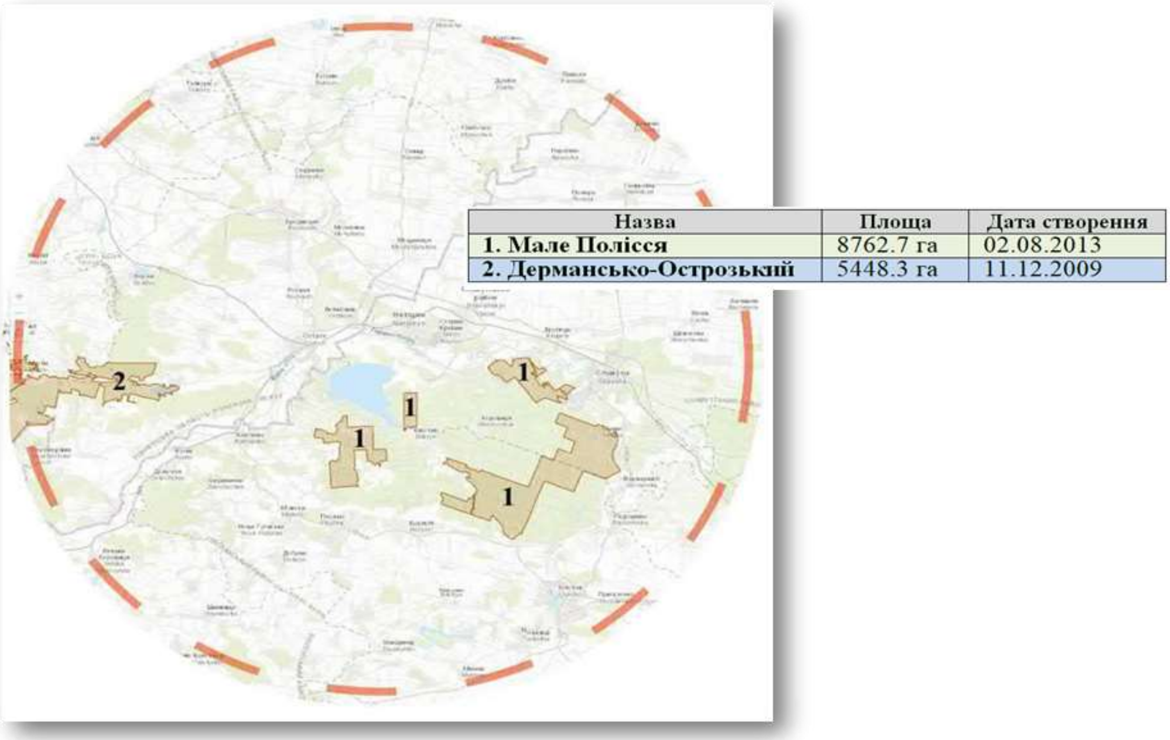
– “Derman-Ostroh” (partially);

– “Male Polissia”.

The Derman-Ostroh National Nature Park is located in the southern part of Rivne region, in the Zdolbuniv and Ostroh districts.

The park is based on 18 existing objects of the nature reserve fund, including the Bushchansky botanical reserve of national importance, botanical reserves of local importance Tract “Bir”, “Kruglyak swamp”, “Zbytynka river floodplain”, landscape reserves of local importance “Pivdenno-Mostivsky” and “Pivnichno-Mostivsky”, and a forest reserve of local importance “Olkhava”, hydrological reserve of local significance “Zbytynsky”, geological reserve of local significance “Mizotsky Ridge”, ornithological reserve of local significance “Zbytynsky”, hydrological natural monument of local significance “Rynva Spring”, protected tracts “Gurby”, “Mostivske”, “Budky”, “Zinkiv Stone”, “Peklo”, “Turova Grave”.

The park's vegetation is dominated by forest vegetation. Other vegetation types include swamps, marshes, and peaty meadows, which were formed on the site of drained swamps. Swamps are found mainly in and adjacent to the territory of Male Polissia. They are located in the valleys of small rivers. The bswamps are peaty, almost exclusively eutrophic. Forest vegetation is represented by deciduous, mixed and coniferous forests.



Назва	Площа	Дата створення
1. Мале Полісся	8762.7 га	02.08.2013
2. Дерманcько-Острозький	5448.3 га	11.12.2009

Figure 3.1 – National natural parks within the KhNPP 30-kilometer supervised area

The Nature Park “**Male Polissia”** is located in the Izyaslav and Slavuta districts of Khmelnytskyi region.

The park's boundaries are conditionally drawn along the valleys of the rivers and the KhNPP cooling pond. In the north – the Goryn River and the cooling pond, the source of the Hnylyi Rih River; in the east – the Goryn River; in the northwest – the Vilia River; in the south – the tributaries of the Goryn and Vilia Rivers.

The park has well-preserved forest vegetation. On the massifs of thick sands, the largest areas are occupied by green moss and blueberry-green moss pine forests. Oak-pine and oak-hornbeam forests do not occupy significant areas. Their main areas are concentrated in the SE “Slavutske Forestry”. Scots pine is found in natural stands in fragments. Black cedar forests occupy small areas in the foothills of the Goryn River floodplain and are represented by fern, pike and sedge cedars with pointed sedge.

The swampy floodplains are occupied by peat bogs and marshy meadows. The area is characterized by large tracts of marshes. All types of matshes of Male Polissia are represented here, and there are few lakes.

The KhNPp 10-kilometer area includes such protected areas as the Pralis reserve located between the KhNPP fire station and the KhNPP training center, the Dorohoshcha reserve near the KhNPP fish farm, the Vilshyna reserve on the outskirts of Netishyn, the May Lily of the Valley botanical reserve, the Klynovetske hydrological reserve and parts of the Male Polissya National Park.

Figure 3.2 – Nature protected areas within the KhNPP10-km area

“Dorohoshcha” is a botanical reserve of local importance located in the Netishyn forestry, SE Slavutske Forestry, near the KhNPP cooling pond.

The protected area is slightly hilly, covered with an almost continuous massif of medieval and mature forest. This area is dominated by a sparsely herbaceous hornbeam-pine forest with oak, birch, and alder in the lower elevations. There is an admixture of sharp-leaved maple and sycamore in the stand. The undergrowth is poorly detected, it is represented by hazel, warty larch.

The grass stand is sparse, dominated by yellow archangel, and European bentgrass. There are many rare and uncommon species in the grass stand. The fir clubmoss was found here. It grows in two large clumps in the natural slope of alder-hornbeam-pine forest of sparse herbs. The growth of species listed in the Red Book of Ukraine are identified in the reserve – forest lily and broad-leaved helleborine. In the lowlands, large patches of prickly pear form a boreal species from the Red Book of Ukraine, which is located at the southern border of its range. There are large populations of Melittis sarmatica and common wolfberry. These species are included in the list of protected species in Khmelnytskyi region.

"Pralis" is a forest reserve of local importance located in the Kryvynske forestry of the SE Slavutske Forestry.

The protected area is an old oak-hornbeam forest. The age of the preserved old oaks, which form the basis of the stand, is about 200 years, their height reaches 22-24 m, the average trunk diameter is 90-92 cm, and there are some oak trees with a trunk diameter of 110 cm. In addition to oak, the first tier contains old pines and some birches. Hornbeam forms a dense second tier 14-16 meters high. Numerous undergrowth is provided by hornbeam and sharp-leaved maple. Undergrowth is not developed. The herb layer is sparse. Yellow archangel and common quatrefoil dominate. Occasionally there is a forest starflower, May lily. On the edges of the reserve, the Wood cow-wheat, yellow foxglove, tall cinquefoil, and crownvetch. The growth of plant species listed in the Red Book of Ukraine was detected: forest lily, cinquefoil, dark red cinquefoil and rare species of noble liverwort, Austrian fern, May rose, medicinal and multi-leaved hawthorn.

The preserved area of the old hornbeam-oak forest is of great scientific value. This forest plantation is a model of virgin forests, which do not exist in this region. Such forests are listed in the Green Book of Ukraine.

"Lily of the Valley" is a botanical reserve of local importance, located in the Pluzhnyansky forestry, SE Izyaslavske Forestry, near the village of Pluzhne. The reserve was transferred to the jurisdiction of the Male Polissia National Park.

The territory of the reserve is characterized by a leveled relief, sod-podzolic sandy soils, medieval pine forest with an admixture of oak. The grass cover, dominated by lily of the valley, is uneven. In the reserve, lily of the valley blooms profusely, has a high vitality, and is distributed over the entire area, forming spots.

Along with the lily of the valley, there are mainly northern (boreal) species - blueberries, club-leaved plantain, heather, lingonberries, and Koeleria glauca. All of these are mostly Central Polissia species, which are also common in the Male Polissia area. A rare species of this group is the narrow-leaved gerbil. Among the Red Book plants, a relict plant of the Tertiary period, wolf's berry, was found on the territory of the reserve.

“The Klynovetsky tract” is a hydrological reserve of local importance located in the Pluzhnyansky forestry, SE Izyaslavske Forestry.

The ecotope, which is typical for Male Polissia, is protected and consists of a lowland forest tract with alder-birch and pine forests with an admixture of maple, ash and spruce, as well as pine plantations.

A special rarity of the reserve's dendroflora is a specimen of the common oak over 400 years old. Several left tributaries of the Vilia River (a tributary of the Horyn River) originate and flow in the reserve. The herbaceous cover includes typical forest plants (e.g., ground elder, hairy sedge, European bindweed, male and lady fern), meadow and wetland plants (water horsetail, water chickweed, and alternate-leaved golden-saxifrage), and wetland plants (swamp horsetail reeds, forest reed, double-leaved mint, water marshmallow). There are areas with different types of willow: brittle, purple, white, and ash willow. A plant of the Red Book of Ukraine, wolf berries, was found, as well as a rare sedge in Khmelnytskyi region.

The KhNPP supervised area includes 10 protected tracts. Only the protected tract “Vilshyna” was observed not far from KhNPP.

“Vilshyna” is a protected tract of local importance located in the Kryvynske forestry, SE Slavutske Forestry in the eastern part of Netishyn.

The protected area is a part of the foothills of the Goryn River floodplain, which is clearly distinguished in the relief, occupying a natural depression. The site is characterized by rather significant moisture, especially in the area adjacent to the peaty meadow. Black alder grows in the low-lying, waterlogged part of the tract. In the part of the tract adjacent to the road, elevations are observed, resulting in old pine trees among the alder plantations. The majority of the tract is forested, the smaller part is occupied by peat meadows.

The predominant fern alder forest is dominated by marsh thelipteris, and in the higher parts - by female shieldwort and Chartres shieldwort. Male shieldwort also occurs here. Typical alder companion plants grow in alder, such as false and elongated sedges, sweet-bitter nightshade, marsh wolfsbane, and marsh cleavers. In the cereal-fern alder, you can see thin broom, blueberry clumps. Along the edge of the tract, large spots (several tens of square meters) are formed by rough blackberries. This is a Carpathian species, which is located here at the eastern border of its range. There is also a species of blackberry called bearberry (Nesian blackberry), as well as a Central European species called small-flowered dog rose.

In the southern part of the tract, a peaty meadow has formed on a flat elevation on the site of a reduced alder tree. There are some specimens of overgrown alder on it. The meadows are pike-small sedge meadows with soddy pike, yellow, black, and prostrate sedges.

Large populations are formed by river thistle, willow weeping grass, and marsh puddleweed. Also, populations of two species of meadow-marsh orchids listed in the Red Book of Ukraine - meat-red and spotted finger-root orchids - were found. They bloom and bear fruit. Less common species include the marsh trident, four-winged St. John's wort, and tall valerian, a valuable medicinal plant.

During the faunal field surveys, the primary focus was on the KhNPP impact zone and the areas immediately adjacent to this zone. Surveys were also conducted in more remote areas. The surveys and observations were conducted within the territories of the Nature Reserve Fund (NRF) of Ukraine (NNP “Male Polissia”, forest reserve of local importance “Pralis”, botanical reserve of local importance “Dorohoshcha”, landscape reserve of local importance “Myslyatynskyi”, park-monument of landscape art of local importance “Kryvynskyi”, on the border of the protected tract of local importance “Vilshyna”). Surveys within the territory of the Izyaslavsko-Slavutskyi Emerald Network were also perfomed. In addition, observations were conducted within settlements, on agricultural areas, near water bodies, within exploited forest areas, etc.

Birds. Bird surveys were conducted on road routes within the 30-km zone of the KhNPP in combination with short-term spot and walking surveys. A total of 92 locations were surveyed.

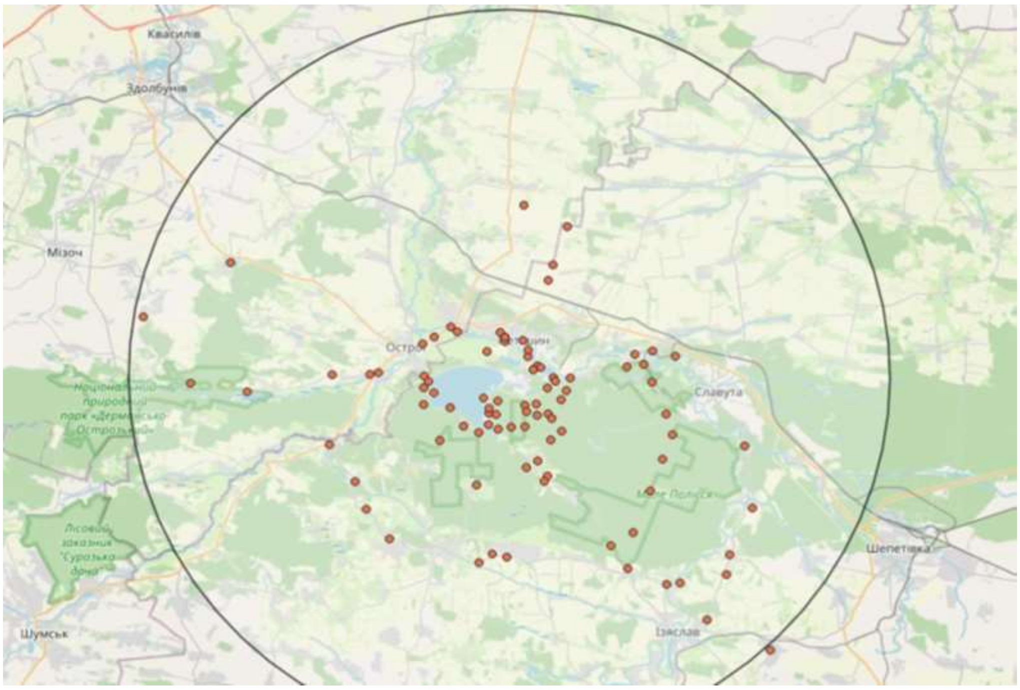


Figure 3.3 – Locations of bird surveys

Based on the analysis of the field survey data, a total of 87 species of birds were recorded, of which 18 are included in the species list of Resolution 6 of the Bern Convention:

– Botaurus stellaris (Linnaeus, 1758) – The great bittern

– Ixobrychus minutus (Linnaeus, 1766) - The little bittern

– Casmerodius albus (Egretta alba) ((Linnaeus, 1758) - Great egret

– Ciconia nigra (Linnaeus, 1758) - Black stork

– Ciconia ciconia (Linnaeus, 1758) - White stork

– Pernis apivorus (Linnaeus, 1758) - European honey buzzard

– Milvus migrans (Boddaert, 1783) - Black-crowned Falcon

– Circus aeruginosus (Linnaeus, 1758) - Harrier

– Circaetus gallicus (Gmelin, 1788) - Snake-eater

– Haliaeetus albicilla (Linnaeus, 1758) - White-tailed eagle

– Sterna albifrons (Pallas, 1764) - Little tern

– Sterna hirundo (Linnaeus, 1758) – Common tern

– Caprimulgus europaeus (Linnaeus, 1758) - Redshank

– Alcedo atthis (Linnaeus, 1758) - Common kingfisher

– Dryocopus martius (Linnaeus, 1758) - Black woodpecker

– Anthus campestris (Linnaeus, 1758) - Tawny pipit

– Lanius collurio (Linnaeus, 1758) - Red-backed shrike

– Ficedula albicollis (Temminck, 1815) - Collared flycatcher

Mammals

1. *Bats*. Currently, the list of species confirmed to be present within the study area includes 10 species:

- Barbastella barbastellus (Schreber, 1774) - barbastelle bat
- Eptesicus serotinus (Schreber, 1774) - serotine bat
- Myotis dasycneme (Boie, 1825) - pond bat
- Myotis daubentonii (Kuhl, 1817) - Daubenton's bat
- Myotis nattereri (Kuhl, 1817) - Natterer's bat
- Nyctalus leisleri (Kuhl, 1817) - Leisler's bat
- Nyctalus noctula (Schreber, 1774) - common noctule
- Pipistrellus kuhlii (Kuhl, 1817) - Kuhl's pipistrelle
- Pipistrellus nathusii (Keyserling & Blasius, 1839) - Nathusius' pipistrelle
- Pipistrellus pygmaeus (Leach, 1825) - soprano pipistrelle

Two species, B. barbastellus and M. dasycneme, are listed under Resolution 6 of the Bern Convention.

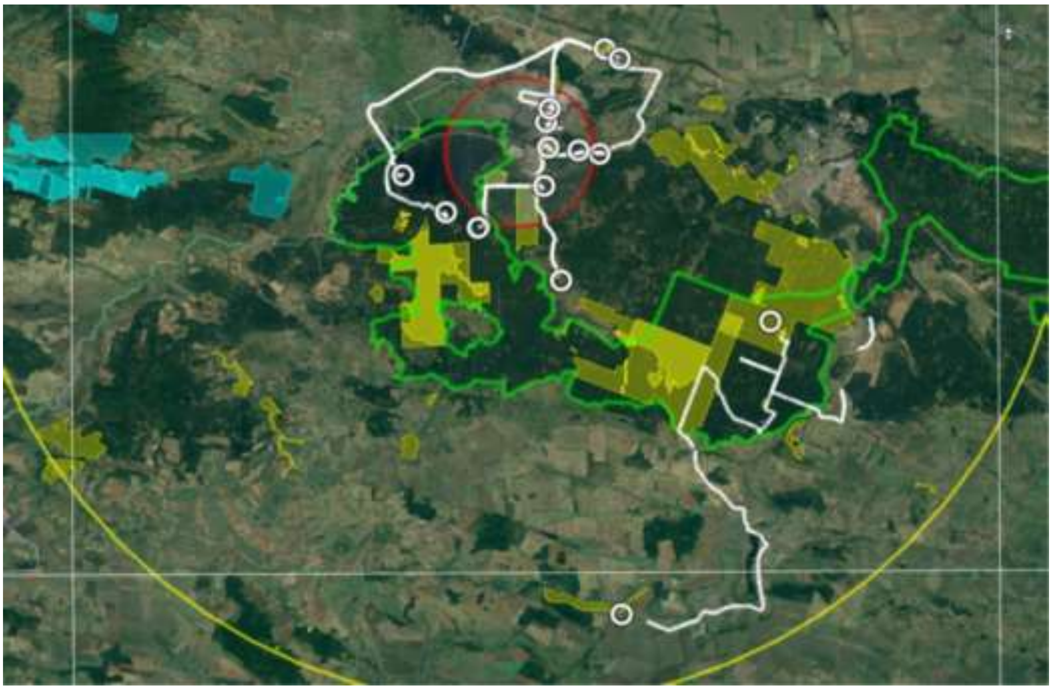


Figure 3.4 – Schematic map of survey routes and stationary observations of bats in the KhNPP supervised area

White lines and circles - bat surveys; red contour - 3-km NPP zone, yellow contour - boundaries of the 30-km NPP zone, green contour - boundaries of the Izyaslavsko-Slavutskyi Emerald Network site; yellow polygons - natural reserve fund of Khmelnytskyi region, blue polygons - natural reserve fund of Rivne region

2. *Predators.* Following the surveys, three locations of otters (Lutra lutra) were identified within the KhNPP planned activity territory and 30 km surrounding area, see Table 3.5

Table 3.5 – Otter (Lutra lutra) location surveys

Location characteristics	**Location**
Otter feeding table	A dam between a cooling pond and a relatively small reedbed.
Traces of activity (prints in the sand)	The bank of Dziolova pond near Komarivka village
Otter feeding table	Dam on the Gnylyi Rih River

3. *Rodents.* Field surveys of beaver (*Castor fiber)* conducted around the KhNPP site indicate that beaver occupation of wetlands is sporadic.

Most of the water bodies are former sand quarries, have a large depth and a large area of open water, and thus are of poor quality for beaver habitat. The Goryn River is also unsuitable for beaver habitat because of its fast flow. Therefore, only two beaver settlements were found in the quarry ponds.

A study of small forest lakes south of the Goryn River channel indicates that they were also inhabited by beavers in the past, as evidenced by very old wood gnawings and several old ruined huts. However, no inhabited locations have been found here.

The reason for the disappearance of the beaver lies in the succession of woody vegetation along the banks of water bodies. Currently, the predominant species here is a pine tree of a ripening age, which creates a thick canopy of the upper tier, suppressing the growth of hardwoods.

A completely different picture has emerged in the southeastern part of the KhNPP cooling pond. Most of the cooling pond has a large depth and area devoid of near-water vegetation.

In general, the eastern part of the cooling pond coast with numerous canals, streams, and lakes has a very high habitat value for beaver. In particular, 4 beaver huts were recorded on one of the channels (up to 5m wide).

3.7.1Emerald Network

The current scheme of the Emerald Network of Ukraine (https://rm.coe.int/updated-list-of-officially-adopted-emerald-sites-december-2019/168098ef51?fbclid=IwAR3Sfh-F_w0fpHBkCggkU1Xc1bUbo57vMgDhu1Fcgq-gFvM5QaceWsnOlt4) was approved in 2019.

The Emerald Network is focused on the conservation of specific species and habitats in Ukraine, including 264 species and 117 habitats, each of which has prescribed conditions for their conservation.

There are two approved Emerald Network protected territories in the KhNPP supervised area (Updated list..., 2019):

– Derman-Ostroh National Nature Park;

– Male Polissia National Nature Park became a part of the Iziaslavsko-Slavutytskyi Emerald Network, which includes the territories directly adjacent to the KhNPP, including the cooling pond.

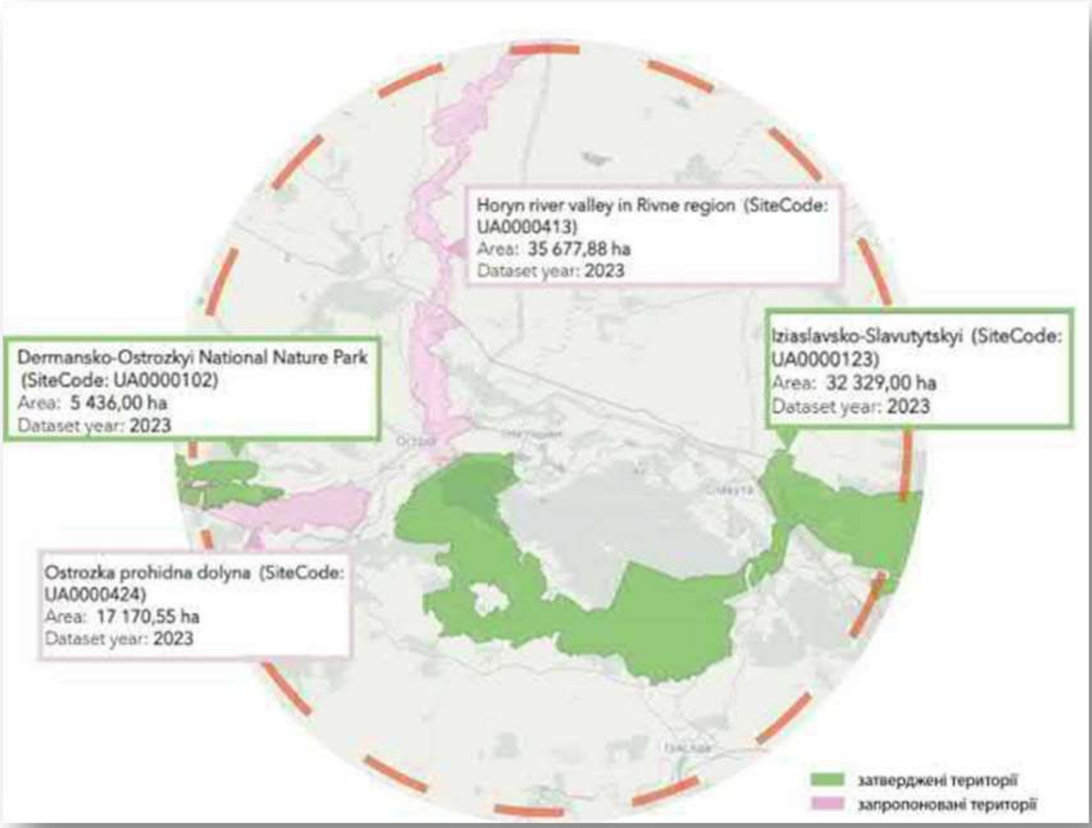


Figure 3.5 – The Emerald Network protected territoriers within the KhNPP 30-km supervised area (from the map of the European Emerald Network https://emerald.eea.europa.eu/).

3.8 Characterization of the distribution of all negative factors in the area of influence of the planned activity

To analyze the indicators of all negative factors in the area of possible impact of the design facility, the data from the safety analysis reports for KhNPP units were considered and included.

Based on the analysis of external extreme impacts, it was determined that KhNPP buildings and structures may be exposed to the following negative factors:

- tornado;
- earthquake;
- fire (smoke);
- toxic and corrosive emissions into the atmosphere.

In the event of any of these incidents, KhNPP personnel must take adequate measures in accordance with the regulations and instructions of the Ministry of Emergencies of Ukraine.

3.8.1 Natural hazards

Natural meteorological phenomena [41] include phenomena that are particularly dangerous in terms of their intensity, area of distribution and duration:

- heavy rains (rainfall of at least 50 mm within 12 hours or less);

- large hail (diameter of at least 20 mm);
- wind with a speed of at least 25 m/s, hurricanes, squalls and tornadoes;
- heavy fog (visibility less than 100 meters);
- severe snowstorms (with a wind speed of at least 15 m/s), snowfall (precipitation of at least 20 mm in 12 hours or less);
- heavy ice (diameter of deposits not less than 20 mm)

3.8.1.1 Heavy rain and large hail

During KhNPP operation, heavy rains over the industrial site and events related to large hail did not cause any disruptions in plant operation.

3.8.1.2 Tornadoes

According to the zoning of tornado events [31], the KhNPP site is located in a tornado-prone area. According to the catalog of registered tornadoes in the USSR, [31] and the data of the Hydrometeorological Service of Ukraine [42] no tornadoes were registered directly within the KhNPP supervised area.

3.8.1.3 Heavy fogs

Heavy fogs are observed during the cold season. The fog classification by its origin is not of fundamental importance for NPPs. Whatever the type of fog, its presence does not contribute to the dispersion of impurities in the surface layer of atmospheric air. No heavy fogs were observed on the territory of Khmelnytskyy region, including in the vicinity of KhNPP.

3.8.1.4 Blizzards, snowfalls, ice

During KhNPP operation, severe snowstorms, heavy snowfalls, and ice that occurred in the areas adjacent to the plant did not create any emergencies at the plant.

3.8.1.5 Dust storms

The probability of intense natural dust storms in the northern and western regions of Ukraine (where KhNPP is located) is about 5%, i.e. they are possible once in 20 years.

During the plant operation, natural meteorological events that occurred in the areas adjacent to the plant, including severe dust storms did not create any emergencies at KhNPP.

3.8.1.6 Earthquake

The results of instrumental seismological surveys show that the KhNPP site is quiet from the seismic point of view.

The seismic score with regard to seismic microzoning for the KhNPP site is:

- design basis earthquake – 5 points;
- maximum credible earthquake – 6 points;
- seismicity of the site (PGA) according to the deterministic analysis of seismic hazard for KhNPP is 0.1g.

3.8.1.7 Floods

Based on the available information on the hydrological water bodies state in the KhNPP 30-km affected area, where the AP1000 units 5& 6 are to be deployed, it can be concluded that this territory is relatively well studied in hydrological terms. Most of the State Emergency Service of Ukraine hydrometeorological stations have more than 50 years of observations. The observation at these stations includes all the water regime elements. The Water Cadastre availability allows using the observation data of the State Emergency Service of Ukraine Hydrometeorological Center as a basis for the regional river water regime features and obtaining calculated hydrological parameters characterizing the water content of the NPP water supply sources.

A flood commission is appointed every year before the spring floods at NPP, and in some cases also before the summer and autumn floods. According to [43], the commission inspects and checks the flood (high water) preparation of all hydraulic structures, their mechanical equipment, lifting devices, and flood passage management and, after the flood has passed, re-inspects the structures.

A flood spillway is located at 14+00 Sta of the barrier dam to allow for reservoir blowdown with water discharge through the bottom outlet. The water is partially discharged during floods of exceptional recurrence, coinciding with periods of full reservoir filling. The flood spillway consists of two spillway shafts, three spillway tunnels with a cross section of 3.0×3.0 m, a spillway in the lower reaches and a breakwater in the upper reaches. The flood spillway discharge at 0.01% is 110.0 m3/s.

In case of technological need, the reservoir is purged and water is discharged through the bottom outlet. Water is partially discharged through the flood spillway during floods of exceptional recurrence, coinciding with periods of full reservoir filling.

The maximum design discharge of a rainfall flood in the Hnylyi Rih River with a given probability of exceedance (under natural conditions) is 140 m^3/s. The runoff volume is 32.8 million m3. The maximum water discharge from the Hnylyi Rih River with a given probability of exceedance and flood transformation is 110 m^3/s. The capacity of the spillway structures is shown in Table 3.6. The dependence of the water discharge Q through the flood spillway on the water level H in the cooling pond is shown in Figure 3.6.

Table 3.6 – Spillway structures capacity

Name of spillway structures	**Capacity (m^3/s) at the water level in the reservoir**	
	NWL (203.0 m asl)	**MFL (203.7 m asl)**
Flood spillway	does not operate	110.0
Flood spillway bottom outlet	14.0	-

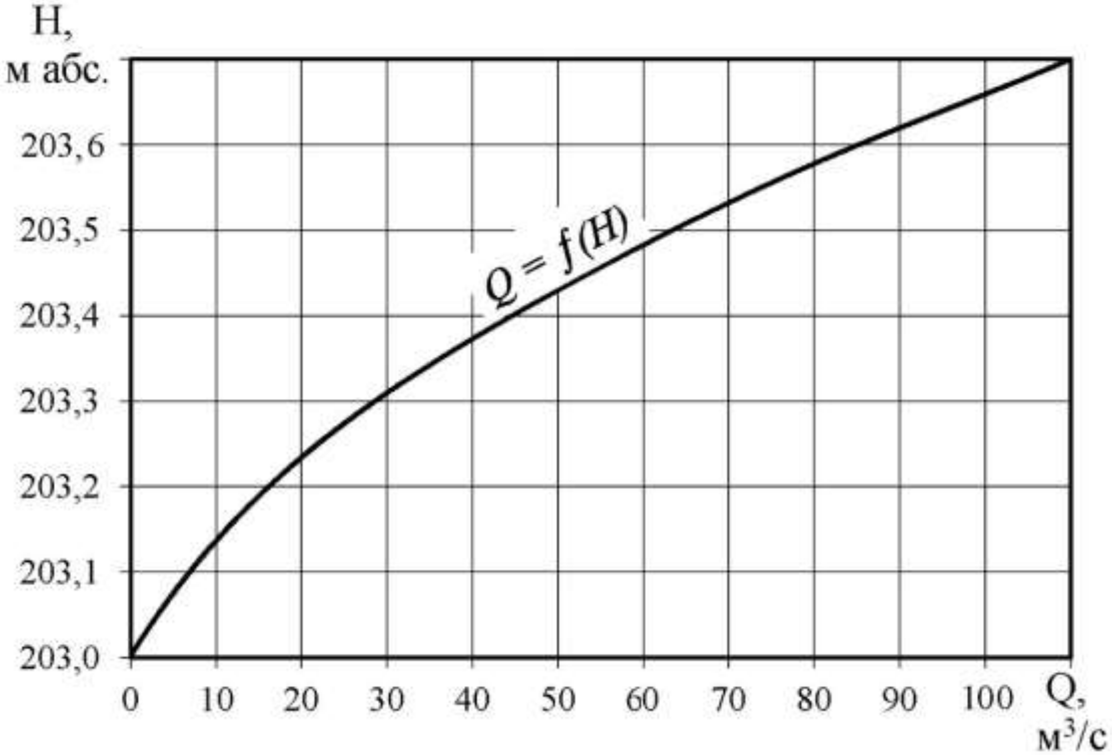


Figure 3.6 – Dependence of water flow Q through the flood spillway on the water level H in the cooling pond

Flooding of the areas adjacent to the downstream side of the dam should be monitored regularly. During the inspection of the area adjacent to the dam, flooding is visually detected. At the identified flooded areas, a detailed survey is performed: the spread area and groundwater depth are measured. Following the survey, the need for and methods of drainage of flooded land shall be determined in cooperation with the land user.

3.8.2 Hazards of anthropogenic origin

KhNPP structures and systems that affect safety are designed to withstand extreme external impacts determined by natural site conditions (seismic impact, tornado, extreme ambient temperatures, etc.). Under these impacts, safety conditions are ensured and, accordingly, there is no additional environmental impact of the NPP.

3.8.2.1 Emissions of harmful chemicals into the atmosphere

KhNPP is located on the territory of Khmelnytskyi region, on the border with Rivne region (at a distance of about 6 km), so it is advisable to indicate the current state of atmospheric air for the two regions in this section. The layout of the KhNPP site is shown in Figure 3.7.

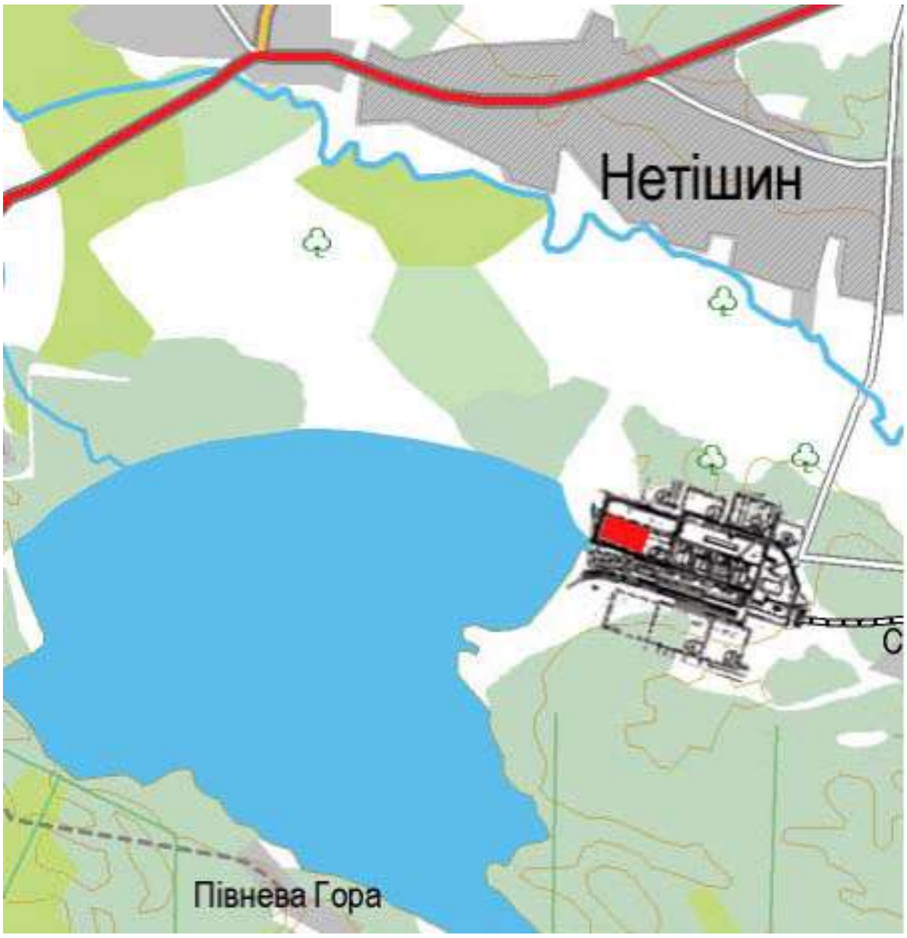


Figure 3.7 – The layout schematic of the KhNPP site location

A number of industrial enterprises are located in the KhNPP supervised area that are sources of harmful chemicals emissions into the atmosphere. Pollutants are generated at industrial enterprises as a result of technological processes or fuel combustion.

Despite a significant amount of annual gross emissions of pollutants, they do not have an extremely large impact on the state of the air basin at the KhNPP sanitary protection and supervised areas, since the concentration of these substances in the air, including the KhNPP emissions, does not exceed the permissible limit concentration.

The current state of the atmospheric air is determined on the basis of continuous monitoring conducted by state authorities: Netishyn City Department of the State Institution "Khmelnytskyi Regional Laboratory Center of the Ministry of Health of Ukraine" and Ostroh City Department of the State Institution "Rivne Regional Laboratory Center of the Ministry of Health of Ukraine"; as well as directly by the relevant KhNPP control services. The data on background concentrations are provided in Appendix E.

3.8.2.2 Natural and anthropogenic processes

Unfavorable natural and anthropogenic processes include such phenomena as landslides, erosion, suffosion, deflation, karst, rainfall, salinity, and flooding.

Prior to the KhNPP construction, there were the following exogenous geological processes:

– territory waterlogging;
– planar erosion (planar washout);
– weathering of argillaceous and siltstone rocks in open pits (exfoliation – "peeling" and cracking of the soil massif in some areas).

During the KhNPP units 1&2 construction, these conditions were improved, namely:

– the site was drained, waterlogging was eliminated, marsh deposits were removed and replaced with sand;
– a redeposited chalk was removed and replaced with sand at the main structures area (main buildings of units No. 1-4), which created conditions for the infiltration of precipitation, i.e., waterlogging prevention;
– the territory was planned, asphalted and landscaped, which completely eliminated erosion;
– a set of protective measures was implemented to prevent weathering of siltstone and mudstone rocks in open pits (incomplete excavation to the design mark, installation of protective concrete coatings before the foundations were installed).

A set of measures was taken at the industrial site to reduce the negative impact of exogenous geological processes. As a result of these measures, no EGPs have been identified and no EGPs are expected to appear.

3.8.2.3 Accidental radioactive contamination of adjacent territories

At present, the radiological situation at the KhNPP site is mainly determined by radionuclides of natural origin. Short-lived technogenic isotopes were not detected in the NPP supervised area.

4 DESCRIPTION OF THE ENVIRONMENTAL FACTORS LIKELY TO BE AFFECTED BY THE PLANNED ACTIVITY AND ITS ALTERNATIVES, INCLUDING POPULATION HEALTH, FAUNA, FLORA, BIODIVERSITY, LAND (INCLUDING LAND ACQUISITION), SOIL WATER, AIR, CLIMATIC FACTORS (INCLUDING CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS), PROPERTY, INCLUDING ARCHITECTURAL, ARCHAEOLOGICAL AND CULTURAL HERITAGE, LANDSCAPE, SOCIO-ECONOMIC CONDITIONS AND INTERACTIONS BETWEEN THESE FACTORS

The planned activity will have an impact on various aspects of the environment. This section is devoted to the description of environmental factors that may be affected as a result of the construction and operation of KhNPP Units 5 and 6. The impact on natural resources, socio-economic aspects, material objects, etc. is considered.

4.1 Population health

The level of environmental risk of radiation exposure at Khmelnytskyy NPP during normal operation and possible emergencies outside the sanitary protection zone does not exceed the acceptable level required by the RSSU-97 [22]. Individual risks of the population stochastic effects due to radiation exposure from aerosol emissions of Khmelnytskyy NPP also do not exceed the acceptable level established by the RSSU-97.

The risks of deterministic effects are equal to zero. It means that even in case of an emergency at Khmelnytskyy NPP, when a significant loss of control over radiation emissions may occur, the expected radiation doses will not reach the level that may cause deterministic effects in the population.

It can be concluded that the level of environmental risk in the operation of the additional two Khmelnytskyy NPP units and their impact on human life and population health does not exceed acceptable levels and can be considered insignificant. The above factual data indicate that the safety measures taken at Khmelnytskyy NPP will be sufficient to prevent exceeding the permissible levels of radiation impact on the environment and population health.

4.2 Condition of fauna

Fauna is one of the main environmental factors that can be affected by the implementation of planned activities.

Based on the conducted study, the commissioning of new KhNPP units will not directly damage animal habitats due to the absence of significant changes in the natural landscape. In addition, the commissioning of new units may positively impact migratory birds.

The construction of new KhNPP units does not predict significant negative environmental consequences, such as the destruction of animal populations, and ecosystems or complete elimination of habitats. However, certain changes will affect populations of several animal species.

Expanding the non-freezing areas of the cooling pond may increase the number of some insect species, including dragonflies, certain species of beetles, and bedbugs. An increased number of blood-sucking dipterans is also possible due to an increasing number of their food sources and shelter.

Increased noise levels resulting from high traffic may have a restricted impact on insects. On the other hand, ground vibration, which also occurs as a result of high traffic, can be a significant disturbance for some insect species.

Groundwater level changes can have an impact on the entomofauna, primarily through changes in phytocoenoses or plant communities. Each plant species may have its consortium of insect species. When meadows are waterlogged, hydrophilic ones often replace mesophilic insect species. As a result, the meadow ecosystem can be replaced by a marsh one, which leads to a general impoverishment of the insect species range.

The commissioning of Units 5 and 6 and the accident-free operation of KhNPP, including six power units in total, will not have a significant negative impact on the overall species diversity of invertebrates and insects.

Increased anthropogenic impact on landscape areas related to the growing population of Netishyn may affect the number of rare insect species in the urban vicinity. It can be caused by various factors, such as the allocation of meadow areas for vegetable gardens, recreational activities, deforestation, and general environmental pollution. At the same time, it has been confirmed that the commissioning and normal operation of Khmelnytskyy NPP Units 5 and 6 will not hurt the fauna in the NPP observation area.

After the commissioning of new power units, additional impacts on the entomofauna may be possible due to various factors. The following are some of them:

1) Water temperature increasing in a cooling reservoir can affect the aquatic ecosystem as a whole, as well as the species diversity and quantity of aquatic insects. Changes in the temperature regime can affect the diversity and activity of insects living in water. However, it is unlikely that the species diversity of the entomofauna of the reservoir will be impoverished.

2) Increase the number of light sources (lamps that attract insects at night). The most commonly attracted insects are lepidopterans (sphinx moths, Noctuidae (owlet moths), geometer moths, lappet moths, pyralid moths, etc.), beetles (staphylinids - rove beetles, beetles, etc.), dipterans (flies, mosquitoes), hymenopterans, lepidopterans, and shield bugs. As a result, at night, insects may migrate from their habitats (from a distance of several hundred meters to two kilometers) to the NPP site. It can hurt the condition of populations of several insect species, but it will not lead to an impoverishment of the species diversity of Khmelnytskyy NPP's facilities. At the same time, this factor will favorably affect the number of nocturnal predators hunting near artificial light sources (some predatory beetles, arachnids, amphibians, etc).

3) A slight increase in the economic and recreational impact on the ecosystems of KhNPP is expected due to the growth of the number of service personnel and the total population of Netishyn. The area adjacent to the plant is under intensive use. There are recreation areas on the banks of the Goryn River. A large area is allocated for gardens,

vegetable gardens, and pastures. As a result, a valuable meadow entomocomplex has disappeared or been severely degraded over a large area, while at the same time, anthropogenic insect diversity has developed to a large extent. Plenty of synanthropic insects (large species of flies, cockroaches, and scale insects) significantly reduce the overall epidemiological situation in the plant area. To avoid infectious disease outbreaks, it is necessary to constantly monitor compliance with sanitary standards by local sanitary supervision authorities not only in residential areas but also in recreational areas.

4.3 Condition of flora

The main impact on the radiation situation in the NPP area is caused by radionuclides of natural origin. This indicates that the contamination levels caused by NPP activities remain at a safe level for nature and people.

The operation of two additional units at KhNPP, includong the above conditions, is not expected to have a significant impact on the structure and dynamics of plant species or change the number of populations of rare and the Red Book plant species.

Under consideration of emergencies, where exposure to flora outside the sanitary protection zone (SPZ) is insignificant, no changes in their structure or other negative changes are expected. However, under significant exposure that may occur in a beyond-design emergency, negative changes are likely to appear in some ecosystems, particularly in pine stands.

Under emergency conditions, the degree of radioactive impact releases on the environment, including forests, depends on various factors, including the release rate and radionuclide structure. It is worth noting that the main dose-forming radionuclide in the beyond-design basis accident is ^{131}I, which can irradiate woody vegetation through aerial contamination. For plants growing inside the SPZ, doses can be high, which can lead to morphological changes.

In the case of a hypothetical emergency, negative changes mainly for pine plantations are possible, when plants absorb a dose from 6 to 10 Gy. Changes will be less noticeable or absent in hardwood plantations, which are less sensitive to radiation. Mixed stands consisting of pine and hardwoods will be described as intermediate, sometimes showing partial morphological or structural changes.

Assessment of the possible accumulation of radionuclides in valuable agricultural plant species within their ecological ranges is important for ensuring food and ecosystem safety. Many radionuclides released as a result of emergencies may not be significant for plant metabolism, but ^{137}Cs and ^{90}Sr are easily integrated into biochemical cycles and accumulate in food chains.

4.4 Land resources

Before the construction of KhNPP Units 5 and 6, the project envisages the removal of topsoil formed on top of the fill soils and its storage in dumps near the construction site for further use.

The construction site will be filled with suitable local soils to the appropriate design elevations. The thickness of the fill layer is expected to be from 0.2 m to 1 m.

To reduce the environmental impact, the soil removed during construction will be stored at the KhNPP site.

All earthworks will be carried out with the use of moisturizers to prevent dust generation.

As the construction site has already been prepared for the construction of power units 1-4, no significant impact on the structure of vegetation and soil cover is expected during the construction of new power units.

Heavy metal contamination of soil occurs in three main ways: airborne, waterborne, and through the application of fertilizers and pesticides, as well as agricultural processing.

The most widespread and significant source of contamination is air, which is characterized by the intake of heavy metals in the form of aerosols and gases as a result of emissions from industrial enterprises, internal combustion engines, thermal power plants, CHP plants, and after households use natural fuel (coal) for space heating.

Since there are no large industrial facilities within thirty kilometers of Khmelnytskyy NPP, the main source of heavy metals from the air is roads and the burning of solid fuels for heating residential buildings.

According to the research results, the content of copper, zinc, cadmium, and lead in the soils of the territory adjacent to KhNPP is at the background level. There is a possibility of slight extra anthropogenic lead inputs into the soil of agricultural land adjacent to roads, which will not lead to an excess of average background concentrations of this element and contamination of agricultural products.

In general, pollutant emissions from most pollution sources enter the surface air layer, so they do not enter local and global air flows and are not transported over long distances. Therefore, chemical pollution is local and does not extend beyond the SPZ.

According to the calculations, the KhNPP complex (Units 5 and 6) covers 51.1 hectares. Thus, potential changes in the physical, chemical, and water-physical properties of soils may occur as a result of the impact of already constructed facilities, as well as as a result of increased discharges and emissions from the plant after the launch of power units 5 and 6.

An important impact on soils is man-made contamination of the soil cover with chemical pollutants, including radionuclides. However, being a complex, open, and dynamic system, soils have a certain resistance to anthropogenic load-buffering capacity.

Buffering capacity depends on the physical and chemical properties of soils, their mechanical composition, conditions of economic use, etc. The impact of power units on the soil cover of the region should be assessed taking into account the above-mentioned factors.

Thus, the following conclusions have to be mentioned:

– taking into account insignificant additional environmental contamination with radionuclides during normal operation of the plant (maximum values for Cs-137 - n 10-1 Bq/m2), special agrotechnical measures with changes in the structure of agricultural land use, agricultural sectors re-profiling, and technological processing changes of products are not appropriate;

– according to the research results, the content of copper, zinc, cadmium, and lead in the soils of the territory adjacent to KhNPP is at the background level (also see parag. 5.3.7). There is a possibility of slight extra anthropogenic lead contamination of the soil of agricultural land adjacent to roads, which will not exceed the TLK (Threshold Limit Value) in agricultural products;

– the radiological situation in the area where the plant is located is currently mainly determined by radionuclides of natural origin, global radioactive contamination, and ChNPP contamination. No short-lived man-made isotopes are detected in the 30 km zone of the plant. The territory's 137Cs contamination is close to global levels (about 3 kBq/m^2);

– the surface relief of the area close to the plant and the presence of orographic barriers are taken into account when considering transboundary radionuclide transfer in case of emergencies;

– the impact level will be regional at the maximum design basis emergency and beyond design basis emergency, but neither physical and chemical nor water-physical properties of soils will change; only the chemical elements content will change;

– overall, the analysis of the physical and chemical properties of the region's soils showed that, despite the significant diversity of soil cover, most soils have a significant buffer reserve of resistance to man-made impacts. The construction and operation of KhNPP with six power units will not lead to the exhaustion of this reserve. The landscapes in the vicinity of the plant are a reliable barrier to the expansion of the primary contamination zone through migration.

4.5 Aquatic (water) environment

During the operation of KhNPP Unit 1-2, infiltration of process water caused changes in the groundwater regime within the industrial site. As a result, a rather steady increase in groundwater temperature and salinity is recorded in some areas. This phenomenon is local, does not extend beyond the industrial site, and does not affect water intakes for household water supply.

No additional sources of negative impacts on the hydrosphere are expected to arise in the construction of NPP Units 5-6. Temporary household and storage facilities at the construction site of power units 5 and 6 are provided with water supply and sewerage systems. The existing networks are the source of household water supply for temporary domestic and warehouse facilities. Wastewater is discharged into existing sewerage networks. The generation and discharge of wastewater into the environment is not expected.

NPP impact on surface waters may occur in places of direct contact of NPP process elements and facilities with surface water facilities of common use. These contact points are the water intake and discharge facilities of NPPs.

The operation of NPP Units 5-6 will not cause any significant adverse impact on surface and groundwater, and will not significantly affect the existing groundwater regime. Thus, the implementation of the design solutions will not hurt surface and groundwater.

The commissioning of NPP Units 5-6 will not result in any significant negative impact on surface and groundwater and will not significantly affect the existing groundwater regime. Thus, the implementation of the design solutions will not hurt surface and groundwater.

The operation of KhNPP, including Units 1-6, in an accident-free mode will not affect the groundwater condition in the 30-kilometer zone. The water quality (chemical and bacteriological composition) of water intakes of the centralized household water supply in the 30-kilometer zone of KhNPP is not related to the NPP operation.

4.6 Geological environment

The geological environment of the KhNPP supervised area is characterized by certain differences within a particular part of the territory. In particular, the geological environment of the land area and the industrial site of KhNPP differ in their structure from the geological environment of the supervised area.

The KhNPP impact on the geological environment within the KhNPP industrial site and land area was almost completely formed during the construction of facilities that are part of the power units 1-4 complex. Groundwater is the most vulnerable element of the geological environment. The commissioning of Units 5 and 6 will not significantly affect the existing groundwater regime; it is possible to get a local increase in water temperature, mineralization, or a local slight increase in the groundwater level in a limited area.

In the monitoring area, the impact of Khmelnytskyy NPP, including the facilities of power units 5 and 6, can only be affected in the event of an emergency, with hypothetical contamination of aquifers.

Before construction works started at the KhNPP site, the following exogenous geological processes were reported:

– slight flooding of the territory;
– weathering of the upper soil layers in the open pits.

The set of measures for the KhNPP Units 5&6 construction includes the following ones to improve site conditions:

– additional drainage;
– protection of soil open areas by arranging lawns of meadow grasses to prevent erosion.

The measures to prevent or limit the possible KhNPP impact on the geological environment of the KhNPP industrial site and land area ensure the stability of the geological situation, so the formation of new and further development of existing exogenous geological processes is not expected.

4.7 Atmospheric air

Atmospheric air may be affected during the construction of new KhNPP units, and depending on the focus of the planned activities, radiation and non-radiation impacts on atmospheric air should be considered.

4.7.1 Radiation impact

Radioactive emissions from the NPP ventilation system are one of the main sources of air contamination.

During the entire period of KhNPP operation, no impact of radioactive emissions and discharges on the radiation situation in the area of its location was detected.

The monitoring results of the KhNPP gas and aerosol emissions into the atmosphere from ventilation pipes of the units 1&2 reactors buildings and the special building in comparison with the established plant emission limits [79] for radionuclide groups are presented below in Table 4.1, according to the data of the Radiation Control Service for 2013-2021.

In accordance with the KhNPP radiation monitoring regulations [51], surface soil contamination is monitored on the territory adjacent to KhNPP.

The observation results show that during the KhNPP operation, the maximum contribution to the specific soil activity is due to the presence of the naturally occurring isotope K-40 and is determined by the natural characteristics of the region. The activity of the most prominent technogenic nuclide Cs-137 is ten times less than K-40.

Table 4.2 shows the measuring results of specific soil cover contamination directly related to the nuclear fuel cycle in 2013-2021, as well as the value of the “zero” background for Cs-137. For each year, the averaged values of sampling activity for measurements are provided, which are combined by the following radius of the KhNPP supervised area:

– 1st radius – KhNPP industrial site;

– 2nd radius – sanitary protection zone (10 km);

– 3rd radius – supervised area (10-20 km);

– 4th radius – supervised area (> 20 km).

The measuring results of Co-60 specific activity in environmental objects are not presented, since these values are below the MDA of the equipment. The MDA of Co-60 measurement is 0.099 Bq/kg.

As can be seen in Table 4.2, the activity of the technogenic isotope Cs-137 in all reporting years does not exceed the zero background level.

According to spectrometric measurements [80], the actual content of radionuclides in surface water as well as the activity index of the considered technogenic isotopes Cs-137, Sr-90, M-3 in relation to the permissible concentrations as per DGN 6.6.1-6.5.001-98 [22], are given in Table 4.3 from 2013 to 2021.

These data indicate a negligible impact of KhNPP on water activity and a large margin of activity up to the regulated values.

Table 4.1 – Average daily gas and aerosol release of radioactive substances into the environment for 2013-2021, Bq/day

Year	Inert gases		LLN		Radioiodine		Total index, %
	$A_{release}$	% of RL	$A_{release}$	% of RL	$A_{release}$	% of RL	
2013	4,47E+10	9,72E-02	3,35E+04	8,17E-04	4,10E+04	4,10E-03	0,10
2014	5,17E+10	1,12E-01	3,73E+04	9,10E-04	1,08E+05	1,08E-02	0,12
2015	5,14E+10	1,12E-01	2,98E+04	7,28E-04	6,99E+04	6,99E-03	0,12
2016	4,31E+10	9,38E-02	3,42E+04	8,34E-04	5,22E+04	5,22E-03	0,10
2017	3,40E+10	7,39E-02	3,94E+04	9,60E-04	3,01E+04	3,01E-03	0,08
2018	3,33E+10	7,24E-02	3,37E+04	8,21E-04	2,94E+04	2,94E-03	0,08
2019	3,74E+10	8,13E-02	3,53E+04	8,60E-04	3,39E+04	3,39E-03	0,09
2020	3,15E+10	6,85E-02	3,47E+04	8,45E-04	3,31E+04	3,31E-03	0,07
2021	3,39E+10	7,38E-02	3,32E+04	8,11E-04	4,51E+04	4,51E-03	0,08

Table 4.2 –Soil contamination in the KhNPP supervised area for 2013-2021, kBq/m^2

Radius	Nuclide	2013	2014	2015	2016	2017	2018	2019	2020	2021
SPZ	Cs-137	1,51E-01	9,12E-02	1,87E-01	1,52E-01	1,25E+00	1,82E-01	5,76E-02	1,08E-01	1,20E-01
	Cs-134	2,41E-03*	4,44E-03*	3,13E-03*	2,80E-03*	8,99E-03*	3,92E-02	2,19E-03*	2,94E-03*	2,63E-03*
	Co-60	3,37E-03*	5,63E-03*	4,10E-03*	4,54E-03*	9,71E-03*	2,55E-03*	2,41E-03*	3,21E-03*	2,86E-03*
	Sr-90	1,41E-01	1,80E-01	2,47E-01	1,41E-01	1,51E-02*	2,27E-01	2,49E-01	1,69E-01	1,38E-01
SPZ - 10 km	Cs-137	3,33E-01	2,31E-01	3,58E-01	2,24E-01	1,08E+00	1,61E-01	1,84E-01	2,42E-01	1,83E-01
	Cs-134	2,61E-03*	4,86E-03*	3,25E-03*	2,72E-03*	1,51E-01	2,75E-02	1,87E-03*	4,01E-03*	2,15E-03*
	Co-60	3,38E-03*	6,23E-03*	3,97E-03*	2,91E-03*	9,17E-03*	1,83E-03*	1,94E-03*	4,86E-03*	2,30E-03*
	Sr-90	1,80E-01	9,60E-02	3,21E-01	1,23E-01	2,03E-02*	2,42E-01	2,58E-01	2,10E-01	2,00E-01
10 - 20 km	Cs-137	3,59E-01	3,42E-01	2,78E-01	3,09E-01	2,52E+00	1,57E-01	1,71E-01	1,78E-01	1,99E-01
	Cs-134	3,16E-03*	1,06E-02*	3,97E-03*	3,04E-03*	1,49E-02*	4,94E-02	2,10E-03*	3,86E-03*	2,83E-03*
	Co-60	4,59E-03*	9,25E-03*	4,96E-03*	3,80E-03*	1,49E-02*	3,34E-03*	2,24E-03*	4,17E-03*	3,16E-03*
	Sr-90	4,12E-01	1,77E-01	2,95E-01	1,18E-01	3,01E-02*	2,96E-01	2,71E-01	2,35E-01	2,65E-01
> 20 km	Cs-137	2,88E-01	2,09E-01	4,55E-01	3,17E-01	-	1,93E-01	1,77E-01	2,19E-01	2,73E-01
	Cs-134	3,80E-03*	8,32E-03*	5,36E-03*	1,30E-03*	-	2,00E-03*	2,46E-03*	6,43E-03*	5,63E-03*
	Co-60	5,71E-03*	1,22E-02*	7,33E-03*	1,55E-03*	-	2,00E-03*	2,78E-03*	7,18E-03*	7,17E-03*
	Sr-90	2,13E-01	1,86E-01	2,32E-01	1,62E-01	-	1,68E-01	2,57E-01	2,73E-01	1,94E-01

Table 4.3 – Average annual specific activity of radionuclides in rivers and reservoirs in the KhNPP area, Bq/m^3

Sampling place	Radionuclide		Year								
			2013	2014	2015	2016	2017	2018	2019	2020	2021
Cooling pond	Cs-137	A	7,08E+00	6,70E+00	6,00E+00	9,69E+00	6,19E+00	8,34E+00	1,22E+01	1,35E+01	9,59E+00
		% of PC	7,08E-03	6,70E-03	6,00E-03	9,69E-03	6,19E-03	8,34E-03	1,22E-02	1,35E-02	9,59E-03
	Cs-134	A	4,78E-01	3,87E-01*	3,41E-01*	5,38E-01*	2,28E-01*	3,69E-01*	4,57E-01*	5,77E-01*	5,29E-01*
		% of PC	6,82E-04	5,53E-04	4,86E-04	7,68E-04	3,26E-04	5,26E-04	6,52E-04	8,24E-04	7,55E-04
	Co-60	A	4,08E-01*	5,09E-01*	4,00E-01*	4,30E-01*	3,41E-01*	2,41E-01*	4,86E-01*	6,09E-01*	5,66E-01*
		% of PC	5,09E-04	6,36E-04	5,00E-04	5,37E-04	4,26E-04	3,01E-04	6,07E-04	7,61E-04	7,07E-04
	Sr-90	A	1,47E+01	1,59E+01	1,33E+01	1,36E+01	1,45E+01	3,61E+01	7,84E+00	7,56E+00	6,91E+00
		% of PC	1,47E-01	1,59E-01	1,33E-01	1,36E-01	1,45E-01	3,61E-01	7,84E-02	7,56E-02	6,91E-02
	H-3	A	4,90E+04	6,13E+04	6,59E+04	4,96E+04	3,05E+04	3,93E+04	5,24E+04	7,37E+04	6,86E+04
		% of PC	1,63E-01	2,04E-01	2,20E-01	1,65E-01	1,02E-01	1,31E-01	1,75E-01	2,46E-01	2,29E-01
the Goryn river (to NPP)	Cs-137	A	5,89E+00	3,67E+00	4,78E+00	3,89E+00	1,19E+01	6,52E+00	1,01E+01	1,09E+01	1,11E+01
		% of PC	5,89E-03	3,67E-03	4,78E-03	3,89E-03	1,19E-02	6,52E-03	1,01E-02	1,09E-02	1,11E-02
	Cs-134	A	3,28E-01*	2,17E-01*	2,89E-01*	2,34E-01*	2,50E-01*	1,78E-01*	6,51E-01*	5,52E-01*	3,88E-01*
		% of PC	4,69E-04	3,09E-04	4,12E-04	3,34E-04	3,57E-04	2,54E-04	9,29E-04	7,88E-04	5,54E-04
	Co-60	A	5,06E-01*	2,95E-01*	3,89E-01*	3,12E-01*	2,62E-01*	2,00E-01*	7,63E-01*	5,69E-01*	4,07E-01*
		% of PC	6,32E-04	3,68E-04	4,86E-04	3,89E-04	3,27E-04	2,50E-04	9,53E-04	7,11E-04	5,08E-04
	Sr-90	A	1,04E+01	1,45E+01	1,23E+01	1,16E+01	1,47E+01	1,04E+01	6,16E+00	5,43E+00	5,01E+00
		% of PC	1,04E-01	1,45E-01	1,23E-01	1,16E-01	1,47E-01	1,04E-01	6,16E-02	5,43E-02	5,01E-02
	H-3	A	2,71E+04	3,06E+04	2,74E+04	1,73E+04	3,57E+04	2,80E+04	8,27E+03	4,75E+03	4,25E+03
		% of PC	9,03E-02	1,02E-01	9,12E-02	5,77E-02	1,19E-01	9,33E-02	2,76E-02	1,58E-02	1,42E-02

the Goryn river (control station)	Cs-137	A	5,00E+00	5,56E+00	4,34E+00	7,67E+00	7,23E+00	8,49E+00	1,15E+01	1,20E+01	9,28E+00
		% of PC	5,00E-03	5,56E-03	4,34E-03	7,67E-03	7,23E-03	8,49E-03	1,15E-02	1,20E-02	9,28E-03
	Cs-134	A	2,61E-01*	2,39E-01*	2,95E-01*	3,89E-01*	1,89E-01*	2,06E-01*	5,82E-01*	4,26E-01*	5,38E-01*
		% of PC	3,73E-04	3,41E-04	4,21E-04	5,55E-04	2,69E-04	2,94E-04	8,31E-04	6,08E-04	7,68E-04
	Co-60	A	3,50E-01*	3,39E-01*	3,95E-01*	3,06E-01*	2,34E-01*	2,22E-01*	5,82E-01*	4,69E-01*	5,94E-01*
		% of PC	4,38E-04	4,23E-04	4,93E-04	3,82E-04	2,92E-04	2,78E-04	7,27E-04	5,86E-04	7,43E-04
	Sr-90	A	1,57E+01	9,15E+00	1,21E+01	1,25E+01	1,23E+01	1,34E+01	6,76E+00	2,56E+00	4,28E+00
		% of PC	1,57E-01	9,15E-02	1,21E-01	1,25E-01	1,23E-01	1,34E-01	6,76E-02	2,56E-02	4,28E-02
	H-3	A	3,90E+04	5,59E+04	4,34E+04	3,34E+04	2,18E+04	2,52E+04	1,17E+04	9,08E+03	8,30E+03
		% of PC	1,30E-01	1,86E-01	1,45E-01	1,11E-01	7,27E-02	8,38E-02	3,91E-02	3,03E-02	2,77E-02
«*» - values corresponding to ½ minimum measured activity											

The absolute value of the dose rate measured by the monitoring points of the ARSMS during the entire period of operation does not depend on their location relative to KhNPP and is determined by the natural background and emissions of radionuclides of global origin. The dynamics of changes in the radiation background in the monitoring area are caused by the release of technogenic radionuclides as the Chornobyl accident results, global radiation emissions, and radiation background fluctuations.

The commissioning of KhNPP Units 5 and 6 will not lead to significant changes in the radiation situation at the NPP and adjacent monitoring areas. See also paragraphs 1.5.1 and 5.3.7

4.7.2 Non-radiation impact

The start-up boiler house chimney emissions may have a significant impact on the air environment around Khmelnytskyy NPP.

Since the launch of KhNPP Units 5 and 6 does not include the introduction of new technologies accompanied by the release of new hazardous substances, it can be assumed that the qualitative characteristics of emissions will remain the same as before.

Ground-level concentrations of hazardous substances on the border and beyond the boundary of the SPZ with KhNPP sources comply with the limit values for settlements (See also Appendix C).

The commissioning of KhNPP Units 5 and 6 will not lead to an excess of the standard values of indicators of impact on the environmental situation.

4.8 Climate effects

The impact of the cooling pond on the area's microclimate is considered to be insignificant. The area of influence of the cooling pond is assessed to the distance of approximately 1000 meters. Quantitative changes in meteorological characteristics in the impact zone of KhNPP cooling systems are considered insignificant. The commissioning of power units 5-6 will not significantly affect the region's climate, see also parag. 4.2. Information on the climatic characteristics of the region is provided in Appendix D.

4.9 Architectural, historical, and cultural monuments

The placement of cultural heritage sites outside the site planned for the construction of KhNPP Units 5 and 6 indicates that these properties will not be directly damaged by the construction of new power units and related infrastructure. Thus, it can be confirmed that cultural heritage sites remain protected from the negative impact of construction.

New driveways, soil dumps, and other infrastructure that may appear in the construction zone of the power units have no impact on cultural property, as they are located outside their territory.

4.10 Socio-economic factors

The construction of nuclear power units can have a significant impact on the socio-economic population’s life. Here are some aspects that may be particularly notable:

- increase in the employment rate;
- development of energy supply and affordable electricity;

– improving the living conditions and welfare of the population.

The commissioning of new NPP units is not directly related to the increase in disease and deterioration of population health in the surrounding areas.

The construction of units 5 and 6 will contribute to the provision of new employment opportunities in Netishyn and the KhNPP region, and facilitate drifting of the qualified personnel.

The involvement of university graduates from different Ukrainian regions with the appropriate education and qualifications is a reasonable and effective approach to the construction and commissioning of KhNPP Units 5 and 6. It makes it possible to take advantage of the potential of employees from different regions of the country and ensure a sufficient number of qualified specialists to perform various jobs at the plant.

The involvement of the required number of engineering and technical specialists and workers to perform construction and assembly works at KhNPPs 5 and 6 units of Khmelnytskyy NPP will be decided by construction and assembly organizations on their own.

The development of social infrastructure during the construction of Units 5 and 6 is an important aspect of the project, as it contributes to the improvement of living conditions for residents and employees involved in the project. The construction of social facilities, such as residential buildings, schools, kindergartens, medical facilities, cultural centers, and sports facilities, helps to create comfortable conditions for the life and development of the local community.

The substantial expansion of KhNPP indeed provides prospects for the development of new production facilities in the region. The expected population growth in Netishyn, which is associated with the expansion of the energy infrastructure, creates demand for various services and goods.

During the construction phase, 2,880 temporary workers are planned to be employed in the 1st shift at Units 5 and 6, who will live in Netishyn only during the units' construction.

The staffing for KhNPP Units 5 and 6 is 1003 people (see Table 4.4). Due to simplification of the design of units with AP 1000 because of the reduction in the number of equipment, the operation of such units requires significantly less technical personnel .

Table 4.4 – Comparative table of staffing levels

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
BUSINESS OPERATIONS / EXECUTIVE MANAGEMENT ЕРІВНИЦТВО АЕС									
NPP Manager	CEO (General Director) of NPP	1	1	1	1	1	1	-	1
Chief Engineer of NPP	Chief Engineer - First Deputy CEO	-	-	-	-	-	1	-	1
QUALITY ASSURANCE									
QA Manager	The Head of the QA section	-	1	-	1	1	1	-	1
QA Supervisor	Deputy Head of the QA section	19	5	14	3	3	3	3	6
QA Auditor	Quality auditor	-	4	-	10	8	8	8	16
SUBTOTAL QA		**19**	**10**	**14**	**14**	**12**	**12**	**11**	**23**
NUCLEAR SAFETY									
Nuclear Safety Manager	Deputy Chief Engineer for Nuclear Safety	1	1	1	1	1	1	-	1
Nuclear Safety Specialist	Lead Nuclear Safety Engineer	5	-	10	-	1	1	1	2
Emergency preparedness manager	Head of the Emergency Management	2	2	1	1	1	1	1	2
Guard	Guard	77	-	135	7	75	75	75	150
Security Manager	Head of the Security Service	1	1	1	1	1	1	-	1
Emergency Preparedness Specialist	Lead Engineer for the Emergency Management and Response	5	1	4	2	2	2	2	4
SUBTOTAL NUCLEAR SAFETY		**91**	**5**	**152**	**12**	**81**	**81**	**79**	**160**
ENGINEERING									

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
Engineering Manager	Deputy Chief Engineer for Technology and Engineering	-	1	-	1	1	1	-	1
Systems Engineering Manager	Head of the Systems Engineering Department	-	1	-	1	1	1	1	2
System engineers	System engineers	26	14	42	23	25	25	25	50
Program Engineering Manager	Head of the Program Engineering Department	-	1	-	1	1	1	1	2
Program Engineers	Software engineer	24	3	16	10	10	10	10	20
Reactor and Fuel Engineering Manager	Head of Fuel and Reactor Department	-	1	-	1	1	1	1	2
Reactor Engineers	NPP equipment operation engineer	28	8	4	3	3	3	3	6
Fuel Handling Supervisor	Deputy Head of Department for Fuel and Reactor Handling	-	1	-	-	1	1	1	2
Fuel Handling Technician	Fuel handling engineer	-	3	-	-	3	3	3	6
Engineering analysis manager	Head of the Engineering and Technical Analysis Department	-	1	-	1	1	1	1	2
Engineer Analysis	Process and analysis engineer	21	4	10	3	2	2	2	4
Design Engineering Manager	Head of the design and development department	-	1	-	1	1	1	1	2
Design Engineers	Designer	15	58	28	15	15	10	10	20
Design / Drafting	Designer	5	-	-	-	-	5	5	10
Licensing Manager	Head of the licensing department	-	1	1	1	1	1	1	2
Licensing Engineers	Licensing engineer	9	11	6	6	6	6	6	12

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
Engineers	Head of the Information Technology Department	-	1	1	-	1	1	1	2
IT Technicians	IT Engineer	-	26	4	-	20	20	20	40
Document Control and Records Manager	Head of the Department of Documentation Management and Accounting	-	1	1	-	1	1	1	2
Document control clerk	Document control clerk	8	4	6	-	1	1	1	2
Reords /archiving clerk	Records and archiving accounting technician	-	4	6	-	1	1	1	2
SUBTOTAL ENGINEERING		**136**	**145**	**125**	**67**	**96**	**96**	**95**	**191**
OPERATIONS									
Operations Manager	Deputy Chief Operating Engineer	2	1	-	3	1	1	-	1
Shift Manager (licensed)	NPP shift supervisor	-	8	-	5	7	7	7	14
Shift Supervisor (licensed)	Reactor shift supervisor	-	8	-	5	7	7	7	14
Shift Support Supervisor	Shift supervisor of a NPP power unit (stage)	-	-	71	5	7	7	7	14
RO (Reactor operator) / TO (turbine operator) (licensed)	Turbine and reactor control operator	78	16	-	10	14	14	14	28
Work Control (SRO)	Leading engineer of reactor control	-	-	-	5	7	7	7	14
Non-licensed Operator	Operator	-	40	-	30	35	35	35	70
SUBTOTAL OPERATORS		**80**	**81**	**71**	**68**	**78**	**78**	**77**	**155**
Operations Support Manager	Head of the Operations Support Department	-	1	-	-	1	1	1	2
Operational support Engineers	Operation support engineer	-	12	19	-	7	7	7	14

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	**Power unit No.6**	**Total**
Lock out-Tag out Engineers	Head of the Department of Repair Planning and Implementation	-	1	-	-	1	1	1	2
Lock out-Tag out technicians	Repair planning engineer		4	-	-	3	3	3	3
SUBTOTAL OD		**-**	**18**	**19**	**-**	**12**	**12**	**12**	**24**
Chemistry Manager	Head of the chemical shop	1	1	-	1	1	1	1	2
Chemistry Supervisor	Deputy Head of the chemical shop	5	2	21	5	2	2	2	4
Chemistry Analyst	Laboratory assistant of chemical analysis	6	8	-	12	9	9	9	18
Chemistry Programs Technicians	NPP chemical water treatment worker	8	3	3	-	2	2	2	4
SUBTOTAL CHEMISTRY		**20**	**14**	**24**	**18**	**14**	**14**	**14**	**28**
Fire Protection Engineer	Head of the Fire Protection Service	-	2	2	1	1	1	-	1
Fire Protection Brigade	Lifeguard	-	35	-	-	35	35	-	35
SUBTOTAL FIRE PROTECTION		**-**	**37**	**-**	**-**	**36**	**36**	**-**	**36**
SUBTOTAL OPERATIONS		**100**	**150**	**116**	**87**	**140**	**140**	**103**	**243**
MAINTENANCE									
Maintenance Manager	Deputy Chief Maintenance Engineer	-	1	-	1	1	1	-	1
Maintenance Superintendents (mechanical / electrical / I&C / Inspections and Test /Preparation)	Heads of Maintenance Departments	-	5	-	4	5	5	5	10
Maintenance Supervisors	Maintenance Specialist	-	22	-	8	10	10	10	20

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
Mechanical Technicians	Mechanical maintenance Engineer	-	56	-	40	20	20	20	40
Electrical Technicians	Electrical Engineer	-	44	-	20	20	20	20	40
I&C Technician	Engineer for maintaning the control measurement devices and automatic	-	47	-	30	25	25	25	50
Inspection and Test Technicians	Control Computer System Inspection and Test Engineer	-	7	-	-	9	9	9	18
Maintenance Support	Maintenance Locksmith	27	57	30	-	15	15	15	30
SUBTOTAL MAINTENANCE		**27**	**239**	**30**	**103**	**105**	**105**	**104**	**209**
LEARNING ORGANIZATION									
Learning Organization Manager	Deputy Chief Engineer for Personnel Training	-	-	-	1	1	1	-	1
Training Manager	The Head of the Personnel Training Center	2	1	-	-	1	1	1	2
Training Supervisors	Senior Personnel Training Instructor	-	5	-	2	3	3	3	6
Licensed Operator Instructors	licensed Operator Instructor	-	5	-	6	10	10	10	20
Non-licensed Operator Instructors	Operator training instructor	-	3	-	-	4	4	4	8
Maintenance Instructors	Maintenance Instructor	-	3	-	2	3	3	3	6
RP Instructors	RP Instructor	40	1	36	2	1	1	1	2
Chemistry Instructors	Chemistry Instructors	-	1	-	2	1	1	1	2
Engineering Instructors	Engineering Instructor	-	2	-	2	2	2	2	4
Simulator coordinator and IT	Simulator Instructor	-	3	-	-	3	3	3	6
Training Technician	Personnel training instructor	-	4	-	-	2	2	2	4

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
SUBTOTAL TRAINING		**42**	**28**	**36**	**17**	**31**	**31**	**30**	**61**
Performance Improvement Manager	Head of the HR Department	-	1	-	-	1	1	-	1
Analysis and Improvement Supervisor	Deputy Head of the HR Department	-	1	-	-	1	1	1	2
Analytics Improvement specialist	Human Resources Management Engineer	-	8	-	2	6	6	6	12
HP Supervisor	Head of the Occupational Safety Department	-	1	-	-	1	1	1	2
HP Specialist	Senior Occupational Safety and Health Engineer	-	3	-	-	2	2	2	4
SUBTOTAL PI/HP		**-**	**14**	**-**	**2**	**11**	**11**	**10**	**21**
SUBTOTAL LEARNING ORGANIZATION		**42**	**42**	**36**	**20**	**42**	**42**	**40**	**82**
RADIATION PROTECTION									
Radiation Protection (RP) Manager	Head of the Radiation Protection shop	-	1	-	1	1	1	1	2
RP Supervisor (Head of the laboratory, RP daytime/shift supervisors)	Shop Shift Supervisor (head of the laboratory, RP day/shift supervisors)	-	5	-	5	5	5	5	10
RP Technician	RP Engineer	37	-	30	18	7	7	7	14
ALAR Technician	Radiologist Engineer	7	21	5	-	3	3	3	6
Dosimetrist (daytime/shift personnel)	Dosimetrist (daytime/shift personnel)	-	24	-	-	4	4	4	8
Radwaste Technician	Radwaste processing engineer	14	5	16	-	1	1	1	2
SUBTOTAL RADIATION PROTECTION		**58**	**56**	**51**	**24**	**21**	**21**	**21**	**42**
WORK MANAGMENT									

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
Work control manager	Head of the Production Support Department	1	1	-	1	1	1	-	1
Work control Supervisor	Deputy Head of the Production Support Department	-	1	11	2	1	1	1	2
Week coordinator	Work Control Engineer	-	4	-	-	2	2	2	4
Work preparation technician	Work Organization Engineer	-	11	-	-	5	5	5	10
Planner Technician	Planner Engineer	2	4	-	-	2	2	2	4
Outage Planner Manager	Head of the Outage Planner Department	-	1	-	-	1	1	1	2
Outage Planner Technician	Maintenance preparation Engineer	2	4	7	-	2	2	2	4
Planner Technician (design modifications)	Design Modifications Engineer	-	1	-	-	1	1	1	2
SUBTOTAL WORK MANAGEMENT		**5**	**27**	**18**	**3**	**15**	**15**	**14**	**29**
SUPPLY CHAIN									
Supply Chain Manager	Head of Logistics Department	-	1	-	-	1	1	1	2
Materials Purchasing Supervisor	Deputy Head of the Logistics Department	-	1	1	-	1	1	1	2
Services Purchasing Supervisor	Senior Logistics Engineer	6	1	2	-	1	1	1	2
Materials Purchasing Tech.	Equipment Purchase Engineer	-	1	1	-	1	1	1	2
Services Purchasing Tech.	Logistics economist	2	2	2	-	1	1	1	2
Warehouse Supervisor	Head of the Warehouse Management	-	1	4	-	1	1	1	2
Warehouse Technician	Warehouseman	10	21	10	-	5	5	5	10

Position according to Westinghouse Electric Company	Position by Ukrainian standards	IAEA 1052	PWR Spain	PWR USA	AP1000 USA	AP1000 Recommendation.	Adopted for power units 5,6 AP1000 of Khmelnytskyy NPP		
							Power unit No.5	Power unit No.6	Total
SUBTOTAL SUPPLY CHAIN		**18**	**28**	**20**	**-**	**11**	**11**	**11**	**22**
TOTAL		**497**	**703**	**563**	**331**	**524**	**525**	**478**	**1003**

The total number of operating personnel at Unit 5, including NPP management and deputy chief engineers, is 525 people, and at Unit 6 - 478 people.

The number of administrative personnel for each unit is assumed to be 15% of the total number of employees at the unit:

The total number of operating personnel at power units 5 and 6 is:

- for power unit No. 5 $525 \cdot 0{,}15=79$ people,
- for power unit No. 6 $478 \cdot 0{,}15=72$ people,

The total number of operating personnel at Units 5 and 6 is as follows:

- for power unit No. 5 525+79=604 people,
- for power unit No. 5 478+72=550 people.

The total number of personnel at the facility is 604+550=1154 people.

4.11 Technogenic environment

Subject to compliance with design and construction standards, the impact of the new facilities within Units 5 and 6 on the existing utilities, buildings and structures is acceptable.

5 DESCRIPTION AND THE POSSIBLE ENVIRONMENTAL IMPACT ASSESSMENT OF THE PLANNED ACTIVITY, INCLUDING THE MAGNITUDE AND SCOPE OF SUCH IMPACT (AREA AND POPULATION THAT MAY BE AFFECTED), NATURE (IF ANY - TRANSBOUNDARY), INTENSITY AND COMPLEXITY, PROBABILITY, EXPECTED ONSET, DURATION, FREQUENCY AND INEVITABILITY OF THE IMPACT (INCLUDING DIRECT AND ANY INDIRECT, CUMULATIVE, TRANSBOUNDARY, SHORT-TERM, MEDIUM-TERM AND LONG-TERM, PERMANENT AND TEMPORARY, POSITIVE AND NEGATIVE IMPACT)

Investigating the potential environmental impact of a planned activity is critical to ensuring environmental sustainability. For this reason, it is important to analyze the magnitude and scope of the possible impact, including the area of the territory and the number of people who may be affected. It is necessary to take into account the nature of the impact, its intensity, and complexity, probability, expected onset, duration, frequency and inevitability. Various possibilities of impacts are considered, including direct and indirect, spillover, cumulative, transboundary, different durations and types of impacts, and positive and negative aspects.

5.1 Preparatory and construction works and the planned activity implementation, including (if necessary) dismantling works after completion of such activity

Description and assessment of the possible environmental impact of the planned activities include impact assessment during preparatory and construction activities, operation of KhNPP, and decommissioning and emergency situations.

5.1.1 Preparatory and construction works

Description and assessment of potential environmental impacts of preparatory and construction activities, namely [5]: location, duration, content, main equipment and technologies, planned temporary structures, transport and utility networks, natural resource requirements and sources of these resources, management of construction and other solid waste, as well as liquid waste generated during their implementation, compliance with air quality standards and maximum permissible noise levels concerning the nearest residential area is presented in paragraphs 1.5.2, 5.3 of this report, respectively.

During units construction, there will be some negative impacts, namely:

– excavation of soil for the arrangement of technological equipment, structures, pipelines, other utility networks, and wells for household needs;

– road pavement construction;

– preparation of construction materials (cement, concrete, etc.) and their transportation;

– welding and cutting of metal structures (“assembly works”);

– painting works;

– operation of motor vehicles and other construction equipment with internal combustion engines, etc.

Construction and assembly machines and vehicles are the main sources of pollutant emissions due to the combustion of gasoline and diesel fuel in internal combustion engines, as well as the use of mineral oil for the operation of mobile compressors and transformers. To reduce the impact of emissions, all facilities must be subjected to a second full technical inspection following their operating manuals before being put into operation.

To reduce emissions of pollutants from internal combustion engines, the following measures are provided:

– timely inspection and maintenance of equipment;
– regulation of engines following the established standards to ensure complete combustion of fuel, which reduces its consumption and emissions of toxic substances;
– controlling the toxicity of exhaust gases before they are released to the line;
– reducing the time spent driving cars in variable modes;
– reducing the time of engine operation in low-speed and idling modes;
– maximizing the use of electrically driven lifting mechanisms.

To control pollutant release from motor vehicles, as well as to ensure measures to reduce them to the regulatory level, it is planned to organize a control and regulation point for vehicles equipped with gas sampling equipment and gas analyzers.

To reduce the noise level during construction and demolition works at the construction site and ensure the noise regime at the site follows the requirements of regulatory documents, it is necessary to:

– ensure that vehicle engines are silenced while on the construction site;
– turn off loudspeaker communication;
– do not carry out welding work without installing protective screens;
– exclude the performance of work accompanied by noise over the permissible norm;
– exclude the operation of equipment that has a noise and vibration level exceeding the permissible standards;
– to soundproof the engines of construction machines, replace protective covers and hoods with multilayer coverage;
– to isolate local sources, use temporary noise screens, noise curtains, and tents (for example, place compressors in a sound-absorbing tent).

Fire safety of NPP units is ensured following the requirements of regulatory acts on fire safety in force in Ukraine:

– Civil Protection Code of Ukraine No. 5403-VI dated 02.10.2012;
– NAPB A.01.001-2014 “Fire Safety Rules in Ukraine”;
– DBN B.1.1-7:2016 “Fire Safety of Construction Facilities. General requirements";
– NAPB B.01.014-2007 “Fire Safety Rules for Nuclear Power Plant Operation”;
– NAPB B.01.012-2019 “Rules for Fire Protection”;

– IB.0.3707.0003 “Facility-wide Instruction on Fire Safety Measures”.

Fire safety measures include a set of forces and means, as well as legal, organizational, scientific, technical, economic, and social measures aimed at fighting fires. The measures are aimed at preventing fires, ensuring facility safety, and protecting personnel and equipment in the event of a fire.

Particular attention is focused on fire protection of security systems, as well as systems and elements important for safety. When designing them, we used non-combustible cable products, efficient heat dissipation systems, and means of physical separation and isolation of backup channels from each other to prevent common cause failures in case of fire.

At each operating NPP, in normal operation (as well as at all stages of occurrence and elimination of consequences of a possible nuclear or radiological emergency and in the post-accident period), continuous monitoring of the radiation situation in the premises, on the plant site and in the supervised area is carried out under the Regulations on Radiation Monitoring during Operation of NPP Facilities. In addition to laboratory monitoring methods, each NPP has an automated radiation monitoring system (ARMS) consisting of automated monitoring stations. Monitoring is carried out continuously in an automatic mode, which allows promptly receiving information from the monitoring stations, conducting systematic data analysis, and performing radiation forecasts for all settlements within the 30-kilometer zone around the NPP.

Each operating NPP has an Emergency Plan document that regulates the actions of the administration and personnel in the event of an emergency at the site. The NPP emergency plan is developed based on the requirements of the current legislation of Ukraine in the civil protection field, norms, rules, and standards on nuclear and radiation safety, adopted with due regard to the recommendations of international organizations in the field of nuclear energy use, in particular, the IAEA practical recommendations on the organization of emergency planning.

During the construction period, the operating organization will make additions to the NPP emergency plan action existing records that regulate the procedure for actions of the administration and personnel in the event of an emergency depending on its classification and will be approved by the regulatory authority.

5.1.2 Implementation of planned activities

Operation is an activity aimed at achieving safely the purpose for which the NPP was constructed, including operation at capacity, start-ups, shutdowns, tests, maintenance, repairs, nuclear fuel transfers, in-service inspections, and other related activities. Scheduled activities are carried out in compliance with safety principles and criteria [24].

KhNPP safety is ensured through the consistent implementation of the deep-combat defense strategy based on the use of [24]:

– systems of physical barriers to the spread of ionizing radiation and radioactive substances into the environment;

– systems of technical and organizational measures to protect physical barriers and maintain their effectiveness to protect personnel, the population, and the environment.

It is envisaged to control the radiation situation in the buildings, on the KhNPP territory, in the sanitary protection zone and supervised area and to carry out radiation monitoring [24].

Automatic fire detection and extinguishing systems, automated fire warning systems, and smoke protection of buildings (premises) that are not connected to the environment are envisaged [24].

As part of the planned activities, the Company plans to establish a repair and maintenance service. The equipment repair is aimed at solving the following tasks:

– ensuring the trouble-free functioning of systems and equipment within the project's design life and maintaining their design characteristics;
– restoration of the equipment and systems operability in case of their failure (damage) during operation;
– improving the performance of systems and equipment through their reconstruction and modernization.

Repair and maintenance of systems and equipment is carried out to maintain their technical condition and reliability throughout their service life within the efficiency and safety limits established by regulatory documents, and to ensure that the nuclear power plant meets safety requirements throughout its entire service life. Repair and maintenance is carried out in compliance with nuclear and radiation safety requirements and do not threaten the environment and the population.

The planned activities take into account the possible impact on the environment - emissions and discharges of pollutants, noise, vibration, light, heat and radiation pollution, radiation and other impact factors, as well as waste management operations. Constructions, systems, and components are designed to reduce radiation and any other impact on the environment, the public, and personnel. During operation and temporary maintenance and repair activities, the generation of solid and liquid radioactive waste and other waste is considered under the current legislation. The environmental impact assessment during the planned activities is presented in paragraph 5.3.

5.1.3 Works during the decommissioning

The general safety objective during NI decommissioning is to protect personnel, the population, future generations of people, and the environment from possible negative impacts of nuclear facility decommissioning activities.

The operating company, based on the regulatory legal acts requirements, determines in the decommissioning strategy specific safety objectives for NI decommissioning and criteria for the final state of the NI site.

Safety of NI decommissioning is ensured through consistent implementation of the defense-in-depth strategy based on the use of a system of physical barriers to prevent the spread of radioactive substances and ionizing radiation and to ensure the protection of personnel, the population, and the environment from the ionizing radiation effects as well as a system of technical and organizational measures to protect physical barriers and maintain their effectiveness.

The main objective of implementing the defense-in-depth strategy during NI decommissioning is to timely identify and eliminate factors that lead to violations of safe NI decommissioning, emergencies, and prevent their development into accidents, limit and eliminate the consequences of accidents

5.1.3.1 Basic options for power unit decommissioning

To select and justify a decommissioning strategy for a power unit, the following options for its decommissioning may be considered:

– immediate dismantling ("Immediate dismantling" option);
– safe preservation of the power unit with further delayed dismantling ("Delayed Dismantling" option).

Both of these scenarios have identical initial and final states, and approximately the same focus of work and activities, but differ in cost characteristics.

Immediate dismantling is characterized by a rather short duration (on average, 10-15 years), a large amount of radioactive waste generated, and increased dose exposure of personnel involved in the work (2-3 times higher than for the delayed dismantling option), and a higher potential for impact on the public and the environment. The use of this scenario requires a developed infrastructure and a high level of technological training (development of unique robotic devices, special technologies, etc.) as well as the availability of sufficient cost in the decommissioning fund. The advantage of immediate dismantling is that the site can be vacated in a short time.

Delayed dismantling depends on the following decisions:

– the duration of the period of safe storage (from 30 to 100 years) ;
– the amount of equipment to be stored;
– the defined limits of protective barriers.

Currently, the option of delayed dismantling is preferable for the decommissioning of KhNPP units 5, 6 for the following reasons:

– there are no technologies for remote dismantling of radiation-contaminated equipment in Ukraine;
– the amount of high-level radioactive waste produced is much less than for the immediate dismantling option;
– there is no confidence that sufficient funds will be accumulated in the decommissioning fund for immediate dismantling at the time of power units' decommissioning;
– there is no information on the future need to immediately vacate the power unit site.

Based on the experience of decommissioning PWRs around the world, the best option for a delayed dismantling strategy is to allow the most contaminated part of the reactor facility to remain in operation for 30 years. This period is determined primarily by the nuclide cobalt-60, which is the main dose-forming nuclide with a half-life of 5.27 years.

5.1.3.2 Nuclear safety in decommissioning

The main source of nuclear hazard at the decommissioning stage is spent nuclear fuel to be removed from power unit.

The design of the AP1000 unit includes a technological complex for nuclear fuel management that ensures the safety of storage, transportation, technological and operational procedures.

5.1.3.3 Ensuring industrial and fire safety and physical protection in decommissioning

During decommissioning, the general industrial, fire, and physical safety of power units 5 and 6 is ensured based on design solutions under applicable rules and regulations.

These types of security should be ensured under the requirements of the relevant regulatory documents in force at the time of implementation of specific stages and performance of a series of works.

Fire safety must also meet the requirements of the defense-in-depth strategy under the requirements of the NPP.

The Decommissioning Project should determine the main approaches to ensuring general industrial and fire safety.

5.1.4 Conclusion

During preparatory and construction works and implementation of the planned activity, including dismantling works after the completed activity, the possible environmental impact is taken into account - emissions and discharges of contaminants, noise, vibration, light, heat and radiation pollution, radiation, and other impact factors, as well as waste management operations. Means of controlling and monitoring the impact of the planned activity, as well as measures to mitigate this impact, will be provided. The decommissioning strategy and approaches will be defined in the Decommissioning Project.

5.2 Use of natural resources, including land, soil, water and biodiversity during the planned activity

This section describes and assesses the potential environmental impact of the planned activity arising from the use of natural resources, including land, soil, water resources, and biodiversity. The assessment is important for ensuring sustainable development and maintaining ecological balance.

5.2.1 Soils

The geosystems of the 30-km area belong to 15 geochemical classes, distinguished by typomorphic elements. The main classes are acidic calcium (more than 30% of the territory) and calcium acid-gleyed (more than 10%).

The main type-forming elements are As, Zr, Br, Y, Ca, Si, and sometimes Pb, Mn, and Se. Type-forming elements can be of both natural and technogenic origin.

Of the 15 types, the most abundant is the AsZrBr type. It should be noted that As and Zr are the most common microelements in the 30-kilometer area. They are type-forming elements both in geosystems of broad-leaved landscapes with light gray and gray forest sandy and sandy loamy soils with low humus content (forest terraces), neutral acidity and low content of exchangeable cations (Ca, Mg), and in geosystems with higher humus content and exchangeable cations.

The diversity of soil-forming rocks in these landscapes allows us to conclude that the presence of As, Zr, Br in amounts exceeding the Clarke number is not so much related to the chemical composition of the soil-forming rocks as to agricultural activities and the secondary supply of these elements to the soil after the decomposition of the primordial vegetation that accumulated them. Most geosystems of the H+ - Ca2+ class have long been used in agriculture, and the amount of humus in soils is gradually decreasing and mostly does not exceed 3%, with sporadic 5-7% of humus in leveled areas of elevated forest plains under natural vegetation.

5.2.1.1 Radionuclide contamination of the Khmelnytskyy NPP supervised area

Radionuclides are of technogenic and natural origin. This contamination consists of a superposition of global fallout, fallout from the Chornobyl accident, and fallout caused by aerosol emissions from KhNPP Units 1&2. No other technogenic radionuclides were detected. This confirms the plant operation in normal mode. The level of the supervised area contamination does not create any restrictions on agriculture. Thus, the radiological situation in the vicinity of KhNPP is currently within the regulatory limits. The construction and operation of the new power units will not significantly affect the environment, see also parag. 5.3.7.

5.2.1.2 Sources of contamination and assessment of the impact of Units 5 and 6 on soils during normal operation

As a result of the mechanical impact associated with any construction, the soil cover is almost completely destroyed in the allocated area. However, the area of mechanical impact during KhNPP construction is clearly delineated by the agreed allocated boundaries.

Given the fact that radionuclides enter the soil in very small amounts, they cannot affect soil fertility in any way. Their content in soils is much lower than nutrients and they do not pose a threat during plant growing. The radionuclides in soils also do not affect the products quality and yield, see also parag. 5.3.7.2.

From the agrotechnical point of view, correct land use helps to reduce the intensity of radionuclide migration through agrobiocenoses, increase soil fertility and reduce erosion processes.

5.2.1.3 Assessment of possible changes in physical, chemical and water-physical properties of soils including land use characteristics

Following the analysis of the NPP operation impact on soil conditions, radioactive substances have normally no effect on the physicochemical and water-physical properties.

5.2.1.4 Assessment of soil degradation

The main types of soil degradation in the study area are associated with intensive agricultural cultivation, drainage reclamation, and further development of reclaimed land. Their intensive cultivation and use in field crop rotations lead to unjustified losses of soil organic matter.

The degree of degradation is influenced by an increase in ash content (by 20-40%) of the volume weight, the decrease in filtration coefficients and in total moisture content, in some cases by almost 2 times.

Changes in agrochemical parameters during soil degradation are shown by a certain acidification of the soil solution reaction, a decrease in the gross nitrogen content of intensively cultivated areas. There are profound changes in the qualitative composition of organic matter. Humic acids accumulate and fulvic acids decrease. The humus type develops from fulvate-humate to humate-fulvate and humate. According to the modern assessment scale, the degree of soil degradation is defined as weak, medium, high and crisis.

Mineral soils are not subject to degradation processes as intensively as organogenic soils. The research identified that mineral soils are subject to mechanical, biochemical and chemical degradation. If the soils are located within operating drainage systems, the degradation processes usually increase.

Mechanical degradation is shown in two forms: erosion and physical. Water and wind erosion processes are particularly common on soils of light texture. Water erosion increases with the steepness of slopes and plowed areas, which affect the soil washout. Wind erosion degradation in the study area is weak, and water degradation is weak and medium.

Physical soil degradation is caused by soil compaction and decrease in agronomically valuable meso-aggregates. Drained soils, which include sod-podzolic, sod and meadow soils, are characterized by a weak, medium and high degree of degradation.

According to the parameters of soil degradation in terms of total porosity, mineral soils in the KhNPP impact area are characterized by weak, medium, high, and some areas of reclaimed sod-podzolic soils are characterized by a crisis degree of arable horizons degradation. Drainage and intensive agricultural use of soils have led to a deterioration in their structural and aggregate state.

Most of the drained loamy granulometric soils are characterized by a high and crisis level of degradation.

Soil degradation processes associated with the KhNPP construction extend only to the industrial site area. Their presence in the KhNPP 30-kilometer area is practically unrelated to the plant's operation.

5.2.1.5 Influence of landscape and geochemical barriers on the pollutant redistribution

Various barriers may be formed based on the complexity of geomorphological, orographic, landscape and geochemical structures, heterogeneity of ravine, gully and river network density, mosaic soil cover, diversity of physical, chemical and water-physical soil properties in geosystems of the KhNPP 30-kilometer impact area. These are phytobarriers, orographic and landscape-geochemical barriers, on which deposition, accumulation and long-term radioactive elements fixation will occur.

The role of these barriers is ambiguous, both in the structure of biogeocenoses and in the time aspect. The soil is a significant biogeochemical barrier in automorphic landscapes, while biota and, above all, microbiota in accumulative landscapes and coniferous communities. The soil barrier functions in relation to radionuclides are the most significant among all components of biogeocenoses. At the same time, the release of radionuclides with gravitational moisture outside the soil profile is no more than one hundredth of a percent per year. Thus, the soil accumulates the main amount of activity: from 80 to 95% (including microbiota) in forest ecosystems and up to 100% in agroecosystems (depending on the period of plant vegetation). However, the barrier functions of soils in relation to different radionuclides are shown in different ways. 137Cs is adsorbed most intensively, 90Sr, 106Ru, Pu are adsorbed much less intensively. It should be emphasized that high sorption capacity of soils for 137Cs is typical for all types of soils and phytocoenoses, including sod-podzolic sandy soils. The exception is peat soils.

The barrier functions of ecosystems and their individual components have a certain temporal dynamics. It is known that a phytocoenotic barrier is clearly visible for a number of macro- and microelements during the growing season. The barrier functions are further transferred to the soil again. For radionuclides, this is shown in a different way. Nevertheless, these aspects have not yet been fully studied and require clarification and confirmation.

A horizontal migration of radionuclides with surface and intra-soil runoff is practically not expressed in forest landscapes. However, a process of radionuclide redistribution between landscapes is evidenced by a constant decrease in contamination density of eluvial landscapes and a corresponding increase in contamination density of accumulative landscapes. From the ecological point of view, the absence of significant inter-landscape radionuclide redistribution indicates localization of releases within the area of primary contamination. This makes it possible to state that the expansion of the primary contamination area and the formation of secondary contamination areas in forest landscapes do not occur.

The border and the forest canopy will serve as short-term barriers to radioactive pollutants. The KhNPP 30-kilometer impact area is well forested (average forest cover is 28%), while the forest cover of the nearer, 10-kilometer area is about 50%. Pine forests with a share of hornbeam and oak predominate, with hornbeam and oak forests in the northern part. Thus, forests in the supervised area are one of the main barriers that prevent secondary radionuclide redistribution.

As mentioned above, soils are an excellent barrier to further spread (redistribution) of the main radiologically significant radionuclides. There are also quite mobile radionuclides (tritium, chlorine-36), but their role in the formation of dose loads on the population is insignificant. A secondary contamination will occur mainly due to mechanical migration with erosion products and flushing (radionuclides adsorbed on soil particles move with them). The experience of Chornobyl proves that secondary radionuclide redistribution between landscape elements does not have a significant impact on changes in the radiological situation and amounts to less than 1% of the total initial contamination of the landscape.

Given the low mass (substance) radionuclide content even in the NPP accidental releases, the natural mechanisms of soils are sufficient for its firm fixation.

5.2.1.6 Assessment of orographic factors for the primary and secondary pollution fields and orographic barriers

A primary contamination field, under KhNPP normal operation, will occur depending on climatic conditions, primarily a long-term wind regime (recurrence of winds of certain direction and speed), including the roughness of the earth's surface (orographic conditions and height of vegetation cover).

According to the nearest meteorological stations (Shepetivka and Rivne), the area is dominated by winds from the west (20.4% and 24.7%, respectively), southeast (14%) and south (15.7% and 11.4%). Thus, radioactive releases will be mainly dispersed in the east, northwest and north directions.

To the east and north of KhNPP, there is the valley of the Goryn River with elevations ranging from 212 to 230 m and a forested denudation-accumulative flat plain with elevations ranging from 233 to 240 m. In the northwestern direction from the station, there is a denudation-accumulative wavy plain with elevations of 266 m.

The elevation at the KhNPP site reaches 204.6 m, and vent stack is 100 m. Even if we assume that the emissions will be included exclusively into horizontal air mass flows, there are no surfaces on their way that exceed 300-meter hypsometric marks. The height of trees is on average 20 to 25 meters. Therefore, the area does not contain landscape and morphological obstacles to the pollution dispersion in the direction of the prevailing winds.

Orographic and phytobarriers to the airborne pollutant transfer can be formed exclusively in the southern, south-southwest and west-north directions at a distance of 12.5 to 17 km from the station. It is in the southern and south-southwest directions from the plant that the forested elevated structural and denudation plain of the Podolian Upland with elevations up to 320 m is located, and in the west-west-north direction – the forested elevated structural and denudation plain of the Myzotskyi Ridge with elevations up to 315 m.

There will be either orographic barriers or phytobarriers under hypothetical design basis accidental releases with release heights of 0 m and 48 m (206.6 m above sea level – the height of the earth's surface in the industrial site area), if they are absorbed into horizontal air flows, in whatever direction they are dispersed. The height of the accidental release source is determined in terms of conservative estimates for the near area – 0 m and applies to both beyond design basis and design basis accidents. This height is not conservative for a transboundary transfer.

Thus, the surface relief of the plant's near area and the barriers should be included when modeling the dispersion of gas and aerosol emissions and the dispersion of emissions in hypothetical emergency situations.

5.2.1.7 Characteristics of long-term behavior of radiologically significant radionuclides in soils

This section describes the behavior of the main radiologically significant radionuclides (^{90}Sr, ^{137}Cs, and actinides) and their long-term migration in soil in case of one-time (accidental) contamination. Chronic normalized NPP radionuclide releases under normal operation do not lead to significant contamination of the environment and its components; the role of short-lived release radionuclides and radioactive inert gases in long-term migration through biological chains and, accordingly, formation of additional exposure of the population when entering the body with food is negligible.

Geochemical radionuclide migration has very low rates even under favorable conditions, and therefore landscape self-cleaning, based on it only, is impossible. Landscape and geochemical barriers are volumetric natural bodies within which the conditions of chemical elements migration change. Mechanical barriers are, first of all, relief features that prevent or facilitate radionuclide redistribution between landscapes and their elements. Biocenoses or their separate layers form biogeochemical barriers. In this case, the stand, shrub layer, grass and moss-lichen covers, forest floor, sod or steppe mat, as well as underground biomass and soil itself perform the role of the barrier. The soil is the main barrier to further radionuclide redistribution between biogeocenose elements.

Soil is a crucial link for incorporating the radionuclides into biogeochemical migration chains in terrestrial ecosystems. The dynamics of radionuclide transfer in the soil-plant link is generally determined by the dynamics of three groups of processes, namely:

– radionuclide mobilization-immobilization in the soil root layer;
– radionuclide removal from the root layer;
– radionuclide physical decay.

The intensity of the first two processes depends primarily on the initial physical and chemical forms of fallout and the dynamics of their transformation in the soil and the soil cover characteristics.

To estimate the removal of radiologically significant radionuclides from the soil root horizons of meadows and arable lands, the values of ecological (T_{ecol} – without the rate of radionuclide physical decay) and effective ($T_{ef} = T_{ecol} \cdot T_{1/2}/(T_{ecol} + T_{1/2})$ – with the rate of radionuclide physical decay) semi-cleaning periods of these horizons are calculated in Table 5.1.

Table 5.1 –Semi-cleaning periods of root soil horizons of meadows and arable lands from ^{90}Sr and ^{137}Cs

Soil	**^{90}Sr**				**^{137}Cs**			
	Meadow (0-5 cm)		**Arable land (20 cm)**		**Meadow (0-5 cm)**		**Arable land (20 cm)**	
	T_{ecol}	**T_{ef}**	**T_{ecol}**	**T_{ef}**	**T_{ecol}**	**T_{ef}**	**T_{ecol}**	**T_{ef}**
Automorphic mineral light mech composition	11-19	6-8	21-32	12-15	60-150	20-25	26-45	14-18
Automorphic mineral heavy mech composition	15-32	10-15	37-129	16-23	150-400	25-27	60-150	20-25
Hydromorphic organic soil	100-160	22-24	103-233	22-25	11-20	8-12	30-60	15-20
Organogenic dehydrated	-	-	-	-	17-83	11-22	-	-
Hydromorphic minerals	-	-	-	-	45	18	-	-
Low humic sand	2.2-6	2-5	2.2-7.6	2-6	-	-	-	-

The intensity of ^{137}Cs redistribution in the soil profile is low. In the period from 10 to 15 years after passing the ecological semi-cleaning periods from ^{137}Cs of 5-cm natural meadows soil horizons formed on the light mechanical automorphic mineral soils are from 60 to 150 years, on the heavy mechanical automorphic mineral soils from 150 to 400 years, on the hydromorphic organogenic soils from 11 to 20 years, on the hydromorphic mineral soils from 17 to 83 years, on drained organogenic soils about 45 years.

The vertical ^{90}Sr transfer intensity in mineral soils significantly exceeds cesium radioisotopes transfer intensity. The ecological semi-cleaning periods from ^{90}Sr of 5-cm natural meadows soil horizons formed on the light mechanical automorphic mineral soils are from 11 to 19 years, on the heavy mechanical automorphic mineral soils from 15 to 32 years, on the hydromorphic organogenic soils from 100 to 160 years.

The problem should be noted on intensive vertical ^{90}Sr transfer in the profile of soil differences typical for Ukrainian Polissia – weakly sodded, slightly humic sands, where the radionuclide migrates at a rate of 2 to 6 cm year-1.

Depending on the physical and chemical properties and moisture content, the values of the ecological semi-cleaning periods of the upper 5-cm horizons of soils, meadows and fallow lands from ^{241}Am vary from 25±10 to 650±180 years, and from 100±45 to 260±120 years for Pu isotopes.

The values of ecological semi-cleaning periods from ^{137}Cs in the agrocenoses soil arable horizons are as follows: for light mechanical automorphic mineral soils – from 26 to 45 years, for heavy mechanical automorphic mineral soils – from 60 to 150 years, for hydromorphic organogenic soils – from 30 to 60 years. The values of ecological semi-cleaning periods from ^{90}Sr in the agrocenoses soil arable horizons: for light mechanical automorphic mineral soils – from 21 to 32 years, for heavy mechanical automorphic mineral soils – from 37 to 130 years, for hydromorphic organogenic soils – from 100 to 230 years.

The values of effective semi-cleaning periods of the upper natural meadow soil horizons and arable soil horizons, which reflect the radionuclide redistribution in the soil profile and the rate of physical radionuclide decay are characterized by lower values – from units to tens of years.

The maximum values of effective semi-cleaning periods from ^{137}Cs are characterized by the upper natural meadow soil horizons (25 to 27 years) and agricultural land arable soil horizons (20 to 25 years) formed on the heavy mechanical automorphic mineral soils. Hydromorphic organogenic soils (8 to 12 years old) are characterized by the lowest T_{ef} values. In general, according to the ^{137}Cs migration mobility index, the supervised area soils can be classified as follows: peat-bog > sod-podzolic > gray forest > black soil.

Areas with critical (in terms of ^{137}Cs biological mobility) hydromorphic organogenic soils are located in small areas throughout the 30-km area, but they occupy the largest areas in the eastern (semi-hydromorphic), southeastern (semi-hydromorphic and hydromorphic), and southwestern (hydromorphic) sectors.

The minimum values of effective semi-cleaning periods from ^{90}Sr were established for light mechanical mineral soils (6 to 8 years and 12 to 15 years, respectively, for the upper natural meadow soil horizons and agricultural land arable soil horizons). An abnormally high intensity of ^{90}Sr transfer was noted above in weakly sodded, slightly humic sands, the effective semi-cleaning period from this radionuclide being from 2 to 6 years.

Thus, sandy and sandy loamy sod-podzolic soils are critical in terms of ^{90}Sr mobility in them. Such soils occupy more than 20% of the supervised area territory.

Additional levels of soil contamination under plant normal operation are very low in mass terms (concentration units) and therefore the impact of contamination on soil will be negligible. Therefore, special agrotechnical measures aimed at reducing the impact on soil are not appropriate under plant normal operation, see also clause. 5.3.7.2.

5.2.2 Water resources

Water is one of the main resources used under planned activity, and it is important to avoid negative impacts on both surface and groundwater.

5.2.2.1 Surface water

NPP impact on surface waters can be observed in places of direct contact of NPP process elements and structures with surface water bodies of public use. Such contact points are KhNPP water intake facilities.

The service water supply plan for units 5 and 6 was designed as a reverse scheme with cooling towers as radiators. The KhNPP cooling pond in the adopted cooling and process water supply plan for units 5 and 6 is a source of water intake for cooling tower feeding and blowdown and for other process systems needs, and is also used to discharge blowdown water. The cooling pond water losses are replenished by 100% accumulation of the Hnylyi Rih river flow and makeup by a pumping station from the Goryn River based on a special water use permit.

The additional water pumping station functions to feed the cooling pond to replenish the irrecoverable losses in the service water consumption system and is designed to take in water from the Goryn River at a flow rate of up to 30m ^{3}/s. To meet the total service water demand of Units 5 and 6, it is necessary to withdraw additional water throughout the year, cover the demand in the summer and autumn period by operating the cooling pond, replenish it with runoff from the Goryn River from December to April and with runoff from the Hnylyi Rih River throughout the year, and set a new limit for additional water withdrawal.

The cooling pond chemistry and its quality are determined by such components as the Hnylyi Rih River flow, partial water intake from the Horyn River, and the hydrochemical features of the makeup water (also see Table 5.2). According to O.O. Alekin classification, the Hnylyi Rih River and the Goryn River water belongs to the hydrocarbonate class, calcium group, the second type, according to the predominant quantitative composition of calcium ions and hydrocarbonate ions. Due to changes in the concentrations of total water hardness and bicarbonate ions, as well as their ratio, the cooling pond gradually changes and moves from the calcium to the sodium group.

Table 5.2 - Quality of the KhNPP cooling pond source water and the Gnylyi Rih and Goryn rivers feedwater

№	**Chemical indicator**	**Measurement units**	**Circulation water (cooling pond)**	**Make-up water of the cooling pond (Gnylyi Rih River)**	**Makeup water of the cooling pond (Goryn River)**
1	Hydrogen index	unit	8,275	7,83	7,91
2	General hardness	mg-eq/dm^3	5,25	6,11	6,20
3	Calcium	mg/dm^3	70,14	97,65	97,92
4	Sodium	mg/dm^3	79,9	7,41	15,27
5	Transparency	cm	49,5	35,91	30,64
6	Alkalinity	mg-eq/dm^3	5,27	5,46	5,48
7	Permanganate oxidizability	mgO/dm^3	8,32	7,67	4,70
8	Chlorides	mg/dm^3	50,76	13,57	24,99
9	Sulfates	mg/dm^3	120,15	44,37	50,04

Commissioning of the designed AP1000 units 5&6 will not increase the heat load on the cooling pond due to the use of cooling towers as a cooling system and the absence of heat exchange water discharge.

The commissioning of units 3&4 will increase the volume of heated water entering the pond, which will facilitate increasing the temperature, water evaporating and creating conditions for increasing the total mineralization content.

The hydrochemical forecast of the cooling pond water quality during the power units commissioning was made by PLC Lviv ORGRES. The forecast was made using a mathematical modeling program for an average water year (50% availability), for the first and second design years and the year of salt equilibrium. The results of the hydrochemical forecast are presented in Table 5.3.

Table 5.3 – The hydrochemical forecast

Season	General H_{gen}, mg-eq/dm^3	Carbonate H_{carb}, mg-eq/dm^3	Noncarbonate $H_{noncarb}$, mg-eq/dm^3	CalciumCa^{2+} mg/dm^3	Magnesium Mg, mg/dm^3	Natrium Na, mg/dm^3	Chloride Cl, mg/dm^3	Sulphate SO_4^{-2}, mg/dm^3	HydrocarbonateH CO_{3-} mg/dm^3	Ions sum mg/dm^3
First calculated year										
Spring	5.07	2.53	2.54	65.30	21.98	14.55	25.70	54.78	154.47	336.80
Summer	6.03	3.20	2.83	79.49	25.11	16.83	29.35	62.27	195.07	408.10
Autumn	6.93	4.10	2.83	95.73	26.13	19.92	30.92	63.61	250.03	483.30
Winter	7.72	4.88	2.94	110.0	27.11	16.51	32.15	64.59	297.92	548.60
Second calculated year										
Spring	6.50	4.37	2.13	92.40	23.00	13.32	28.14	51.76	266.32	475.10
Summer	6.07	3.68	2.39	78.49	26.24	15.47	32.06	58.92	224.78	436.00
Autumn	6.97	4.56	2.41	94.80	27.19	15.64	33.45	60.47	277.88	509.40
Winter	5.53	5.32	2.44	109.12	28.12	15.30	34.55	61.98	324.29	573.30
The year of salt balance										
Spring	6.31	4.44	1.87	87.56	23.66	12.53	29.70	49.83	270.69	474.00
Summer	5.90	3.00	2.90	73.85	26.97	14.60	33.78	56.78	231.57	437.50
Autumn	6.80	4.66	2.14	90.44	27.87	14.82	35.07	58.46	284.24	510.90
Winter	7.60	5.42	2.18	104.99	28.76	14.52	36.08	60.08	330.32	574.80

According to the forecast results, we can note changes in the main ingredient concentrations, such as total water hardness (5.90-7.60 mg-equ/dm^3), the amount of calcium ions (73.85-104.99 m/dm^3) and hydrocarbonate ions (231.57-330.32 mg/dm^3). The total mineralization will be 437.5-574.8 mg/dm^3. In terms of total mineralization (including calcium, magnesium, chlorides, sulfates, and bicarbonates), the concentration will increase without exceeding the MPC for fishery water bodies, while the sodium concentration will slightly decrease.

In addition, the commissioning of units 3 and 4 will increase the heated water flow into the cooling pond from 50.0 m $^{3/}$s for one power unit to 200.0 m $^{3/}$s for four power units and the existing water cooling technology, and water losses due to additional evaporation from the cooling pond surface will amount to 53.1 million m $^{3/}$year. Due to the use of cooling towers, the amount of additional evaporation will not change when units 5 and 6 are commissioned.

Based on the permissible cooling water temperature (no more than 33 °C), the cooling pond is designed to remove heat from the 4000 MW NPP equipment (4 power units), including master repair schedule. When units 3 and 4 are commissioned, the heat load on the pond will significantly increase, with production and natural losses increasing significantly.

In 2023, the affiliate SS “Atomprojectengineering” performed the KhNPP cooling pond thermal calculation including the KhNPP AP1000 units 5 and 6 construction [34], which resulted in determining the temperature of the cooled water in the pond during operation of one, two, three and four and six power units with a capacity of 1000 MW each:

– during the operation of two power units in summer, the water temperature in the underwater channel (at the turbine condensers inlet) is 24.4-25.5 °C
– during the operation of three power units in summer, the water temperature is 30.0-30.8 °C, which is less than the standard temperature value of 33.0 °C;
– during the operation of four power units, the water temperature in summer months is 33.0-33.2°C and will already reach the critical temperature under technological conditions 33.0 °C [27];
– during the operation of units 5 and 6 – according to the AP1000 process flow diagram, developed by Westinghouse, the purge water from the tower cooling basin of the CWS system is combined with the purge flow from the SWS system, taken from the pump discharge header and sent to the purge sump of the wastewater collection and disposal system for further discharge into the KhNPP cooling pond. Based on the operating conditions of the cooling and blowdown water removal scheme, it can be concluded that the cooling pond receives water already cooled to ambient temperature. Thus, the operation of power units 5 and 6 will not affect the value of additional evaporation from the reservoir and the temperature regime in the reservoir as a whole.

For the operation of units 3&4, in order not to exceed the permissible cooling water temperature, it is envisaged to construct a 1300.0 m flow control dam.

The dam construction will allow to improve the efficiency of cooling circulating water in the pond and ensure the necessary temperature conditions for the operation of six units even in the most unfavorable "hot" hydrometeorological conditions.

The construction of such a dike also helps to avoid a significant dependence of the pond temperature on the most unfavorable wind conditions with westerly winds of 3-6 m/s.

5.2.2.2 Groundwater

The NPP groundwater monitoring network was installed in 1989. The stationary groundwater monitoring network includes 189 wells, which are equipped for the Upper Proterozoic aquifer. The purpose of hydrogeological monitoring is to control the stability of groundwater regime criteria (level, temperature, chemistry) and assess the impact of anthropogenic factors on groundwater. The monitoring network is almost constantly being reconstructed to repair out-of-service wells. Groundwater conditions are assessed in two aquifers:

– quaternary aquifer (groundwater – H1);
– pressure aquifer (Vendian – H2).

During the operation of units 1 and 2, the anthropogenic impact of the NPP had almost no effect on the groundwater level, since the observation point and the NPP industrial site are located in close proximity to drainage systems, but it affected their chemical composition and temperature as a result of infiltration of industrial water into the ground due to leaks from water supply systems. The groundwater level and the piezometric level of the pressure aquifer can be traced at almost the same elevations, as there is a hydraulic connection between the horizons.

Seasonal fluctuations in the groundwater level averaged 0.5 m in 2017, 0.56 m in 2016, 0.7 m in 2015, 0.52 m in 2014, 0.72 m in 2013, and 0.73 m in 2012. Groundwater levels are stable and respond only to seasonal climate changes.

The difference in groundwater temperature within the industrial site is 10.0 °C. The background temperature is 9.0-10.0 °C. The increase in groundwater temperature was recorded in the following areas: in the unit 1 main building area along the western wall, along the unit 2 main building perimeter, along the eastern wall of the unit 3 main building (central part), near the unit pumping station No. 1, east of the spray cooling pond, along the special building perimeter.

The pressure aquifer water temperature, and the groundwater temperature, is also higher than the background temperature in some areas. The background temperature is 10 °C. The temperature fluctuations within the industrial site is 10.5 °C, with a maximum of 20.5 °C.

Areas with increased groundwater temperatures and the pressure aquifer water practically coincide, water temperature in both horizons being almost identical.

The groundwater chemistry has not significantly changed in recent years. The groundwater chemical composition in both aquifers within the industrial site is characterized by heterogeneity, i.e. significant fluctuations in mineralization over short distances.

The following areas where increased groundwater mineralization was recorded were identified as follows: in the southwestern corner of the unit 3 main building, along the eastern wall of the unit 1 main building, near the northeastern corner of the special building, in the area between unit pumping stations 1 and 2.

It should be emphasized that, according to the monitoring data, chemical and thermal contamination of groundwater and hydraulically connected groundwater in the upper part of the Upper Proterozoic horizon is localized only within the NPP site; groundwater chemistry background (i.e., unaffected by technogenesis) values and temperature were recorded on the site periphery. At the same time, within the industrial site, there is not a continuous field of technogenically contaminated groundwater, but rather disconnected local areas where groundwater is characterized by increased mineralization and temperature.

Groundwater is widespread in the area. The creation of the KhNPP cooling pond, laying of the outlet and inlet channels, and drainage network led to the transformation of hydrogeological conditions. The drainage network allows maintaining, in general, the level as specified during the design.

It is almost impossible to fully predict quantitative changes in the groundwater chemistry and temperature associated with the anthropogenic impact of NPP facilities, as possible losses of chemically contaminated and hot water are unpredictable. However, no significant changes in groundwater are expected during normal operation. The dynamics of changes in groundwater conditions for 2018-2023 according to the "KhNPP Non-Radiation Factors Impact Assessment Report" for 2022 and 2023 see also [44, 45], are in Table 5.4.

Table 5.4 – Dynamics of changes in groundwater conditions (in terms of pollutants/chemicals)

Name of pollutants/chemicals	**Content of pollutants/chemicals, mg/dm3**					
	2023	**2022**	**2021**	**2020**	**2019**	**2018**
Industrial site (H1 horizon)						
pH, units	6.85	7.53	7.50	7.70	7.39	7.33
total hardness, mg-eq/l	10.54	10.90	13.01	9.38	8.94	8.3
calcium, mg/l	151.8	155.33	182.51	131.9	130.73	—
magnesium, mg/l	36.3	38.30	46.42	33.90	29.42	—
potassium, mg/l	9.03	8.60	9.59	10.07	9.24	—
natrium, mg/l	22.4	20.96	20.26	27.36	25.53	26.33
salt ammonium, mg/l	5.83	5.12	1.48	1.99	1.7	3.04
carbonate, mg-eq/l	0.02	0.03	0.02	0.02	0.02	0.02
bicarbonate, mg-eq/l	4.03	4.15	3.97	3.51	3.37	3.46
chloride, mg/l	27.47	28.56	29.68	25.86	21.31	20.27
nitrite, mg/l	0.08	0.05	0.13	0.05	0.07	0.57
nitrate, mg/l	3.65	2.14	2.34	2.00	2.61	5.96
sulfate, mg/l	483.01	517.44	582.04	388.00	357.03	325.15
permanganate oxide, mgO/l	—	—	—	—	—	—
dry residue, mg/l	869.11	901.71	996.40	692.24	676.98	642.41
Industrial site (H2 horizon)						
pH, units	7.17	7.71	7.72	8.00	7.66	7.62
total hardness mg-eq/l	7.22	8.58	9.55	6.97	7.46	6.82
calcium, mg/l	92.91	116.19	130.26	90.02	101.99	—
magnesium, mg/l	31.37	33.83	37.15	30.04	28.95	—
potassium, mg/l	9.84	8.81	8.29	9.20	8.98	—
natrium, mg/l	64.96	63.70	61.91	63.37	66.38	69.56
salt ammonium, mg/l	1.62	1.91	1.67	1.58	1.79	2.38
carbonate, mg-eq/l	0.07	0.05	0.04	0.08	0.06	0.07
bicarbonate, mg-eq/l	4	4.38	4.28	3.48	3.93	3.69
chloride, mg/l	24.9	42.88	39.43	36.97	40.75	37.13
nitrite, mg/l	0.07	0.08	0.12	0.03	0.05	0.06
nitrate mg/l	1.13	0.68	0.63	0.56	0.63	0.49
sulfate, mg/l	255.5	322.17	314.40	308.94	256.84	236.52
permanganate oxide, mgO/l	—	—	—	—	—	—
dry residue, mg/l	610.37	717.92	724.84	644.78	624.84	583.2

5.2.3 Biodiversity

The KhNPP is located in the forest-steppe region of western Ukraine. The ecological state around the nuclear power plant is in harmony with nature, flora and fauna, and is characterized by a high degree of species diversity.

The Hnylyi Rih River has turned into a large lake with powerful waves. Commercial fish are grown in its depths, many birds' nests and fowl are found on its stretch and riverside. The surrounding forests are natural parks protected by the state. A variety of endemic plants are preserved here.

The cooling pond includes a unique ecosystem, which is peculiar by the fact that the pond`s southwestern and eastern near-shore areas are shallow and marshy. These are the excellent places for spawning most fish, of which 23 species have been registered here, including a significant crayfish population. According to the KhNPP engineering design, fishing activities are carried out in full at the pond. In spring, several thousands of black carp fry are released into the KhNPP pond, from which individuals with an average weight of 3-4 kilograms grow by autumn. The material for offspring is obtained in incubators located in the biomelioration section of the hydrotechnical shop.

The territory around the pond is characterized by biodiversity: pine, hornbeam-oak, and birch forests, swamp, and lakes surrounding it contribute to the comfortable living of entire bird colonies. In winter, many waterfowl find shelter here: the warm water and the availability of various foods attract them. Swans, in particular, have been choosing a pond for wintering for ten years.

Within the KhNPP SPA and SA, the radiation parameters do not exceed natural values and are at the level of natural background values measured before the start-up of the nuclear plant; no significant changes are envisaged during the construction and operation of new power units, see also clause 5.3.7.3.

The start-up of units 5 and 6 and the accident-free operation of KhNPP as part of six units will not have a negative impact on the general species diversity of invertebrates and insects, see also subpara. 1.5.2 and 5.3.7.3. An increase in water temperature will lead to a quantitative redistribution in the aquatic entomocomplex, and the share of thermophilic and euribiont species will increase. Only the growth of anthropogenic load on the area landscapes, associated with the growth of the population of the city of Netishyn, can lead to a reduction in the number of some rare species of insects in the city's surroundings. This is due to the action of the following factors: the further diversion of meadow areas for vegetable gardens, recreational load (trampling of grass in places of rest, gathering of mushrooms and berries), cutting of forests, general pollution of the environment. At the same time, it was established that the commissioning and normal operation of the KhNPP units 5 and 6 will not have a negative impact on the animal world in the KhNPP supervised area.

It is worth noting that the new power units of KhNPP are being built on the existing NPP site, and therefore, during the implementation of the planned activity, including the expected transport connections for the implementation of the planned activity, there is no impact on the flora and fauna. In case of deforestation during construction, compensatory measures will be provided. Violations of the fodder base, shelters, nesting places and migration routes of animals are not expected.

5.2.4 Conclusions

Based on the results of the assessment, it was determined that the impact on the environment caused by the use of natural resources in the process of carrying out the planned activity, in particular land, soil, water and biodiversity, is negligible, see also clauses 1.5, 5.3.

Soil degradation processes associated with the construction of KhNPP extend only to the area of the industrial site. Their presence in the 30-kilometer area of KhNPP is practically unrelated to the station's operation. Considering the insignificant mass (material) content of radionuclides, even in the emergency emissions of nuclear power plants, the natural mechanisms of soils are sufficient for their firm fixation.

The construction of power units № 5 and № 6 with the AP1000 will not lead to changes in the temperature regime of the water cooling since cooling towers are used as a cooling system. In addition, due to the use of cooling towers as a cooling system and the absence of discharge of heat exchange water, the influence on the chemical composition of the water in the cooling pond is practically excluded. A significant impact on groundwater is not expected.

The commissioning and normal operation of the KhNPP units №5 and №6 will not have a negative impact on the fauna in the KhNPP supervised area.

5.3 Pollutant emissions and discharges, noise, vibration, light, heat, contamination, radiation and other impact factors, as well as waste management operations

The environmental impact should be analyzed based on the assessment of emissions and discharges, including the impact of pollutants, noise, vibration, and heat and radiation pollution.

5.3.1 Pollutant exposure

The impact of pollutants on atmospheric air is assessed together with a current atmospheric air condition. The impact assessment is carried out by design method during the construction and operation stages see para. 1.5.2.1. Based on the results, the MAC (maximum acceptable concentration) is not expected to exceed and no environmental impact is expected to occur.

5.3.2 Thermal effects

A nuclear power plant is a source of significant heat releases. Approximately two-thirds of thermal generation cannot be used to generate electricity and is discharged into the environment.

The heat is mainly transferred to the environment by convection and water evaporation.

Water evaporation in circulating cooling systems leads to salt accumulation. Processing limits on salt in the cooling water require that cooling systems be purged to maintain the salt regime at an acceptable level.

The service water supply plan for KhNPP units 1, 2 (3, 4) nonessential services (Group B) is recycled with a combined cooling pond type: off-stream from the Goryn River and channel from the Hnylyi Rih River. The KhNPP cooling pond was constructed for the plant process needs and is a body of special water use. The service water supply plan for essential services (Group A) is designed as a recycling system with spray ponds.

The service water supply plan for units 5 and 6 is designed as a reverse water supply with cooling towers as a coolant. The KhNPP cooling pond in the adopted cooling and service water supply plan for units 5 and 6 is a source of water intake for cooling tower basin makeup and blowdown and for the needs of other process systems, and is also used for blowdown water discharge.

The service water system (SWS) and circulating water system (CWS) refer to the designed systems involved in the equipment cooling at the AP1000 units 5 and 6. SWS and CWS are used to supply cooling water to the components of the AP1000 reactor and turbine units and use pond water for blowdown and makeup.

CWS and SWS for units 5 and 6 are cooled using cooling towers. Upon cooling tower basin blowdown, water is taken and transfered to the waste water system blowdown sump for further discharge into the cooling pond. Based on this cooling and blowdown water discharge scheme, it can be concluded that the cooling pond receives an ambient temperature cooled water. Thus, the operation of units 5 and 6 will not affect the additional pond evaporation value.

For the units 1-4 cooling systems, the heat exchanger emissions are transferred to circulating cooling water, which removes heat to the atmosphere using the cooling pond for the turbine building main cooling system and Group B cooling system, as well as spray ponds for Group A cooling system.

[redacted]

The cooling system for Group A at units 1, 2 (3, 4) is a safety system designed to remove excess heat from the reactor to the ultimate heat sink during normal operation and in emergency situations. The system is designed to be independent of other cooling systems. The number of cooling system independent channels corresponds to the number of Emergency Core Cooling System channels.

[redacted]

Table 5.5 shows the power units 1-4 designed heat discharges to the cooling pond.

The Group A designed heat releases of the units 1-4 reactor building under nominal mode to the spray ponds are given in Table 5.6.

Table 5.5 – Units 1-4 design heat discharges to the cooling pond

Power unit number	Heat amount		
	Gcal/year	Gcal/day	Gcal/year*
1	2095	50250	13618 x 10^3
2	4190	100500	27235 x 10^3
3	6285	150750	40854 x 10^3
4	8380	201000	54472 x 10^3

Notice*: Heat amount for the annual installed capacity utilization time of 7200 hours

Table 5.6 – The Group A design heat releases of the units 1-4 reactor building under nominal mode to the spray ponds

Power unit number	Heat amount (maximum/minimum)		
	Gcal/year	Gcal/day	Gcal/year
1	20/2.5	480/60	$175.2 \cdot 10^3 / 21.9 \cdot 10^3$
2	40/5	960/120	$350.4 \cdot 10^3 / 43.8 \cdot 10^3$
3	60/7.5	1440/180	$525.6 \cdot 10^3 / 65.7 \cdot 10^3$
4	80/10	1920/240	$700.8 \cdot 10^3 / 87.6 \cdot 10^3$

The environment is also affected by water that enters the atmosphere through additional evaporation and wind droplets from the cooling pond surface. The quantitive values of such water losses are given in Table 5.7.

Table 5.7 – Design values of additional cooling pond evaporation during units 1-4 operation

Month	01	02	03	04	05	06	07	08	09	10	11	12	Per year
Water evaporated during units operation, million m^3													

Unit 1	1.05	1.08	1.12	1.14	1.26	1.18	1.08	1.03	1.12	1.10	1.06	1.06	13.28
Units 1, 2	2.10	2.16	2.24	2.28	2.52	2.36	2.16	2.06	2.24	2.20	2.12	2.12	26.56
Units 1-3	3.15	3.24	3.36	3.42	3.78	3.54	3.24	3.09	3.36	3.30	3.18	3.18	39.84
Units 1-4	4.20	4.32	4.48	4.56	5.04	4.72	4.32	4.12	4.48	4.40	4.24	4.24	5.12

The evaporation value was determined based on the unit installed capacity utilization hours, equivalent to 7200 hours per year.

For Group A cooling system, the design evaporation and wind drift values for spray pond and cooling pond are given in Tables 5.8 and 5.9.

Table 5.8 – Total design water losses due to evaporation and wind drift during operation of units 1-4

Month	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**Per year**
Water losses due to evaporation and wind drift, mln.m^3													
Unit 1	1.16	1.15	1.15	1.18	1.22	1.24	1.36	1.28	1.18	1.13	1.22	1.20	14.48
Units 1, 2	2.32	2.30	2.30	2.36	2.44	2.48	2.72	2.56	2.36	2.26	2.44	2.40	28.48
Units 1-3	3.48	3.45	3.45	3.54	3.66	3.72	4.08	3.84	3.54	3.39	3.66	3.60	43.44
Units 1-4	4.64	4.60	4.60	4.72	4.88	4.88	5.44	5.12	4.72	4.52	4.88	4.80	57.92

Table 5.9 – Specific design water losses due to evaporation and wind drift from spray pond and cooling pond

Parameters	**Quantity**		
	per hour	**per day**	**per year**
Water losses mln.m^3			
Unit 1	0.0017	0.04	14.48
Units 1, 2	0.0033	0.08	28.96
Units 1, 2, 3	0.0051	0.12	43.44
Units 1, 2, 3, 4	0.0068	0.16	57.92

For CWS units 5 and 6, a naturally ventilated cooling tower was adopted to receive heated circulating water from the main condensers and support the heat exchangers. The circulating water is cooled by evaporation and returned to the cooling tower basin. One cooling tower is provided for each of units 5 and 6.

[redacted]

The cooling tower has a hyperbolic design and is constructed of concrete with PVC film (also see Figure 5.1). A cooling tower bypass system is provided for freeze protection. The AP1000 standard main condenser is designed to operate properly over a wide range of circulating water flow rates and inlet temperatures.

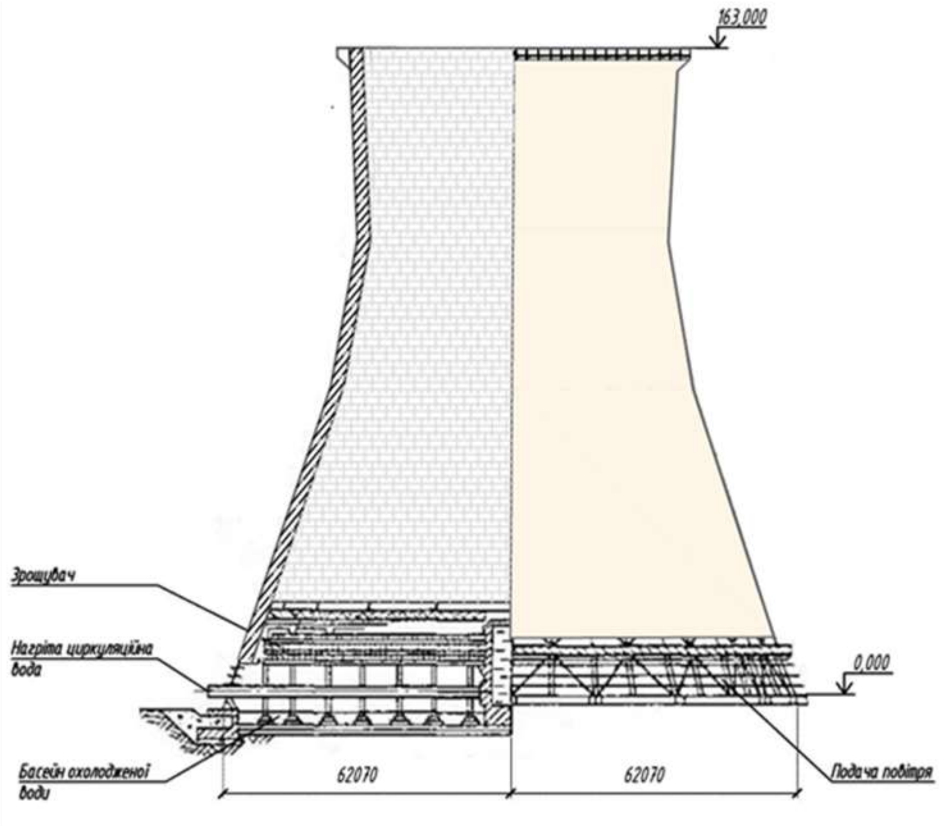


Figure 5.1 - Tower cooling tower

The SWS for units 5 and 6 is cooled by a fan cooling tower (also see Figure 5.2). The cooling tower is a straight, counter-current tower with a suction fan and a clog-resistant film filling. The cooling tower is divided into two chambers. Each chamber utilizes a single propeller-type fan located at the top of the chamber to draw air upward through the fill against the downstream.

Figure 5.2 - Fan-type two-section cooling tower

[redacted]

The configuration and size of the cooling tower allow to achieve the required temperature indicators when cooling the heated water.

The cooling tower design is a fiberglass composite made of refractory materials. The tower skeleton and fan deck are made of pultruded fiberglass, and a tower shell is made of corrugated glass-reinforced polyester or equivalent material. The tower filling, located below the water distribution piping, is made of PVC or polypropylene and is designed to avoid clogging.

The cooling tower performance requirements are tied to the ambient wet bulb temperature of 30°C. The requirements for normal operation at capacity apply continuously and must be met even on the hottest day of the year.

The values of heat emissions to the atmosphere from the CWS and SWS cooling towers in accordance with [32, 33] are given in Table 5.10. Estimated values of water losses due to evaporation and wind removal from cooling towers during operation of units 5&6 are given in Table 5.11. Specific estimated values of water losses due to evaporation and wind removal from the CWS tower-type cooling towers are given in Table 5.12.

Table 5.10 – Thermal releases to the atmosphere from the CWS and SWS cooling towers

Cooling tower type	Cooling tower number, pcs.	Heat amount maximum/minimum		
		Gcal/h	Gcal/day	Gcal/year
CWS cooling towers	2	3810.0/0	91440.0/0	27.4 x 10^6/0
SWS fan cooling towers	Two double-chamber cooling towers	174.6/37.74	4190.4/905.76	1.26 x 10^6/ 0.74 x 10^6
Total	4	3 984.6/37.74	95 630.4/905.76	28.66 x 10^6/ 0.74 x 10^6

Table 5.11 – Design water losses due to evaporation and wind drift during units 5 and 6 operation

Month	01	02	03	04	05	06	07	08	09	10	11	12	Per year
Operating hours	**744**	**647**	**558**	**540**	**558**	**540**	**558**	**558**	**540**	**558**	**655**	**744**	**7200**
Amount of water evaporated during unit operation, million m^3													
Units 5, 6	5.07	4.41	3.80	3.68	3.80	3.68	3.80	3.80	3.68	3.80	4.46	5.07	49.06

Table 5.12 – Specific design water losses due to evaporation and wind drift from the CWS cooling towers

Parameters	Quantity		
	per hour	per day	per year
Water losses mln. m^3			
Units 5, 6	0.0068	0.16	48.96

5.3.3 Wastewater impact

NPP industrial, domestic effluents, stormwater drainage and Netishyn domestic wastewater are not discharged directly into public water bodies. The treated wastewater is discharged to the cooling pond, which is the NPP water body, and thus compensates for water losses in the pond and does not directly affect the degree of surface water pollution. Inputs to eventual AP1000 plant wastewater discharge volumes are in accordance with [46].

The AP1000 units 5 and 6 provide features and provisions to minimize discharges and associated impact on the environment. The AP1000 plant wastewater discharge scheme in accordance with [46] is shown in Figure 5.3.

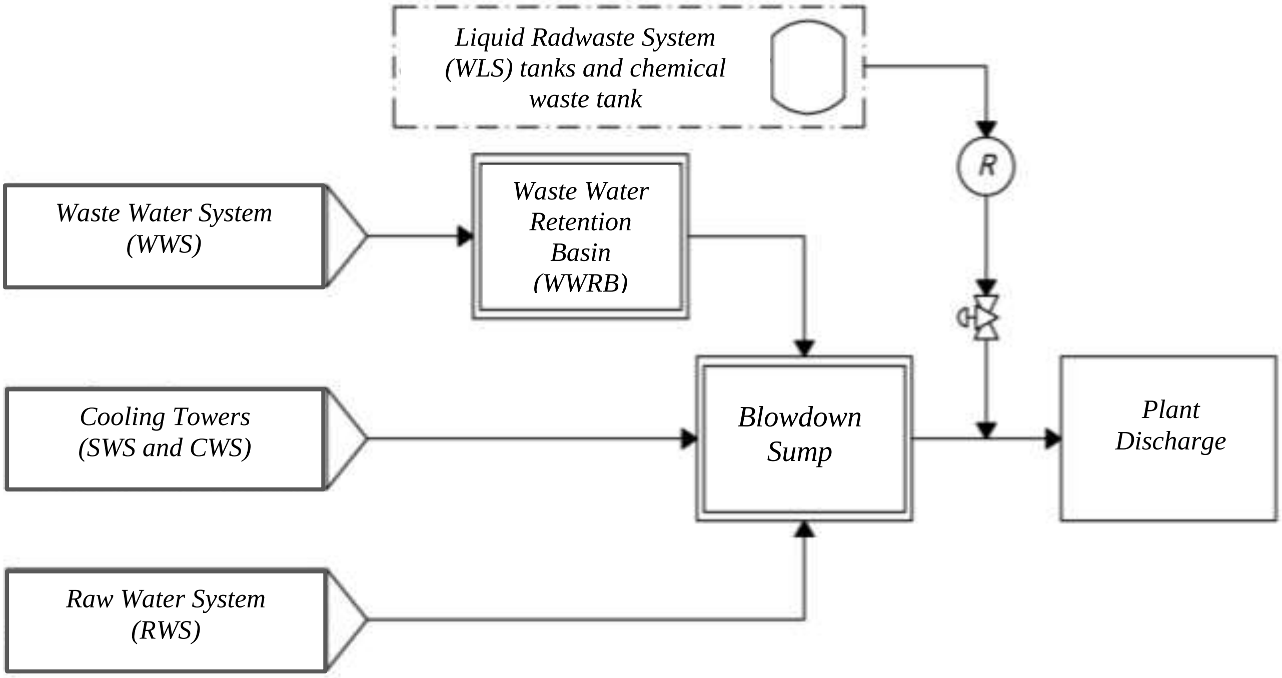


Figure 5.3 – The AP1000 plant wastewater discharge

The WWS collects the non-radioactive plant equipment wastewater, floor drains, process fluids and residual system flushing effluents before treatment and subsequent discharge to the cooling pond. Effluent is collected in the turbine building sumps and discharged to an oil separator, where the oil is coagulated and separated from the water, and solids settle. The waste water without an oil (e.g. rainwater) can be discharged to a special waste water retention basin (WWRB) for settling and treatment. The WWS oil separator removes oil and settling solids from the plant wastewater before discharge into a cooling pond. The used oil is collected in the separator's internal tank. The effluent in the tank is pumped to the blowdown sump. In the event radioactivity is detected in the discharge from the sumps, the waste water is diverted from the sumps to the WLS for processing and disposal. The WWS parameters are shown in Table 5.13.

Table 5.13 – The WWS parameters per one unit

Fluid type	**Flow rate, m^3/h**	**Temperature (max), ℃**	**Pressure (max), MPa**
Wastewater	56.78	48.9	0.76

The CWS cooling tower basin is fed by the RWS. The cooling tower basin also receives a blowdown flow from the SWS. The CWS blowdown flow is taken from the pump discharge header and directed to the WWS blowdown sump for further discharge to the KhNPP cooling pond. Inputs to eventual blowdown water discharge volume from the CWS and SWS are given in Table 5.14.

Table 5.14 – Eventual blowdown water discharge volume from the CWS and SWS per one unit

Fluid type	**Flow rate, m^3/h**	**Temperature (max), ℃**

The CWS cooling tower basin blowdown water	1071.0	3215.0
The SWS fan cooling tower basin blowdown water	14.0	47.0

The wastewater from the WWS and Passive Containment Cooling System (PCS) flows to the Storm Drain System (DRS). Safe leaks and flushing effluent from the tanks, hydrants, and basins in the SWS, RWS, Fire Protection System (FPS), Heating System, and Demineralized Water Transfer and Storage System (DWS) will be diverted to the DRS. The DRS also receives and discharges wastewater from the Gravity and Roof Drain Collection System (RDS).

The Sanitary Drainage System (SDS) collects the sanitary waste from units 5 and 6 restrooms, locker rooms in the turbine building, auxiliary building and annex building and transports it through collectors connected to the building sewage systems to the domestic wastewater treatment plant for a full biological treatment and additional treatment at biological facilities. The capacity of the treatment facilities is 20.0 thousand m^3/day, see also Appendix F the actual average load, as informed by the Khmelnytskyy NPP utility company during the operation of units 1 and 2, ranges from 9.0 to 11.0 thousand m^3/day, including the wastewater from Netishyn in the amount of approximately 8.5 thousand m^3/day. Basen on the preliminary calculations, the power units utility wastewater is approximately 0.38 thousand m^3/day. Thus, the capacity of the existing treatment facilities is sufficient to accept and treat domestic wastewater from the designed units 5 and 6. The SDS output parameters are shown in Table 5.15.

Table 5.15 – The SDS output parameters

Fluid type	Flow rate, m^3/h	Temperature (max),˚C	Pressure (max)
Sanitary waste water	7.95	21.1	Atmospheric

Rainwater from the roofs of buildings and the adjacent territory of units 5 and 6 are to be discharged through the DRS into the SWS inlet channel and used in the NPP cycle, which will reduce the need for fresh additional service water. The discharge volume mostly depends on the expected precipitation. Aside from rainfall collection from each building to the ground and into the DRS, the storm drain release point also handles flows from the PCS, which has a normal expected flow of 0.013 m3 /h, and a maximum flow of 114 m3 /h during off normal events.

5.3.4 Noise exposure

The following factors are considered in the noise impact assessment on the environment:

– the impact of additional noise sources due to the commissioning of units 5 and 6;

– the absence of permanent workplaces for service personnel at the industrial site, outside the production buildings and structures, it is reasonable to conduct a noise impact assessment only inside of these buildings and structures.

In case of construction works at units 3&4, noise impact assessment shall include the noise of construction equipment.

The main building No. 5, 6, a number of auxiliary production buildings and structures are put into operation with units 5&6 at the NPP industrial site.

In these buildings and structures, the source of sound impact on the operating personnel is the rotating equipment installed in them (turbine unit, pumping units, ventilation units), as well as the reducing equipment.

Thermal and sound insulation is performed to reduce noise levels. Sound absorption is also provided by the walls and ceilings of the turbine hall.

In the main building, the production process is fully automated, permanent workplaces of the duty personnel are located in special rooms equipped with soundproof enclosing structures. The design sound pressure level in these rooms, provided by the insulating structures, meets the regulatory requirements for control rooms and laboratories, namely, does not exceed the permissible values given in Table 5.16.

Table 5.16 – Permissible sound pressure levels in control rooms, laboratories, computing machinery

Name	**Octave bands with geometric mean frequencies, Hz**								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Permissible sound pressure level, dB	93/96*	79/83	70/74	63/68	58/63	55/60	52/57	50/55	49/54
Integrated sound level, dBA	60/65								

Note*: The table shows values for control rooms in the numerator and for laboratories in the denominator

During the operation of the installed equipment, the operating personnel either are absent or are there periodically and for a short time (walkdowns). In this case, it is necessary to protect personnel from noise using soundproof cabins and personal protective equipment (earplugs, earphones).

Soundproof cabins of the KVU type are installed.

Areas with a sound level above 80 dBA are marked with safety signs in accordance with the standards.

To protect service personnel temporarily staying on the territory (duty and repair), it is provided to use earphones to reduce noise in the range of 31.5 - 8000 Hz by 7 - 45 dB.

The entity must ensure monitoring the noise level at workplaces in accordance with the standards at least once a year.

5.3.4.1 Noise protection measures during construction

To reduce the noise level during construction and installation works on the construction site, it is necessary to:

– ensure that vehicle engines are turned off while on the construction site;
– turn off loudspeaker communication;
– do not carry out welding without protective screens;
– exclude the performance of work accompanied by noise exceeding the permissible standards;

– exclude the operation of equipment with a noise and vibration level exceeding the permissible standards;

– to soundproof construction machinery engines, use protective covers and hoods with multilayer coating;

– to isolate local sources, use temporary noise protection screens, noise control curtain, tents (for example, place compressors in a sound-absorbing tent).

Construction and assembly machinery and vehicles are the main sources of exhaust gases and noise, which cannot be avoided during the construction process.

5.3.4.2 Noise limitations under the AP1000 operation

The environmental conditions (lighting, noise, ambient temperature, radiation, air quality, and humidity) in the control room, remote shutdown room, and local control stations are determined using generally accepted industrial and human technology standards.

Noise limit criteria applies only to permanently manned locations (e.g., the main control room (MCR) or local control room) in the standard plant design. As a result, few equipment have noise limitation design features in the Nuclear Island area of the AP1000 plant design.

The AP1000 standard design has a noise criterion (NC) NC-45 for rooms with computer and communication equipment; auxiliary control room, access control areas; chemical laboratories, radioactive waste control room, locker room, and resting rooms. Definitions and explanations of NC-45 are given in the relevant documents [47].

Main control room and/or remote shutdown room. The background noise level shall not exceed 65 A-weighted decibels (dB(A)) when the nuclear island HVAC non-radioactive ventilation system (VBS) is in operation. The background noise level shall not exceed 65 dB(A) when the VES associated with the HVAC main control room safety is in operation.

Other areas. The noise level in the auxiliary building areas, except for the MCR and remote shutdown room, is 5 dBA lower than the prescribed level.

Containment. The Containment noise level should be limited to 70 dBA during refueling to maintain proper operation and communication between operators during refueling breaks.

Reducing excessive noise levels

Noise limitation criteria are applied only to areas with permanent personnel (e.g., main control room) in the standard plant design. Thus, not much equipment has noise control design features. Westinghouse uses built-in equipment with silencers, noise-absorbing acoustic panels, and carpeted floors to protect personnel from excessive noise during operation.

Silencers

Silencers are used on the Steam Generator System (SGS) main steam line power operated relief valves (PORV) and in the Main Control Room Emergency Habitability

System (VES) air amplifier and eductor to protect operators from excessive noise when these components are in use.

Main steam line power operated relief valve silencers. The function of the steam generator relief valve silencers is to reduce the audio output of the main steam PORVs to 110 dB(A) at the outlet of the silencer while maintaining a differential pressure less than 0.160 MPa abs (23.2 psia). In addition to limiting, the noise provided from the PORVs operation to the operators, this audio level is the maximum allowed due to operating pressure waves that result in metal fatigue issues that would result in damage to the main steam PORVs. The steam generator relief valve silencers shall be cylindrical in cross section and vertical in orientation, utilizing internal component parts, which include but are not limited to, a pressurized inlet flow diffuser, expansion plenum and acoustic tube module to attenuate the noise generated from the steam from the relief valves.

Air amplifier silencers. The air amplifier silencers are safety-related HVAC silencers and their function is to reduce the noise in the passive air filtration line generated by the operation of the eductor. They are part of the MCR passive air filtration and they act to keep noise levels within the requirement of 65 dB(A) during VES operation. There is one silencer upstream of the eductor and one downstream of the eductor. These silencers are located within the main control room area.

Eductor Bypass Line Silencer. This eductor bypass line silencer is used to reduce the noise level of the VES breathable air into the main control room in the event the bypass line is used in the VES. Under full flow conditions the sound level at a location of 1 meter downstream and 1 meter away from the outside of the uninsulated chamber shall not exceed 65 dB(A). This silencer is located within the main control room area.

MCR acoustic panels

For additional protection against excessive noise in the MCR, acoustic panels are used.

The panels are 25.4 mm thick, and the material composition consists of fiberglass core, zinc-plated steel eyed screws along top edge, and 100% polyester fabric.

These panels are located within the main control room to provide noise abatement for the operators.

Other MCR features

The MCR has concrete and steel walls and ceiling. To reduce the overall noise-level requirements in the MCR, antistatic carpet should be installed on the floor of the MCR. The carpet electrostatic discharge shall have a limit of 3.5kV.

5.3.5 Vibration effect

The AP1000 unit Special Monitoring System (SMS) is a system consisting of the I&C-related systems that provides a special diagnostic and long-term monitoring functions, namely:

– Digital metal impact monitoring system (DMIMS-DX™)
– Vibration integrity monitoring system (VIMS)

– Feedwater vibration monitoring system (FWVMS)

5.3.5.1 Digital Metal Impact Monitoring System (DMIMS-DX)

The Digital Metal Impact Monitoring System (DMIMS-DX) provides for the detection of the presence of metallic debris in the RCS when the debris impacts against the internal parts of the RCS.

The DMIMS-DX system is designed to warn operators about the presence of metal debris in the RCS.

5.3.5.2 Vibration Integrity Monitoring System (VIMS)

The VIMS system is a subsystem of the SMS, which consists of the reactor coolant pump vibration monitoring (RCPVM) and control rod drive mechanism (CFVM) systems.

The main purpose of the VIMS is to provide early detection of abnormal vibration levels of the RCPs and CRDM fans to avoid or reduce damage to this equipment. The plant personnel can use this information to focus their efforts on performing corrective actions to eliminate faults in the primary coolant system and minimize the need for overhauls. The VIMS is a continuous monitoring system that provides information to assist in the evaluation of the performance of the RCPs and CRDM fans.

The main function of the RCPVMS is to monitor the vibration of the four reactor coolant pumps. In addition, the RCPVMS monitors the speed of each pump. The RCPVMS is one of the special monitoring systems designed to protect critical components. The CFVMS processes vibration sensor signals from the CRDM four fans and monitors vibration levels.

All monitored data, along with the configured signal settings and signal status, are formatted and displayed on a local display. The graphical user interface allows the user to look at the various monitors to quickly evaluate the monitoring data of each channel.

5.3.5.3 Feedwater Vibration Monitoring System (FWVMS)

The main purpose of the FWVMS is to provide early detection of abnormal vibration levels of the main and booster feedwater pumps, pump motor and reductor to avoid or reduce damage to this equipment. The FWVMS is a continuous monitoring system that also provides pump speed monitoring.

The AP1000 unit has three feedwater pump channels A, B, and C. Each channel consists of a main pump, a booster pump, an electric motor, and a reductor. All the FWVMS sensors are non-contact vibration displacement sensors.

All monitored data, along with the configured signal setpoints and signal status, are formatted and displayed on the local display.

5.3.6 Ultrasound exposure

No ultrasound exposure from operating mechanical equipment was recorded during the Khmelnytskyy NPP units operation.

A single short-term localized ultrasonic exposure is possible during ultrasonic weld control.

The increase in noise background under heavy traffic will not affect insects. At the same time, ground vibration caused by heavy traffic can be considered a significant disturbance factor. Protected species will not be affected by this factor.

5.3.7 Radiation effect

The key types of the Khmelnytskyy NPP (KhNPP) radiation effects on the air are gaseous radioactive releases from the NPP ventilation system. The impact of KhNPP releases and discharges of radioactive substances over the entire operating period on the radiation situation within the KhNPP area was not detected against the global fallout, as evidenced by the environmental sample results.

The absolute dose rate value at the monitoring stations during the entire operating period does not depend on their location relative to KhNPP and is caused by the natural background and radionuclides fallout of global origin.

The dynamics of radiation background in the supervised area is caused by the release of technogenic radionuclides as a result of the Chornobyl accident, global radiation fallout and fluctuations in the radiation background. Based on the calculations, it can be concluded that the commissioning of units 5 and 6 will not lead to significant radiation situation changes both on the KhNPP industrial site and in the SPZ and SA.

Within the investigations for the construction of units 3 and 4, the experimental works on soil sampling with gamma-emitting radionuclides measuring were performed to obtain data on the territory contamination. Such studies for units 3 and 4 can also be used for the assessment of the AP1000 units 5&6 construction due to the absence of significant anthropogenic impact.

Long-term observations carried out by the KhNPP external dosimetry laboratory prove that there is no significant impact on the SPZ and SA territories.

Figure 5.4 shows the results of gamma background monitoring in the KhNPP SPZ and SA based on the ARSMS stations data.

As shown by the available measurements, the KhNPP site dose exposure values are fully consistent and do not exceed the zero background values specified in the [48].

Figure 5.4 – Gamma background monitoring in the KhNPP SPZ and SA based on the ARSMS stations data

5.3.7.1 Comparative impact analysis of the planned radioactive substances releases during the AP1000 reactors operation and actual KhNPP VVER units releases

Table 5.17 shows the measuring results of the KhNPP gas and aerosol emissions for the period of 8 years: from 2016 to 2023, as reported in [49].

Table 5.17 – Gas and aerosol emissions measuring results at KhNPP for the period of 8 years: from 2016 to 2023, (Bq/year)

	2016	2017	2018	2019	2020	2021	2022	2023
RIG	1,57E+13	1,24E+13	1,22E+13	1,37E+13	1,15E+13	1,24E+13	1,12E+13	1,05E+13
Radioiodine	1,91E+07	1,10E+07	1,07E+07	1,24E+07	1,21E+07	1,65E+07	1,60E+07	1,31E+07
^{3}H*	5,48E+11	3,19E+11	3,07E+11	3,30E+11	5,26E+11	6,35E+11	4,38E+11	2,10E+12
^{51}Cr	1,27E+06	1,16E+06	1,40E+06	1,12E+06	1,47E+06	1,28E+06	1,85E+06	1,86E+06
^{54}Mn	1,95E+05	1,57E+05	1,40E+05	2,26E+05	1,84E+05	1,66E+05	2,32E+05	2,07E+05
^{59}Fe	3,16E+05	2,96E+05	2,88E+05	2,43E+05	3,31E+05	2,92E+05	3,94E+05	3,87E+05
^{58}Co	4,78E+05	1,54E+05	1,44E+05	1,60E+05	3,04E+05	1,55E+05	2,62E+05	2,20E+05
^{60}Co	2,00E+06	1,87E+05	4,23E+05	6,10E+05	1,20E+06	1,70E+05	2,54E+05	2,35E+05
^{95}Zr	2,79E+05	2,73E+05	2,44E+05	2,07E+05	3,08E+05	2,70E+05	3,55E+05	3,65E+05
^{95}Nb	2,39E+05	4,64E+05	1,72E+05	1,95E+05	2,62E+05	1,70E+05	2,72E+05	2,68E+05
^{110m}Ag	1,51E+06	7,15E+06	2,36E+06	1,10E+06	3,98E+05	9,53E+05	4,60E+05	1,19E+06
^{134}Cs	7,67E+05	1,46E+05	1,60E+05	1,43E+05	1,81E+05	1,61E+05	2,23E+05	2,32E+05
^{137}Cs	1,66E+06	1,60E+06	5,22E+05	2,20E+05	2,19E+05	2,47E+05	4,38E+05	4,38E+05
^{89}Sr	1,20E+05	2,15E+04	8,40E+04	6,57E+04	1,96E+04	1,46E+03	1,20E+04	1,30E+04
^{90}Sr	2,66E+05	1,98E+05	2,34E+05	2,46E+05	1,22E+05	5,69E+04	8,58E+04	1,05E+05

According to the information [50], the noble gas releases from the AP1000 unit during normal operation and anticipated operational occurrences are presented in Table 5.18.

Table 5.18 – Noble gas releases during normal operation and anticipated operational occurrences

Nuclide	Activity release (Bq/year) of airborne gases (Note)					
	Waste Gas System	**Containment Building**	**Auxiliary building**	**Turbine Building**	**Condenser Air Removal System**	**Total release**
Kr-85m	4.60E+11	1.40E+11	1.60E+13	8.50E+08	7.80E+12	2.40E+13
Kr-85	3.00E+15	1.10E+13	5.20E+13	2.90E+09	2.60E+13	3.10E+15
Kr-87	negligible	4.40E+10	1.70E+13	2.60E+08	2.20E+12	1.90E+13
Kr-88	6.70E+09	1.00E+11	1.80E+13	9.60E+08	8.50E+12	2.70E+13
Xe-131m	1.10E+15	3.10E+13	1.80E+14	9.30E+09	8.10E+13	1.40E+15
Xe-133m	3.60E+10	6.70E+12	7.40E+13	4.10E+09	3.50E+13	1.10E+14
Xe-133	2.40E+14	8.90E+13	6.30E+14	3.30E+10	2.90E+14	1.30E+15
Xe-135m	negligible	6.70E+10	1.30E+14	7.00E+09	5.90E+13	1.90E+14
Xe-135	negligible	3.10E+12	1.70E+14	2.90E+10	2.60E+14	4.40E+14
Xe-137	negligible	negligible	3.40E+13	1.80E+09	1.60E+13	4.80E+13
Xe-138	negligible	2.90E+10	5.90E+13	3.30E+09	2.90E+13	8.90E+13
Total noble gas						**6.70E+12**

Note: Values less than 3.7E-5 GBq/year are considered to be negligible.

Comparing the values of the total anticipated release of the AP1000 unit with the actual RIG release of the KhNPP units, it can be seen that the anticipated value of the AP1000 unit RIG release is significantly lower.

The anticipated gas and aerosol radionuclide release values for the AP1000 units are given in Table 5.19.

Table 5.19 – Gas and aerosol releases of the AP1000 plant during normal operation and anticipated operational occurrences

Nuclide	Release (Bq/year) of airborne gases (Note)				
	Waste Gas System	**Containment Building**	**Auxiliary building**	**Fuel Handling Area**	**Total release**
Cr-51	negligible	negligible	1.20E+05	6.70E+04	2.30E+05
Mn-54	negligible	negligible	negligible	1.10E+05	1.60E+05
Co-57	negligible	negligible	negligible	negligible	negligible
Co-58	negligible	9.30E+04	7.00E+05	7.80E+06	8.50E+06
Co-60	negligible	negligible	1.90E+05	3.00E+06	3.20E+06
Fe-59	negligible	negligible	negligible	negligible	negligible
Sr-89	negligible	4.80E+04	2.80E+05	7.80E+05	1.10E+06
Sr-90	negligible	negligible	1.10E+05	3.00E+05	4.40E+05

Nuclide	Release (Bq/year) of airborne gases (Note)				
	Waste Gas System	Containment Building	Auxiliary building	Fuel Handling Area	Total release
Zr-95	negligible	negligible	3.70E+05	negligible	3.70E+05
Nb-95	negligible	negligible	negligible	8.90E+05	9.30E+05
Ru-103	negligible	negligible	negligible	negligible	negligible
Ru-106	negligible	negligible	negligible	negligible	negligible
Sb-125	negligible	negligible	negligible	negligible	negligible
Cs-134	negligible	negligible	2.00E+05	6.30E+05	8.50E+05
Cs-136	negligible	negligible	negligible	negligible	negligible
Cs-137	negligible	negligible	2.70E+05	1.00E+06	1.30E+06
Ba-140	negligible	negligible	1.50E+05	negligible	1.60E+05
Ce-141	negligible	negligible	negligible	negligible	negligible
Total radionuclide release					**1.70E+07**

Note: Values less than 3.7E-5 GBq/year are considered to be negligible.

In addition, to detail the information on the site radiation state where the AP1000 units are planned to be located, Tables 5.20 – 5.22 below show the measuring data of the ARSMS station and the KhNPP laboratory measurements. The monitoring station (contamination monitoring station-4) is located in the immediate vicinity of the planned AP1000 units location. The sampling frequency is defined in [51]. It should be noted that the radionuclide activity value, which is at the limit of the lower measurement range, is given in terms of I½ minimum measured activity.

Table 5.20 – Radioactive airborne substances at the contamination monitoring station-4 for 8 years, microBq/m^3

Sampling period	Cs-137	Cs-134	Co-60	I-131	Ag-110 m	Sr-90
3 qtr. 2016	1.56E+00	1.95E-02*	2.50E-02*	2.50E-02*	-	1.70E-01
4 qtr. 2016	6.13E-01	1.21E-02*	1.57E-02*	3.06E-02*	-	4.70E-01
1 qtr. 2017	1.24E+00	1.31E-02*	1.88E-02*	3.22E-02*	-	2.20E-01
2 qtr. 2017	8.03E-01	1.30E-02*	1.53E-02*	3.72E-02*	-	6.70E-01
3 qtr. 2017	3.01E+00	7.42E-03*	7.42E-03*	1.64E-02*	-	2.45E-01
4 qtr. 2017	2.03E+00	1.26E-02*	1.39E-02*	1.92E-02*	-	3.19E-01
1 qtr. 2018	1.46E+00	3.79E-03*	5.30E-03*	9.46E-03*	-	1.76E-01
2 qtr. 2018	4.17E+00	3.06E-02*	3.35E-02*	7.72E-02*	-	3.44E-01
3 qtr. 2018	7.69E-01	1.38E-02*	1.81E-02*	4.23E-02*	-	5.15E-01
4 qtr. 2018	1.18E-00	6.26E-03*	1.02E-02*	1.22E-02*	-	4.09E-01
1 qtr. 2019	7.16E-01	6.41E-03*	8.01E-03*	1.47E-02*	-	1.49E-01
2 qtr. 2019	6.38E-01	2.41E-02*	4.36E-02*	5.28E-02*	-	1.58E-01
3 qtr. 2019	3.82E-01	1.36E-02*	1.58E-02*	2.98E-02*	-	3.85E-01
4 qtr. 2019	3.48E-01	8.54E-03*	9.49E-03*	2.15E-02*	-	3.62E-01
1 qtr. 2020	3.87E-01	5.17E-03*	5.72E-03*	1.25E-02*	-	3.12E-02
2 qtr. 2020	1.63E+00	1.27E-02*	1.40E-02*	2.73E-02*	-	9.16E-02
3 qtr. 2020	3.13E-01	8.20E-03*	9.76E-03*	2.16E-02*	-	2.34E-02
4 qtr. 2020	3.49E-01	2.15E-02*	3.19E-02*	4.41E-02*	-	4.89E-02
1 qtr. 2021	6.40E-01	2.01E-02*	2.99E-02*	4.50E-02*	2.18E-02*	5.57E-02

Sampling period	Cs-137	Cs-134	Co-60	I-131	Ag-110 m	Sr-90
2 qtr. 2021	2.03E+00	2.87E-02*	4.17E-02*	8.25E-02*	3.17E-02*	4.93E-02
3 qtr. 2021	3.46E-01	1.30E-02*	6.06E-02*	4.06E-02*	2.84E-02*	5.36E-02
4 qtr. 2021	6.12E-01	4.10E-02*	2.42E-01*	7.51E-02*	5.53E-02*	7.12E-02
1 qtr. 2022	7.23E-01	3.43E-02*	4.02E-02*	7.06E-02*	4.37E-02*	7.55E-02
2 qtr. 2022	6.82E-01	4.86E-02*	5.48E-02*	1.14E-01*	5.98E-02*	1.26E-01
3 qtr. 2022	8.28E-01	1.08E-02*	1.08E-02*	2.59E-02*	9.81E-03*	5.61E-02
4 qtr. 2022	6.19E-01	1.45E-02*	1.83E-02*	3.54E-02*	1.32E-01*	1.40E-01
1 qtr. 2023	6.26E-01	8.52E-03*	1.03E-02*	2.37E-02*	9.43E-03*	8.06E-02
2 qtr. 2023	1.67E+00	7.25E-03*	7.57E-03*	2.33E-02*	7.88E-03*	1.38E-01
3 qtr. 2023	7.51E-01	8.01E-02*	7.92E-02*	1.64E-01*	3.31E-01	4.51E-02
4 qtr. 2023	4.30E-01	2.02E-02*	6.06E-02*	3.82E-02*	1.05E-01	9.95E-02

Note: Values corresponding to ½ minimum measured activity are marked.

Table 5.21 – The absorbed gamma radiation dose values (mSv) for 2016 – 2023

Monitoring station				
Monitoring station	**2016 1 qtr.**	**2016 2 qtr.**	**2016 3 qtr.**	**2016 4 qtr.**
Site-4	0.21	0.19	0.19	0.16
	2017 1 qtr.	**2017 2 qtr.**	**2017 3 qtr.**	**2017 4 qtr.**
	0.18	0.21	0.20	0.21
	2018 1 qtr.	**2018 2 qtr.**	**2018 3 qtr.**	**2018 4 qtr.**
	0.18	0.19	0.21	0.23
	2019 1 qtr.	**2019 2 qtr.**	**2019 3 qtr.**	**2019 4 qtr.**
	0.23	0.23	0.24	0.19
	2020 1 qtr.	**2020 2 qtr.**	**2020 3 qtr.**	**2020 4 qtr.**
	0.22	0.24	0.22	0.26
	2021 1 qtr.	**2021 2 qtr.**	**2021 3 qtr.**	**2021 4 qtr.**
	0.21	0.23	0.22	0.25
	2022 1 qtr.	**2022 2 qtr.**	**2022 3 qtr.**	**2022 4 qtr.**
	0.25	0.24	0.23	0.23
	2023 1 qtr.	**2023 2 qtr.**	**2023 3 qtr.**	**2023 4 qtr.**
	0.22	0.23	0.24	0.23

Table 5.22 – Exposure dose rate (EDR) at the contamination monitoring station-4 (CMS-4) for 8 years, μSv/h

Year	Month	Minimum EDR on CMS-4, μSv/h	Maximum EDR on CMS-4, μSv/h	Average EDR on CMS-4, μSv/h
2016	1	0,09	0,13	0,1
2016	2	0,09	0,13	0,11
2016	3	0,09	0,14	0,11
2016	4	0,09	0,14	0,11
2016	5	0,09	0,15	0,11
2016	6	0,09	0,14	0,11
2016	7	0,09	0,15	0,11
2016	8	0,09	0,14	0,11
2016	9	0,09	0,13	0,11
2016	10	0,09	0,15	0,11

Year	Month	Minimum EDR on CMS-4, µSv/h	Maximum EDR on CMS-4, µSv/h	Average EDR on CMS-4, µSv/h
2016	11	0,08	0,14	0,1
2016	12	0,09	0,13	0,1
2017	1	0,09	0,12	0,1
2017	2	0,08	0,12	0,1
2017	3	0,09	0,12	0,11
2017	4	0,09	0,13	0,11
2017	5	0,09	0,14	0,11
2017	6	0,09	0,16	0,11
2017	7	0,09	0,13	0,11
2017	8	0,09	0,13	0,11
2017	9	0,09	0,17	0,11
2017	10	0,09	0,16	0,11
2017	11	0,09	0,13	0,11
2017	12	0,09	0,13	0,11
2018	1	0,09	0,14	0,11
2018	2	0,09	0,13	0,1
2018	3	0,09	0,13	0,1
2018	4	0,09	0,13	0,11
2018	5	0,09	0,14	0,11
2018	6	0,1	0,16	0,11
2018	7	0,09	0,16	0,11
2018	8	0,09	0,18	0,11
2018	9	0,09	0,13	0,11
2018	10	0,09	0,18	0,11
2018	11	0,09	0,14	0,11
2018	12	0,09	0,13	0,11
2019	1	0,09	0,12	0,1
2019	2	0,09	0,12	0,1
2019	3	0,09	0,13	0,11
2019	4	0,09	0,15	0,11
2019	5	0,09	0,14	0,11
2019	6	0,09	0,15	0,11
2019	7	0,1	0,13	0,11
2019	8	0,09	0,15	0,11
2019	9	0,09	0,18	0,11
2019	10	0,09	0,13	0,11
2019	11	0,1	0,13	0,11
2019	12	0,09	0,13	0,11
2020	1	0,09	0,16	0,11
2020	2	0,09	0,13	0,11
2020	3	0,09	0,12	0,1
2020	4	0,09	0,14	0,11
2020	5	0,09	0,13	0,11
2020	6	0,09	0,15	0,11
2020	7	0,09	0,15	0,1
2020	8	0,09	0,14	0,11
2020	9	0,09	0,16	0,11

Year	Month	Minimum EDR on CMS-4, µSv/h	Maximum EDR on CMS-4, µSv/h	Average EDR on CMS-4, µSv/h
2020	10	0,09	0,18	0,11
2020	11	0,09	0,14	0,1
2020	12	0,09	0,15	0,11
2021	1	0,09	0,13	0,11
2021	2	0,08	0,12	0,1
2021	3	0,09	0,12	0,1
2021	4	0,09	0,12	0,11
2021	5	0,1	0,13	0,11
2021	6	0,09	0,13	0,11
2021	7	0,09	0,17	0,11
2021	8	0,09	0,14	0,11
2021	9	0,09	0,18	0,11
2021	10	0,09	0,12	0,1
2021	11	0,09	0,15	0,11
2021	12	0,09	0,15	0,11
2022	1	0,09	0,13	0,1
2022	2	0,09	0,12	0,1
2022	3	0,09	0,13	0,11
2022	4	0,1	0,14	0,11
2022	5	0,09	0,13	0,11
2022	6	0,09	0,14	0,11
2022	7	0,09	0,14	0,11
2022	8	0,09	0,16	0,11
2022	9	0,09	0,16	0,11
2022	10	0,09	0,12	0,11
2022	11	0,09	0,13	0,11
2022	12	0,09	0,15	0,11
2023	1	0,09	0,13	0,11
2023	2	0,09	0,13	0,1
2023	3	0,05	0,17	0,08
2023	4	0,05	0,15	0,08
2023	5	0,05	0,12	0,08
2023	6	0,05	0,15	0,08
2023	7	0,05	0,14	0,08
2023	8	0,04	0,19	0,08
2023	9	0,05	0,11	0,08
2023	10	0,04	0,17	0,08
2023	11	0,05	0,13	0,08
2023	12	0,05	0,14	0,07

Thus, following the analysis of the statistical release data for the KhNPP existing units with the anticipated data for the AP1000 units operation, it can be concluded that no significant environmental impact related to emissions during the construction and further operation of units using the AP1000 technology is expected.

In addition, the information provided allows using the input data on the radiation impact assessment performed for KhNPP units 3 and 4, which are also pressurized water units.

5.3.7.2 Anticipated radiation effect on land resources

To obtain data on radioactive contamination of the area under study during the units 3 and 4 completion, the experimental works on soil sampling with gamma-emitting radionuclides measuring were performed. In view of the absence of significant anthropogenic impact, as evidenced by long-term observations and measurements throughout the KhNPP operation, the data of such studies can also be used for the impact assessment during the completion and further operation of units 5 and 6 using the AP1000 technology.

Soil sampling was performed to determine the contamination density in the KhNPP area according to a standard methodology using a drive sampler (sampling depth was 20 cm). About 100 soil samples were analyzed in the process.

The results on ^{137}Cs in the soil within the KhNPP 30-km area are shown in Figure 5.5.

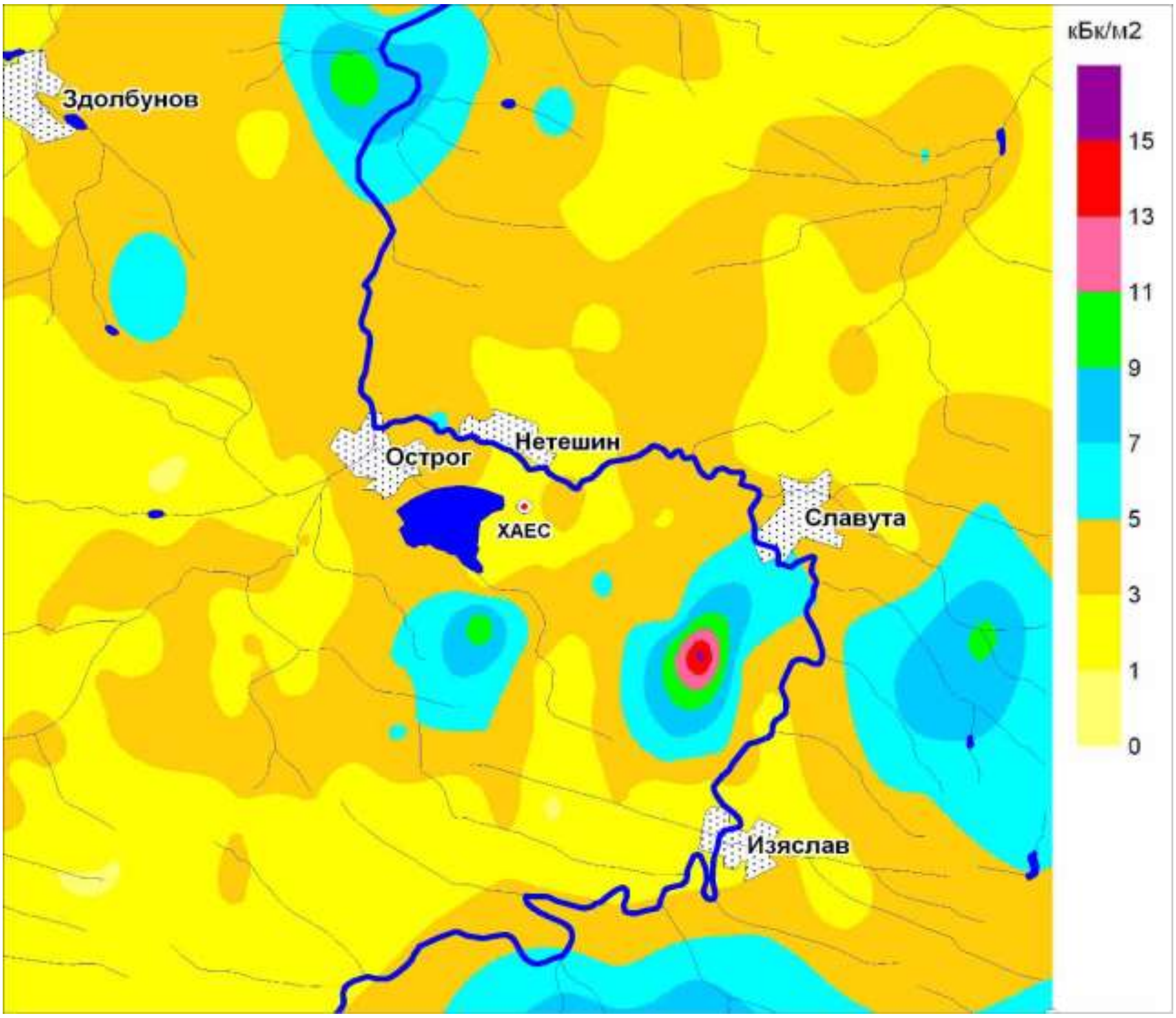


Figure 5.5 – Density of ^{137}Cs contamination in the KhNPP proximity

This radionuclide is of technogenic origin. The contamination shown on the map consists of a superposition of global fallout, fallout from the Chornobyl accident, and fallout caused by aerosol emissions from KhNPP units 1 and 2. The last contamination source is so negligible that its separation from the total contamination is impossible. No other technogenic radionuclides were detected. This confirms the NPP operation in normal mode.

On that basis, it can be stated that the territory under study was contaminated with ^{137}Cs as a result of the Chornobyl accident with the activity from 2 to 10 kBq/m^2. The total contamination is mainly represented by density in the range from 1 to 5 kBq/m^2. A small spot near the village of Khorovytsia is obviously of Chornobyl origin.

With that level of ^{137}Cs contamination, there are no restrictions on agriculture.

The results for ^{40}K in the soil are shown in Figure 5.6.

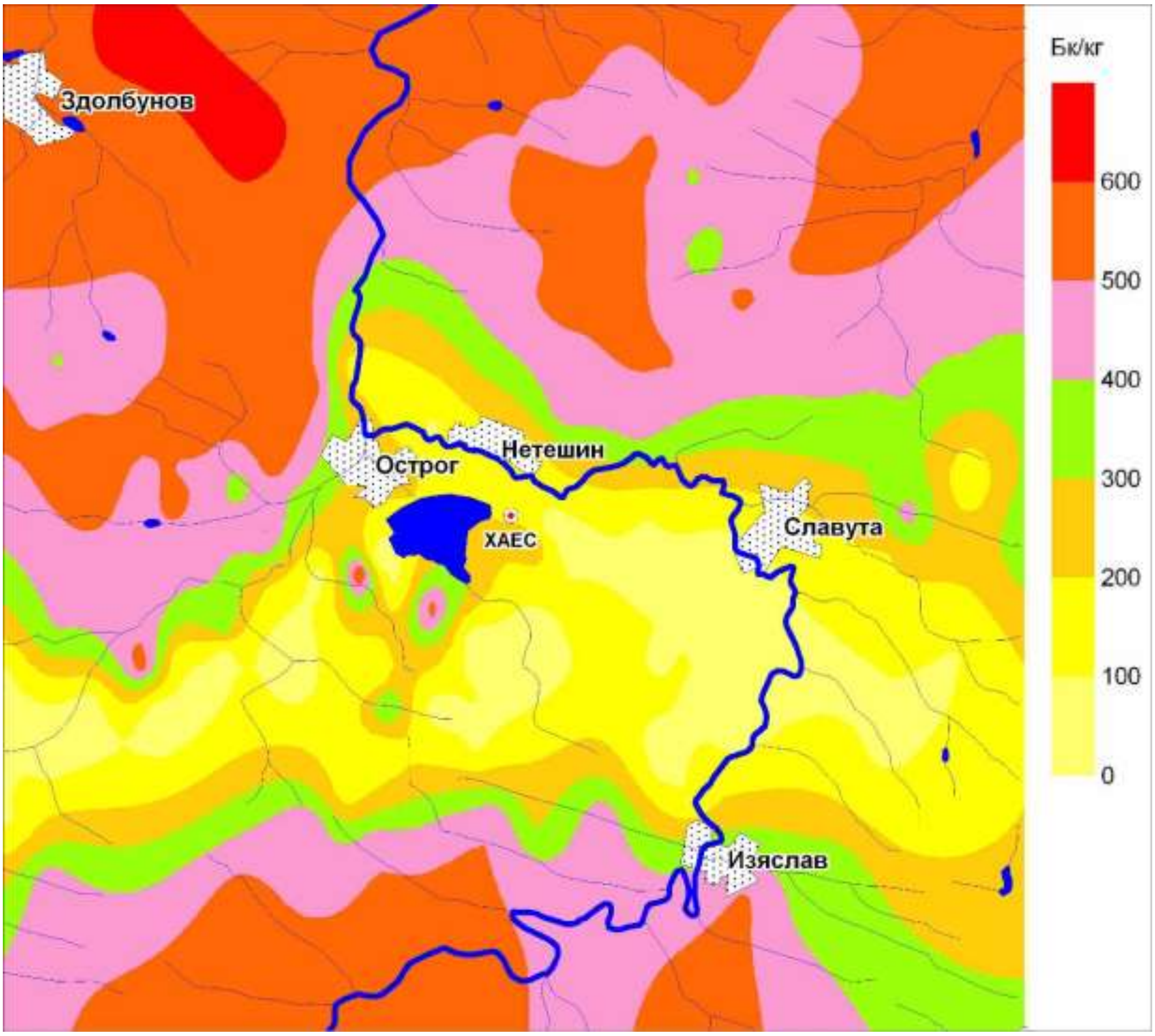


Figure 5.6 – Specific activity of ^{40}K in the soils in the KhNPP proximity (sampling depth – 0.2 m)

This radionuclide is of natural origin and is one of the main natural radionuclides in soils, plants and agricultural production facilities. Potassium radioactivity in soils is primarily determined by its content in the parent rock. The highest concentration is observed in the soil finely dispersed clay fraction. The results showed that the specific activity of the radionuclide in the soils within the studied area ranges from 40 to 700 Bq/kg. The minimum values are typical for light mechanical composition soils (sod-podzolic sandy, sandy loam). The ^{40}K increases with the burden of mechanical composition.

The results for ^{232}Th and its decay products are shown in Figure 5.7. The specific activity of that radionuclide for the territory under consideration varies from 5 to 50 Bq/kg. The wide range of changes in specific activity is explained by the great diversity of soil cover within the investigated area.

Similar to ^{40}K, ^{232}Th in soil is determined by the parent rock, and increases with the burden of soil mechanical composition.

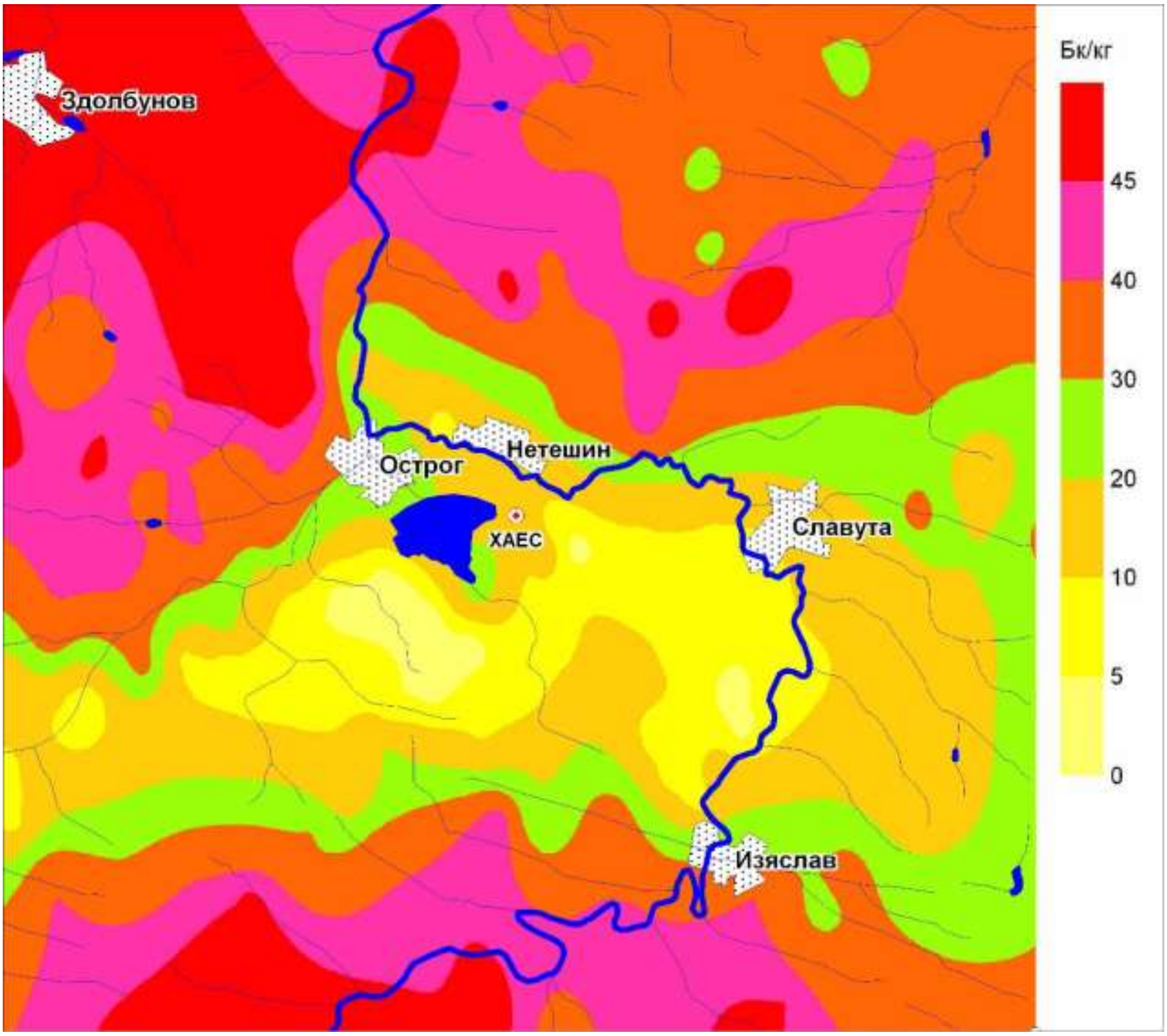


Figure 5.7 – Specific activity of ^{232}Th in soils within the KhNPP proximity (sampling depth – 0.2 m)

Figure 5.8 shows the content of ^{226}Ra, which is a derivative of ^{238}U, in the soils of the area under study. This nuclide and its derivative radionuclides (primarily ^{222}Rn) are of important radiological importance. The main source of this radionuclide in the biosphere is the earth's crust. Clarke number in soils is about 30 Bq/kg. The content of that radionuclide in the topsoil in the KhNPP adjacent territory varies from 3 to 40 Bq/kg. Therefore, the radiological situation in the KhNPP area is currently determined mainly by radionuclides of natural origin.

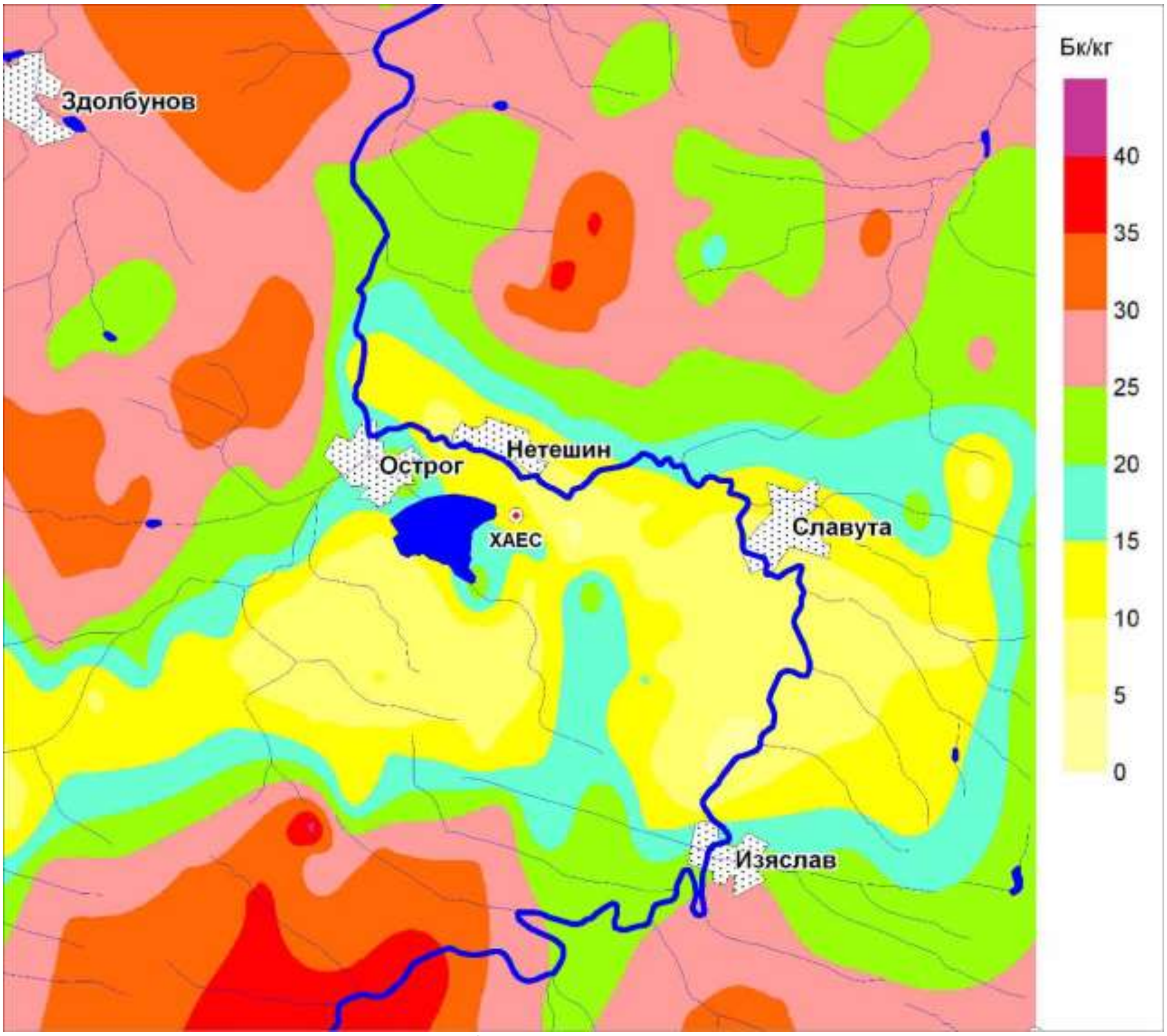


Figure 5.8 – Specific activity of ^{226}Ra in soils within the KhNPP near area (sampling depth – 0.2 m)

As a result of the mechanical impact associated with any construction, the soil cover in the allocated area is almost fully destroyed. However, the area of mechanical impact during the KhNPP construction is clearly delineated by the agreed allocated boundaries.

An important factor affecting the soils is a technogenic contamination of the soil cover with chemical pollutants, including radionuclides. However, being a complex, open and dynamic system, soils have a certain resistance to technogenic load – buffering capacity. Buffering capacity depends on physical and chemical properties of soils, their mechanical composition, conditions of economic use, etc.

The following can be noted based on the abovementioned factors:

– due to the diversity of mechanical composition (from sandy to heavy loam), various degrees of removability, gleying and waterlogging, and a variety of soil-forming rocks, the soil cover of the 30-km area is diverse both in terms of types and area. Gray forest and sod-podzolic soils cover the largest areas in almost all sectors.

– automorphic soils cover the largest areas in the northeastern and northwestern sectors, hydromorphic and semi-hydromorphic soils are found throughout the area, but they cover the largest areas in the eastern (semi-hydromorphic), southeastern (semi-hydromorphic and hydromorphic), and southwestern (hydromorphic) sectors.

– marsh and meadow-marsh (hydromorphic) soils (approx. 10% of the territory) are critical in terms of the cesium isotopes migration mobility. As for the automorphic soils, the most critical for some radionuclides (e.g., 90Sr) are sod-podzolic sandy soils with the lowest porosity, moisture capacity and maximum hygroscopicity (approx. 20% of the territory).

– considering negligible additional environmental radionuclide contamination during normal plant operation (maximum values for Cs^{137} - n 10^{-1} Bq/m^2), special agrotechnical measures with changes in the agricultural land use structure, re-profiling of agricultural sectors and changes in technological processing of products are not appropriate.

– the surface relief of the area close to the plant and the orographic barriers are included when considering transboundary radionuclide transfer in case of accidents.

– under MDBA and BDBA, the impact will be regional, but neither the physical, chemical nor the water-physical soil properties will change; only the content of chemical elements will change.

– in general, the analysis of physical and chemical properties of the region's soils showed that, despite the significant soil cover diversity, most soils have a significant buffer resistance reserve to technogenic loads. The KhNPP construction and operation with 6 units will not lead to the exhaustion of this reserve. The landscapes of the area close to the plant are a reliable barrier to the expansion of the primary contamination area through migration.

The results of long-term observations over radionuclide in the KhNPP supervised area confirm the soil buffering and the absence of significant radiation effects on the soils.

Table 5.23 below shows the data on soil contamination in the KhNPP supervised area for 2023.

Table 5.23 – Soil contamination in the KhNPP supervised area for 2023, kBq/m^2

Radionuclide	SPA		SPA - 10 km		10 - 20 km		>20 km	
	Average value	Maximum value	Average value	Maximum value	Average value	Maximum value	Average value	Maximum value
Cs-137	6,92E-02	1,11E-01	7,20E-02	2,64E-01	8,27E-02	1,69E-01	1,60E-01	-
Cs-134	2,63E-03*	-	4,92E-03*	-	3,04E-03*	-	5,60E-03*	-
Co-60	2,67E-03*	-	3,11E-03*	-	3,22E-03*	-	5,62E-03*	-
I-131	3,09E-03*	-	5,56E-03*	-	3,41E-03*	-	6,47E-03*	-
Sr-90	2,36E-01	-	3,35E-01	3,44E-01	2,94E-01	3,02E-01	1,65E-01	-

Note*: values corresponding to ½ minimum measured activity are marked.

According to the procedure [51] soil contamination is determined once a year.

In 2023, as well as for the entire monitoring period, no cases of exceeding the levels of radioactive substances in environmental objects established by regulatory documents were registered. The volumetric activity of the technogenic cesium-137 isotope in the air did not exceed 4.35 μBq/m^3, which is approx. 180 thousand times lower than the permissible value of cesium-137 in the air for the population established by the regulations [22] – 0.8 Bq/m^3. The volumetric activity of technogenic cesium-137 isotope in water did not exceed 25.3 Bq/m^3, which is almost 4 thousand times lower than the permissible value of cesium-137 in drinking water for the population established by the regulations [22] – 100 000 Bq/m^3. Soil contamination with cesium-137 in the KhNPP area did not exceed 264 Bq/m^2.

5.3.7.3 Impact on flora and fauna

The operation of two additional AP1000 units, including the completion of units 3 and 4, will not affect the structure and dynamics of plant species in general, and will not cause changes in the number of rare and Red Book plant species. The radiation situation within the KhNPP area is currently determined mainly by radionuclides of natural origin. The density of ^{137}Cs contamination of the territory varies in the range of 3-7 kBq/m2. At this level of ^{137}Cs contamination, the flora does not feel any impact and there are no restrictions on nature management.

In the considered emergency situations, the dosed loads on the flora outside the SPA will not lead to changes in its structure and other negative changes. The commissioning of units 5 and 6 and accident-free KhNPP operation as a six-unit plant (including planned units 3 and 4) will not adversely affect the overall species diversity of invertebrates and insects.

5.3.7.4 Technogenic environment

After the commissioning of units 5 and 6, no new technological processes with air emissions of any pollutants other than the existing ones will be introduced at the NPP, i.e. there is no negative impact on the SA facilities.

5.3.7.5 Water bodies impact assessment

No industrial, rain and domestic wastewater from the NPP and domestic effluents from Netishyn are discharged directly into public water bodies. The treated wastewater is discharged into the cooling pond, which is a water body for NPP production use, and thus compensates for water losses in the cooling pond. Given that cooling towers are envisaged for AP1000 reactors, the amount and quality of pollutants entering the cooling pond will be minimal. Moreover, it is envisaged that the parameters of their composition and condition are continuously monitored throughout the entire process media management.

The treated wastewater from the NPP industrial site and Netishyn is not discharged directly into surface water bodies and thus does not have a direct impact on their contamination degree.

When discharging to external water bodies, the radioactive discharge is calculated using the following formula:

$$K_{PHB} = \sum_{i}^{n} \frac{q_i}{Q_{iMC}} \times 100\%$$

where q_i is the actual total intake of the i-radionuclide into external water bodies at the end of the reported quarter since the beginning of the year, Bq, which, in turn, is calculated by the following formula:

$$q_i = \frac{4}{k} \sum_{j=1}^{k} c_i^j$$

Where k is the quarter number in which the monitoring is performed (1, 2, 3, 4); c^j_i is the actual discharge of the i- radionuclide for the j- quarter; Q_{iMS} is a discharge limit (permissible discharge) of the i- radionuclide into external water bodies per year, Bq/year.

To assess and compare the discharges from the existing KhNPP units [49] with the planned discharges according to [50], the data on radioactive discharges to the environment (external water bodies) by KhNPP for 2016-2023 (Table 5.24) and expected AP1000 units discharges (Table 5.25) are presented below.

Table 5.24 – Radioactive discharges into the environment (external water bodies) by the KhNPP units for 2016-2023 (values greater than minimum measured activity were used for calculations)

Period, year	**Radioactive discharges – radionuclide activity, MBq**								**Discharge rate, %**
	^{137}Cs	**^{134}Cs**	**^{60}Co**	**^{58}Co**	**^{54}Mn**	**^{90}Sr**	**^{110m}Ag**	**^{3}H**	
2016	11,01	3,85	-	-	-	2,54	-	2292245	0,16
2017	24,70	15,19	-	-	-	1,27	-	1368952	0,16
2018	11,81	4,27	-	-	-	1,91	-	1979921	0,146
2019	23,70	4,24	-	-	-	1,45	-	2820000	0,214
2020	9,12	1,47	-	-	-	0,72	-	1920000	0,125
2021	8,41	0,87	-	-	-	0,64	0,07	2260000	0,139
2022	6,32	1,33	0,275	-	-	0,68	-	1850000	0,143
2023	7,65	1,21	-	-	-	0,56	-	1040000	0,102

Table 5.25 – Liquid discharge during normal AP1000 plant operation and anticipated operational occurrences

Nuclide	Activity release (MBq/year) to discharge canal (Note)			
	Shim bleed and equip. drains	**Miscellaneous waste**	**Turbine building**	**Total release**
C-14	7.00E-02	negligible	negligible	7.00E-02
Na-24	3.50E+01	2.30E-01	2.80E+00	3.80E+01
Cl-36	negligible	negligible	negligible	negligible
Cr-51	4.50E+01	1.30E-01	2.80E-01	4.60E+01
Mn-54	3.20E+01	7.20E-02	1.40E-01	3.20E+01
Fe-55	4.80E+02	1.10E+00	2.10E+00	4.90E+02
Fe-59	4.90E+00	negligible	negligible	5.00E+00
Co-58	4.10E+02	1.00E+00	2.00E+00	4.10E+02
Co-60	2.20E+02	5.00E-01	9.40E-01	2.30E+02
Ni-63	5.30E+02	1.20E+00	2.10E+00	5.40E+02
Zn-65	1.00E+01	negligible	4.50E-02	1.00E+01
Nb-94	negligible	negligible	negligible	negligible
W-187	2.80E+00	negligible	1.70E-01	3.00E+00
U-234	negligible	negligible	negligible	negligible
U-235	negligible	negligible	negligible	negligible
U-238	negligible	negligible	negligible	negligible
Np-237	negligible	negligible	negligible	negligible
Pu-238	negligible	negligible	negligible	negligible
Pu-239	negligible	negligible	negligible	negligible
Pu-240	negligible	negligible	negligible	negligible
Pu-241	8.00E-02	negligible	negligible	8.00E-02
Pu-242	negligible	negligible	negligible	negligible
Am-241	negligible	negligible	negligible	negligible
Am-243	negligible	negligible	negligible	negligible
Cm-242	negligible	negligible	negligible	negligible
Cm-244	negligible	negligible	negligible	negligible
As-76	negligible	negligible	negligible	negligible
Br-82	negligible	negligible	negligible	negligible
Rb-86	negligible	negligible	negligible	negligible
Rb-88	3.90E-01	negligible	negligible	3.90E-01
Sr-89	2.40E+00	negligible	negligible	2.40E+00
Sr-90	2.50E-01	negligible	negligible	2.50E-01
Y-91	9.00E-02	negligible	negligible	9.10E-02
Zr-95	6.80E+00	negligible	negligible	6.90E+00
Nb-95	6.10E+00	negligible	negligible	6.10E+00
Mo-99	1.90E+01	1.10E-01	5.30E-01	1.90E+01
Tc-99m	1.80E+01	1.10E-01	3.80E-01	1.80E+01
Tc-99	negligible	negligible	negligible	negligible
Ru-103	1.20E+02	3.10E-01	6.60E-01	1.20E+02
Ru-106	negligible	negligible	negligible	negligible
Ag-110m	2.60E+01	5.80E-02	1.10E-01	2.60E+01

Nuclide	Activity release (MBq/year) to discharge canal (Note)			
	Shim bleed and equip. drains	Miscellaneous waste	Turbine building	Total release
Sn-117m	negligible	negligible	negligible	negligible
Sb-122	negligible	negligible	negligible	negligible
Sb-124	negligible	negligible	negligible	negligible
Sb-125	negligible	negligible	negligible	negligible
I-129	negligible	negligible	negligible	negligible
I-131	1.50E+01	6.30E-02	2.50E-01	1.50E+01
I-132	1.90E+01	9.10E-02	8.50E-01	2.00E+01
I-133	2.60E+01	1.70E-01	2.70E+00	2.90E+01
I-134	5.80E+00	3.90E-02	negligible	5.90E+00
Cs-134	7.50E+00	negligible	negligible	7.60E+00
I-135	2.00E+01	1.30E-01	3.20E+00	2.40E+01
Cs-136	9.20E+00	negligible	8.50E-02	9.30E+00
Cs-137	2.30E+01	5.00E-02	1.10E-01	2.30E+01
Ba-140	1.30E+01	4.60E-02	1.10E-01	1.40E+01
La-140	1.80E+01	6.60E-02	2.00E-01	1.80E+01
Ce-144	7.90E+01	1.80E-01	3.40E-01	8.00E+01
Pr-144	7.90E+01	1.80E-01	3.40E-01	8.00E+01
All others	negligible	negligible	negligible	negligible
Total	**2.40E+03**	**6.30E+00**	**2.10E+01**	**2.50E+03**

Note: values less than 3.7E-5 GBq/year are considered to be negligible.

Comparing the planned AP1000 units releases with the actual KhNPP two units releases, it can be concluded that the impact on water bodies during AP1000 plant operation will be at the level of existing area background values and will not lead to an increase in the radiation background and will not exceed the control levels.

5.3.8 Transboundary transfer

Mathematical modeling of dispersion of gas and aerosol radioactive releases performs assessment of transboundary transfer of radioactive emissions in case of a radiation accident at Khmelnytskyy NPP during normal operation of the plant and emergencies, dose loads assessment on the population using the spatial contamination field.

Radioactive transfer modeling was performed using JRODOS (JRodosServerFebruary2019 version). Diffusion model – DIPCOT.

The meteorological conditions of emissions propagation in the atmosphere play a key role in the field formation of the air radioactive contamination and the underlying surface. Since for this problem the period for the release from Khmelnytskyy NPP to reach the borders, for example, with Poland, is about half a day, the temporal dynamics of meteorological parameters due to both the daily variation of the boundary layer characteristics and weather changes on a synoptic scale plays an important role for such periods. Therefore, the most reasonable approach to selecting meteorological scenarios for radioactive release propagation in the atmosphere is not to construct artificial “ultra-conservative” scenarios but to use real data of atmospheric characteristics measurements.

A conservative meteorological forecast based on the results of long-term observations of the meteorological post of the KhNPP branch was used to assess the effects of transboundary transfer:

– wind direction corresponds to the shortest distance to the neighboring countries Poland, Slovakia, Romania, Hungary, and Moldova during the entire emission period;
– wind speed of 1, 2, 3, 5, 10 m/s during the entire emission period (since, based on long-term metrological observations, the average daily wind speed near KhNPP is in the range of 0.8-5 m/s with wind gusts up to 20 m/s);
– atmospheric stability category D.

The height of the reactor vessel pipe of the AP1000 unit, which is planned to be constructed using Westinghouse technology, is approximately 72.500 m from 0.000.

For the calculation, the total emission value corresponding to the maximum design basis accident according to the document [52] and shown in Table 5.26 was taken.

Table 5.26 – Expected total radionuclide composition emission to the environment under the maximum design basis accident (Bq)

Nuclide	0-2 hours	2-8 hours	8-24 hours	24-96 hours	96-720 hour
Xe-133	2.17E+14	1.173E+15	4.33E+15	7.69E+15	1.52E+16
Xe-133m	1.19E+12	9.41E+12	2.44E+13	4.94E+13	2.01E+14
Cs-137	3.03E+12	8.13E+12	5.07E+11	2.59E+09	2.40E+10
I-131	3.34E+13	9.27E+13	9.50E+12	6.24E+12	1.87E+13
Te-131m	7.48E+11	2.32E+12	1.26E+11	2.22E+08	7.40E+07
SR-90	1.37E+11	4.51E+11	2.82E+10	1.48E+08	1.33E+09
Ru-103	2.96E+11	9.71E+11	6.03E+10	2.96E+08	2.15E+09
La-140	2.84E+10	8.94E+10	5.03E+09	1.48E+07	3.70E+06
Ce-141	6.54E+10	2.14E+11	1.33E+10	7.03E+07	4.48E+08
Ba-140	2.76E+12	9.01E+12	5.54E+11	2.96E+09	1.15E+10

Distribution of iodine isotopes by fractions according to the document [52]:

– aerosol form – 95%;
– molecular form – 4,85%;
– organic form – 0,15%.

Google Maps determined the minimum distances to neighboring countries (Figure 5.9). The distance from Khmelnytskyy NPP to the border of neighboring states is shown in Table 5.27.

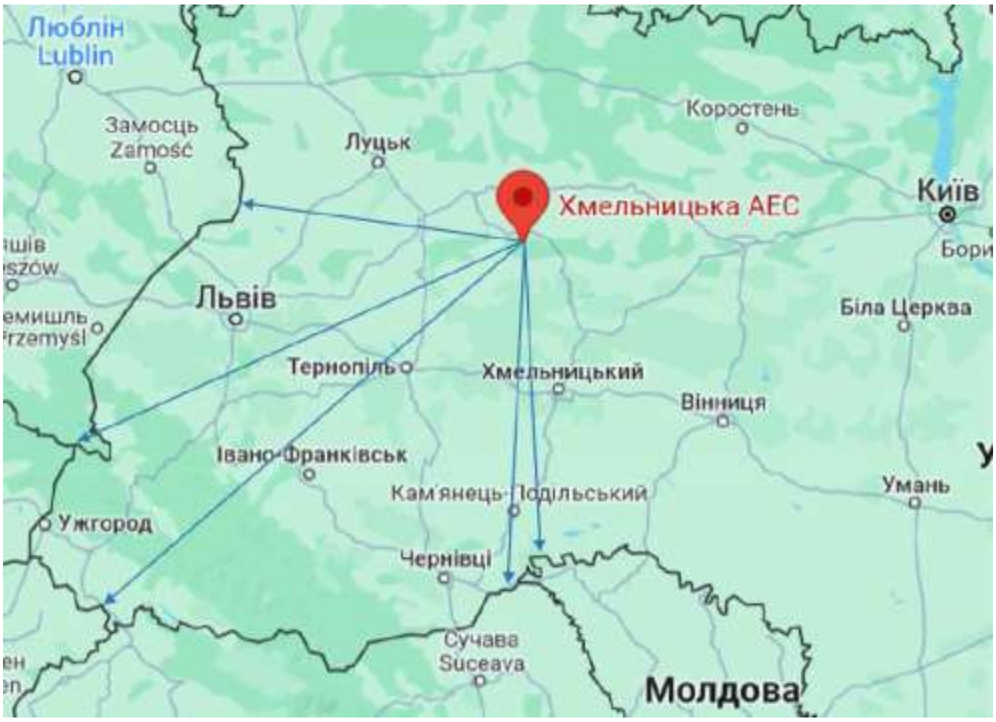


Figure 5.9 – Minimum distances from Khmelnytskyy NPP to the borders of neighboring countries

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Figures 5.10-5.14 show the effective radiation dose distribution map for the neighboring states listed in Table 5.27.

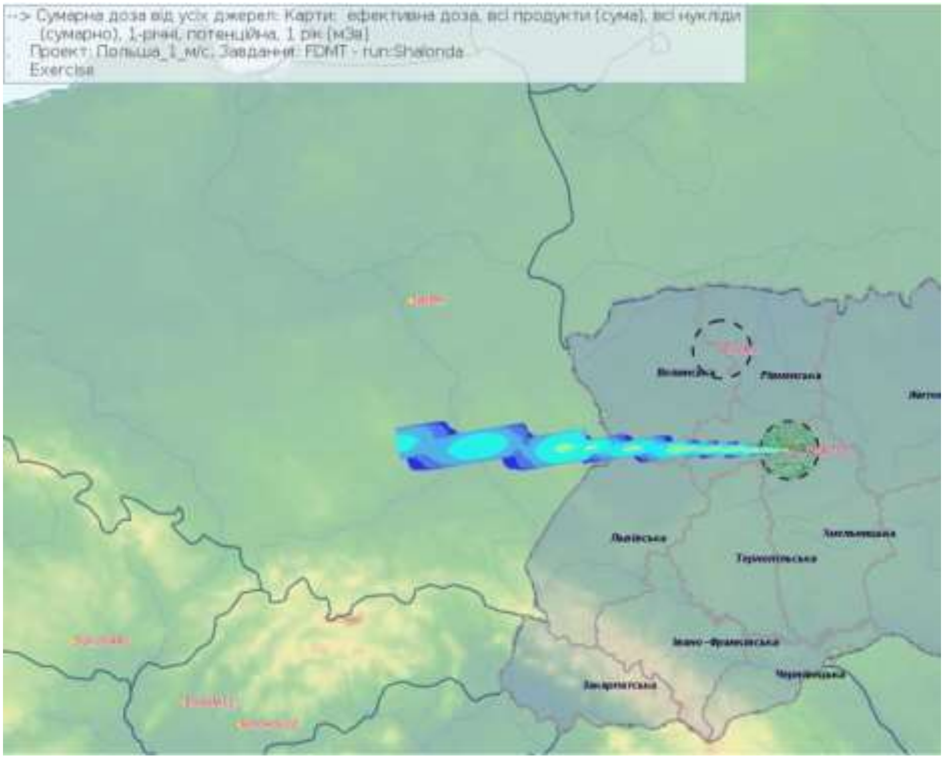


Figure 5.10 – Effective dose map distribution in the direction of Poland

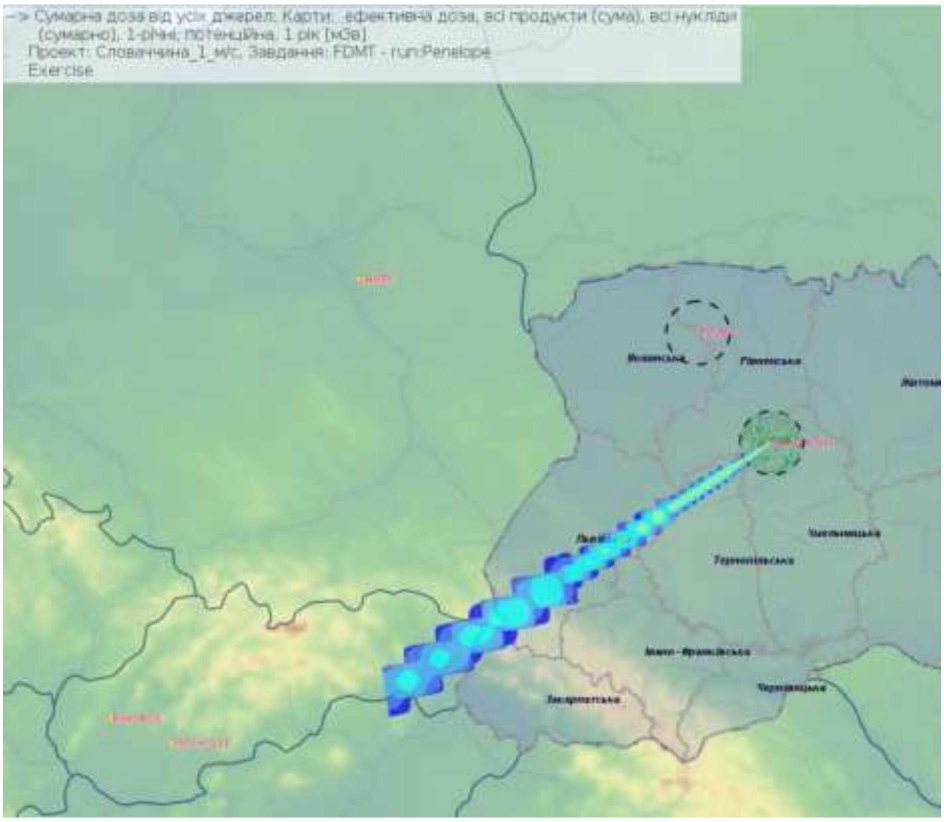


Figure 5.11 – Effective dose distribution map in the direction of Slovakia

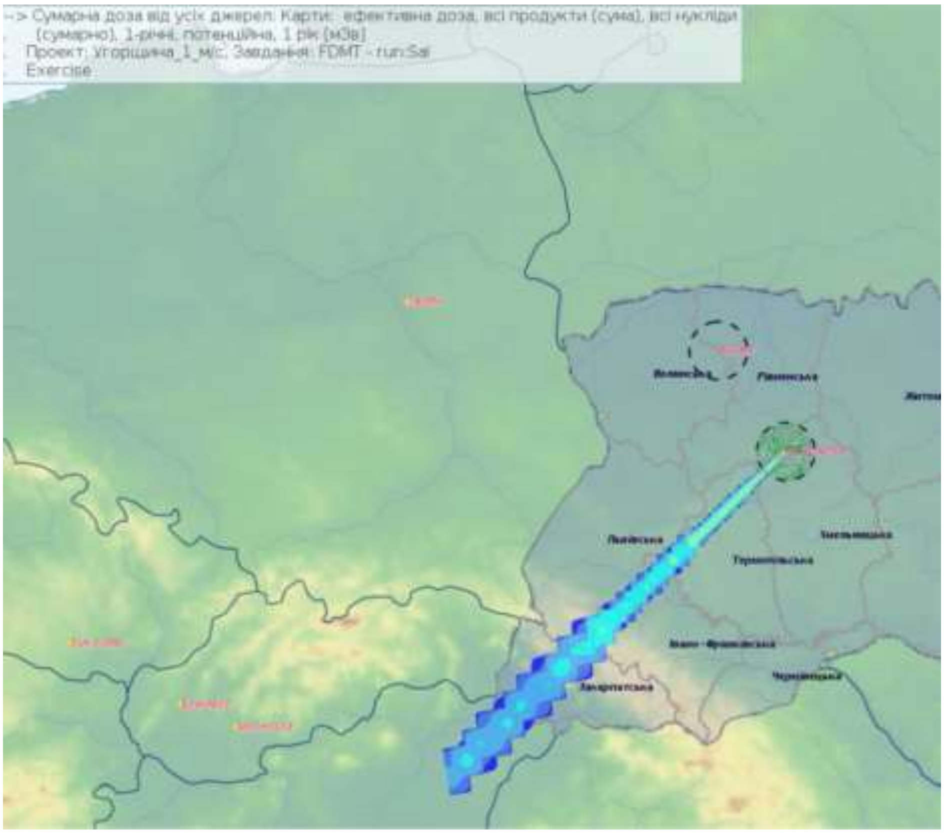


Figure 5.12 – Effective dose distribution map in the direction of Hungary

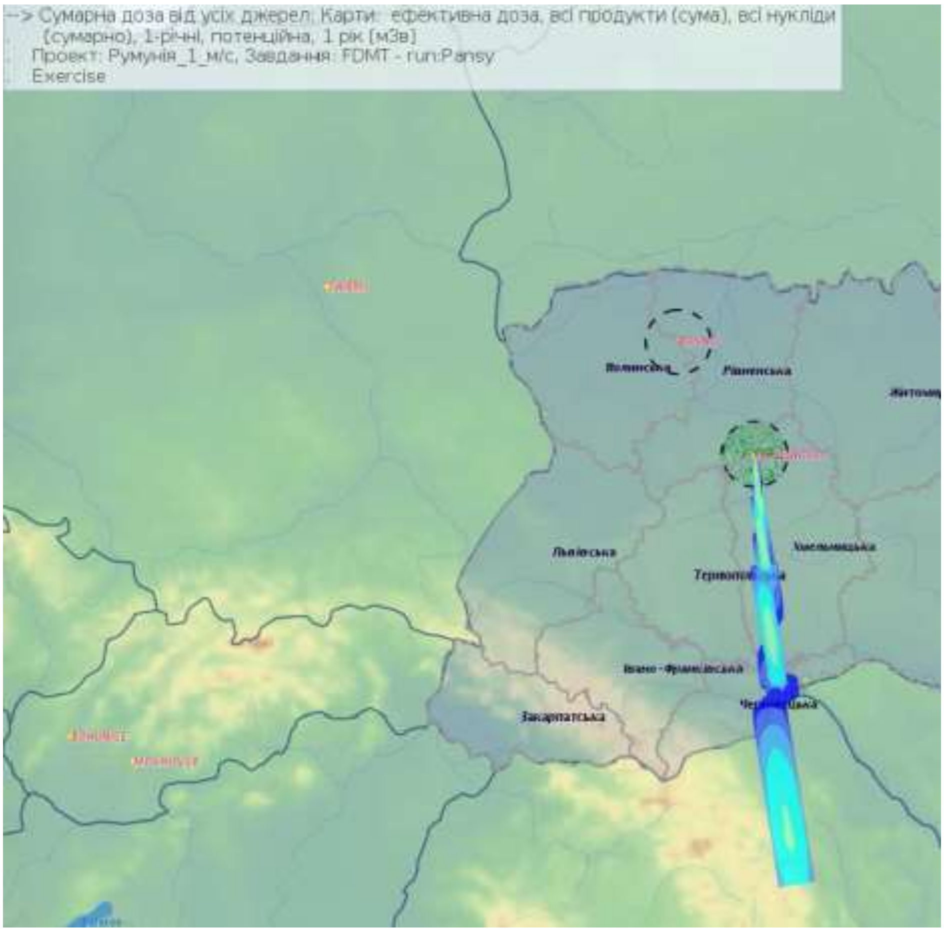


Figure 5.13 – Effective dose distribution map in the direction of Romania

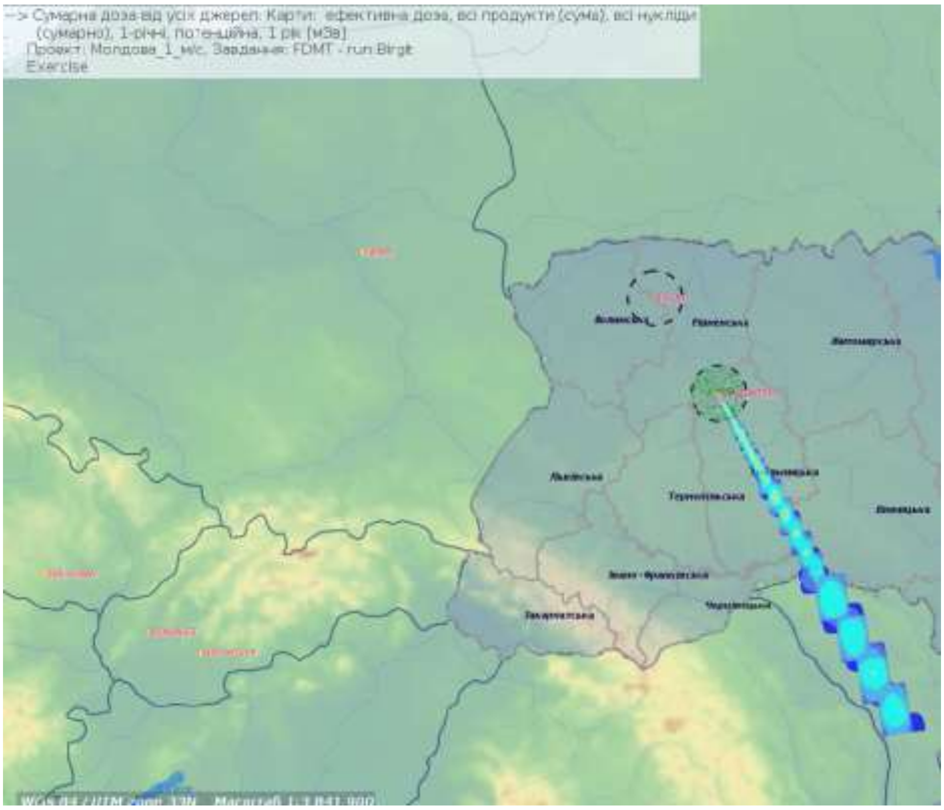


Figure 5.14 – Effective dose distribution map in the direction of Moldova

Section 3.3 of this EIA report provides information on the soil characteristics, the composition of which ensures low mobility and almost complete fixation of heavy metals and radionuclides. Thus, the contamination migration to the neighboring countries is virtually impossible. In addition, when assessing the impact on fauna, according to paragraph 4.3 of this EIA report, it is noted that the releases impact from the six NPP units under normal operating conditions on forestry, mushroom and berry lands, as well as on recreational activities and the quality of forest products is practically absent. Based on the results of the calculations and analysis of the obtained results, it can be concluded that the maximum annual effective dose in the territory of neighboring states at the maximum design-basis accident "from all pathways" is 0.153 mSv, "from all pathways except consumption" is 0.0323 mSv, which is significantly less than the permissible dose limit for the population – 1 mSv under [22]. Thus, considering the peculiarities of the natural and anthropogenic character of the area, the impact on the neighboring countries' territories is practically absent.

It is also worth mentioning that the probability of an accident is extremely low, and the probability of a simultaneous accident at all power units at one site is even more so. Thus, all calculations are usually performed for a single source of a possible accidental release. Moreover, the software tools (RODOS) used to calculate transboundary transfers of releases allow entering data from a specific source.

5.3.9 Calculation of the sanitary protection zone and supervised area

Following the Law of Ukraine on Nuclear Energy Use and Radiation Safety [53], a sanitary protection zone and a supervised area shall be established at the locations of a nuclear facility or a facility intended for radwaste handling. The size and boundaries of these zones shall be determined in the project by the norms and rules in the field of nuclear energy use and shall be agreed with the state nuclear and radiation safety regulatory authority. Radiation monitoring shall be performed in the sanitary protection zone and supervised area.

5.3.9.1 Calculation of the Sanitary Protection Zone

To determine the size of the Sanitary Protection Zone of the AP1000 units, relevant model calculations were performed [54].

Such calculations to determine the size and boundaries of the Khmelnytskyy NPP SPZ were performed following the requirements of the document ISO NNEGC 023:2014[55], which was agreed with the SNRIU and the Ministry of Health of Ukraine. Besides, the impact of operating KhNPP units 1, 2, planned units 3, and 4 with WWER-1000 reactors and planned units 5, and 6 with AP1000 reactors is considered. The size of the sanitary protection zone of KhNPP was determined based on the conditions of not exceeding the established dose criteria for public exposure for:

– normal operation of power units;
– violations of the normal operation of power units with WWER-1000 and AP1000 reactor units;
– design basis accidents at power units with WWER-1000 and AP1000 reactors.

In accordance with [22], the criteria for determining the NPP SPZ size are to follow the non-exceedance the certain radiation levels within and outside the SPZ. The specified exposure levels are set separately for normal operation, as well as for design basis accidents and abnormal operation.

In particular, during normal operation, the dose limit quota for NPP gas and aerosol emissions established by NRBU-97 should not be exceeded, namely, the annual effective dose to the public due to all pathways of dose formation outside the SPZ should not exceed 40 μSv. Non-exceedance of the specified dose shall be ensured for all reference ages specified in NRBU-97 and for all distances equal to or exceeding the distance from the places of possible releases to the SPZ boundaries.

In case of abnormal operation, effective doses to the public outside the SPZ should not exceed 40 μSv for 120 days after such an event.

In the event of design basis accidents, the doses to the public within and outside the SPZ should not exceed the values of unconditional justification levels given in Table D.7.1 of NRBU-97, namely:

a) effective dose:

– children - **10 mSv;**

– adults - **20 mSv;**

b) thyroid dose:

– children **- 100 mSv;**

– adults **- 300 mSv;**

c) skin dose:

– children **- 300 mSv;**

– adults **- 500 mSv.**

Non-exceedance of radiation doses in case of design basis accidents and abnormal operation should be ensured:

- for all reference ages specified in NRBU-97;

- for all distances equal to or exceeding the distance from the places of possible releases to the SPZ boundaries.

According to the results of the calculations, the dimensions of the KhNPP SPZ, which ensure that the dose criteria for public exposure following the requirements of the SOU NNEGC 023:2014 [55], NRBU-97 [22], are not exceeded within and outside its boundary, are shown in Figure 5.15. The calculated boundary of the SPZ is an ellipse with the center in the middle of the segment connecting the locations of the vent pipes of Units 2 and 3. [redacted] The major axis of the ellipse is on a line [redacted] connecting the locations of the vent pipes of power units 1 and 6. The major semi-axis length of the ellipse is 2600 m, and the minor semi-axis one is 2200 m.

The KhNPP SPZ boundaries, defined as a result of the calculation, are almost fully consistent with the existing boundaries (Fig. 5.15), except for its western part. In this area, the calculated SPZ boundary extends beyond the existing one in the western direction by no more than 250 m. At the same time, most of this additional area falls on the water surface of the KhNPP pond. Such a small increase in the calculated SPZ size in the western direction is explained by taking into account the potential impacts of new units 5 and 6. The area of the calculated SPZ is 18.0 km^2, or about 78% of the existing one.

Before construction activities and after the approval of the construction project for KhNPP Units 5 and 6 with the AP1000 reactor, the size of the SPZ will be finally determined based on the results of the Project's expert review.

Figure 5.15 – The KhNPP SPZ boundaries are defined as a result of calculations based on the requirements of the SOU NNEGC 023:2014 [55] (in red). The existing KhNPP SPZ boundaries are shown in a purple circle with a radius of 2700 m.

5.3.9.2 Calculation of the supervised area

To determine the size of the AP1000 units SA, the corresponding model calculations were performed [54].

Such calculations of the SA were performed based on the requirements of the NP 306.2.173-2011 “Requirements for determining the size and boundaries of the NPP supervised area” [60]. At the same time, the calculation of all functions that are compared with the established criteria for determining the NPP SA size was performed taking into account the potential impact of all sources of radioactive releases at the KhNPP site. This means that modeling of consequences of beyond-design-basis accidents, which determines the KhNPP SA size, was performed for each of the six (operating and planned) KhNPP units, namely:

a) operating units 1 and 2 with VVER-1000/V-320 reactors;

b) units 3 and 4 with VVER-1000/466B reactors planned for design and construction;

c) units 5 No. 6 planned for design and construction with a unit electric capacity of about 1100 MW and a thermal capacity of 3400 MW with AP1000 reactor type manufactured by Westinghouse Electric Company.

The SA size is determined so that in case of beyond-design basis accidents, the frequency of which is equal to or exceeds the values of the indicators established by the "General Safety Provisions for Nuclear Power Plants" [6], the doses to the public on the SA border and beyond do not exceed the criteria for the introduction of urgent countermeasures (lower limits of justification) - evacuation and iodine prophylaxis, given in Table D.7.1 of NRBU 97[1] [22]), namely:

a) effective dose – 50 mSv;

b) thyroid dose:

– children – 50 mSv;

– adults – 200 mSv;

c) skin dose – 500 mSv.

Non-exceedance of these doses was demonstrated:

- for all reference ages defined in NRBU-97;

- for all distances equal to or exceeding the distance from the places of possible releases to the SA boundaries.

When calculating the non-exceedance of the specified radiation doses, the types of terrain in the SA and the likely meteorological conditions during the atmospheric transfer of an accidental release are taken into account.

For the considered beyond-design-basis accident scenarios at the VVER-1000 and AP1000 power units, the formation of the following set of circles is required to meet the criteria for not exceeding the effective dose to the public and equivalent skin and thyroid doses:

[redacted]

The combination of circles is shown in Figure 5.16.

[1]) The values of justification limits for doses to the thyroid gland and skin in Table D.7.1 of NRBU-97 are given in terms of absorbed doses (mGy). The numerical values of absorbed doses (mGy) formed by beta and gamma radiation only are equal to the values of equivalent doses (mSv).

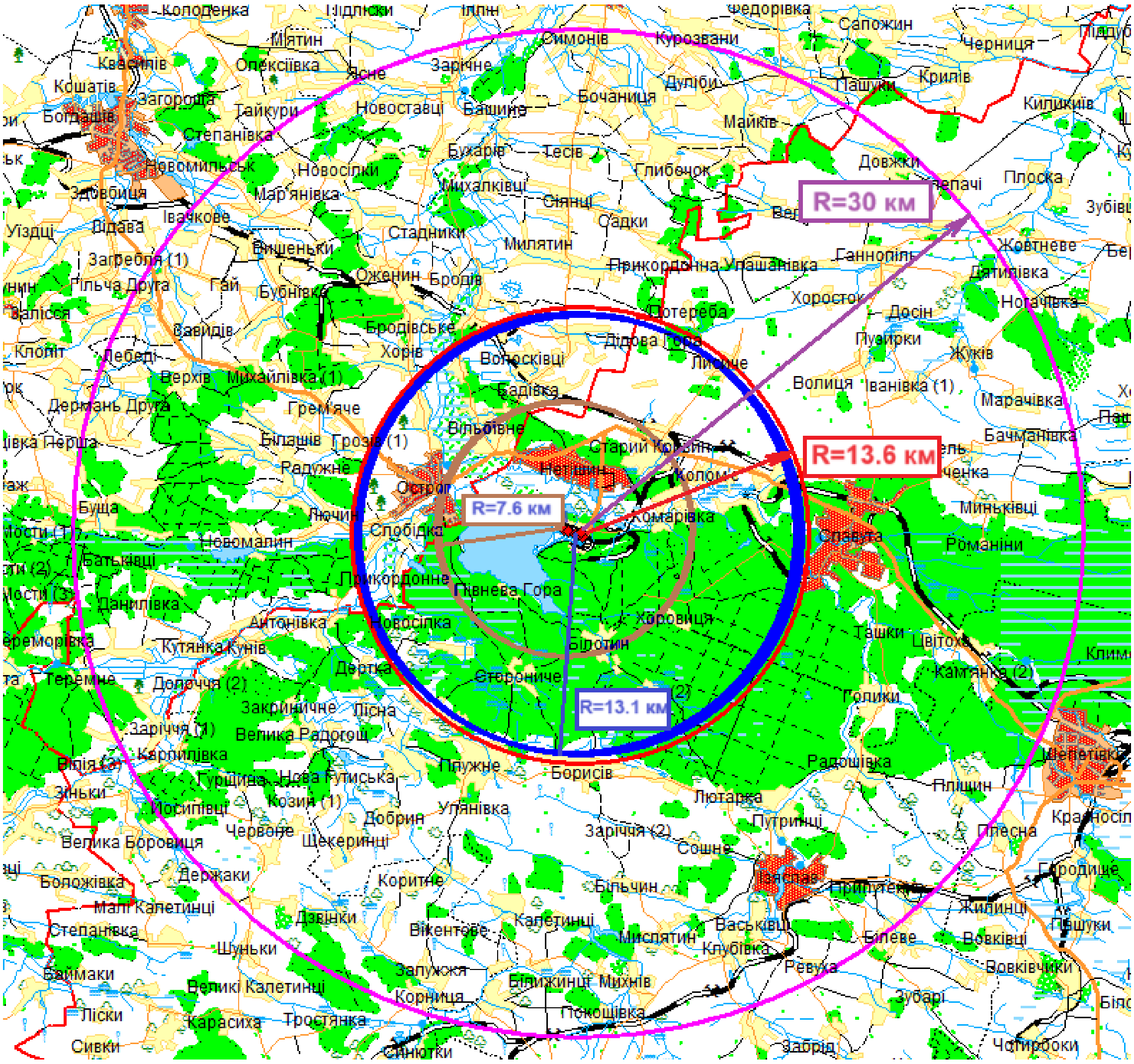


Figure 5.16 – The KhNPP SA boundaries are determined by the calculations in accordance with the requirements of NP 306.2.173-2011 (in red). The boundary of the existing KhNPP SA is shown in a purple circle with a 30 km radius

The Figure 5.16 shows the above four circles in blue for each of the VVER-1000 units 1-4. Two circles with a radius of 7.6 km (shown in brown in Fig. 5.16), corresponding to the calculations for units 5-6 with AP1000 reactors, are shifted from each other by 270 m (distance between the units' vent stacks) and are completely absorbed by the other 4 circles with a radius of 13.1 km obtained for units 1-4. If we assume that the center of the supervised area should remain unchanged, then the circle radius drawn around this center and covering all six circles is 13600 m (shown in red in Fig. 5.16). This value can be taken as the size of the supervised area resulting from the calculations.

The specified size of the KhNPP supervised area, based on the document NP 306.2.173-2011, ensures that the established dose criteria are not exceeded for all reference age groups and in the entire range of meteorological conditions for the dissemination of radioactive releases in the atmosphere and characteristics of the underlying surface.

Prior to the commence of construction activities and after the approval of construction project for the KhNPP units 5 and 6 with the AP1000 reactor, the SA size will be finalized based on the project review results.

5.3.10 Waste treatment

In the course of NPP operation, both radioactive waste and non-radioactive waste are inevitably generated, see also Sections 1.5.1, 1.5.2.3.

Radwaste includes such material objects and substances that are not subject to further use, and whose radionuclide activity or radioactive contamination exceeds the levels established by applicable regulations.

NPP operation inevitably generates liquid, solid, and gaseous radioactive waste. The sources of radioactive waste are NPP equipment and systems containing liquid, solid, and gaseous media.

Liquid radioactive waste is generated during the operation and repair of the main and auxiliary equipment of the reactor unit, and plant-wide systems containing radioactive media or contaminated with radioactive substances, see also Section 1.5.1.4.

Solid radioactive waste is spent reactor internals, pump parts, pipelines, fittings, thermal insulation, ventilation system filters, wiping materials, cotton and film overalls, used PPE, various construction waste, etc., see 1.5.1.5.

Gaseous radioactive waste - volatile emissions (aerosols) of the primary coolant occurred during repair work, small leaks, and disorganized coolant leaks, see also 1.5.1.3.

The AP1000 power unit provides a radioactive waste treatment and management system to support the expected waste generation from plant operation and provides the flexibility and space to install mobile systems during emergencies and special waste treatment systems that may be required in the event of such situations. Below is a list of radioactive waste treatment systems for the AP1000:

– Gaseous Radwaste system (WGS);
– Liquid Radwaste system (WLS);
– Radioactive Waste Draine System (WRS);
– Solid Radwaste System (WSS).

The operating organization is currently implementing a project for the construction of the KhNPP Radioactive Waste Processing Complex (RWPC) at the Khmelnytskyy NPP site. The RWPC is intended for processing radwaste already accumulated in KhNPP storage facilities those generated during the current operation of power units and those that will be generated during the decommissioning of KhNPP power units.

The construction of the RWPS at the KhNPP site will ensure

– increasing the level of personnel protection, the public and the environment from negative radiation impact;

– improvement of the radwaste management system at KhNPP, as well as reduction of the probability of radiation accidents during SRW handling;
– preparation of processed SRW for further shipment to specialized enterprises for disposal following the established acceptance criteria;
– significant reduction of the amount of SRW stored at the KhNPP site due to the introduction of new technologies for their processing.

The main RWPC facilities:

- organic fuel combustion facility;
- pressing facility;
- metal decontamination facility;
- activity measurement facility;
- waste sorting and fragmentation facility;
- cementation facility;
- facility for exemption from regulatory control.

The commissioning of the RWPC in 2025 will ensure the availability of free radwaste storage facilities for the lifetime extension and decommissioning of the operating KhNPP units, storage, and processing of SRW from the new KhNPP units 3, 4 and units using the AP1000 technology. The commissioning of the RWPC will generally improve the safety culture in radwaste management at the KhNPP site.

5.3.10.1 Sources of gaseous radwaste generation

The Radwaste Gas System (WGS) is designed to accept, process, and discharge radioactive waste gases off-site in compliance with the threshold limit value for normal plant operation, including power generation, fuel shutdowns, and reloading.

The AP1000 reactor is designed to accept all potentially hydrogen-containing and radioactive gases generated during the plant operation. The largest amount of gaseous waste is generated during plant operation at the end of the fuel cycle. Gaseous radioactive waste includes:

– gas exhausts, non-condensable gases, and volatile aerosols from equipment operating on radioactive media;
– air that is removed from workspaces.

The gases accumulated in the primary circuit during operation are vented from it. This results in the formation of a LRW stream. Gaseous emissions can also be generated by venting volatile emissions from the primary coolant resulting from small, organized, unorganized leaks.

Before being released into the atmosphere, gaseous waste is subject to treatment.

5.3.10.2 Sources of liquid radwaste generation

The WLS system is designed to manage, collect, treat, handle, store, and dispose of liquid radwaste generated during normal operation.

The system contains components that accept and store radioactive or potentially radioactive liquid waste.

The system's main equipment is the reactor primary coolant drainage tank (RCDT), containment pit, wastewater settling tanks, waste holding tanks, etc.

The system components store and treat waste during normal operation and expected disruptions of normal operation.

The main sources of liquid radioactive waste generation at the AP1000 facilities are:

– primary circuit coolant;
– decontamination water generated during decontamination activities on NPP equipment
– organized and unorganized leaks from equipment containing liquid radioactive media;
– steam generator blowdown water;
– drainage water coming from the Radioactive Waste Drain System (WRS);
– other.

Before liquid waste is discharged and throughout its management, it is mandatory to monitor and control the compliance of radiation parameters of the process medium.

5.3.10.3 Sources of solid radwaste

The main solid radwaste from AP1000 reactors for which the system is designed can be identified as follows:

– spent ion exchange resins;
– spent filter cartridges;
– dry and mixed operational waste generated as a result of the operation of NPP equipment containing radioactive contamination;
– other.

The Solid Radwaste System collects spent ionizers, mixed-action filters, spent filter elements, and dry (solid) and mixed radioactive waste generated during NPP operation in normal operation and in case of expected violations of normal operation. The system is located in the auxiliary and the radioactive waste management buildings.

The mobile systems at the loading area located in the auxiliary building and mobile facilities in the radioactive waste management building are responsible for radioactive waste processing and packaging.

The packaged radwaste is stored in the annex buildings, auxiliary and RAW management buildings before the disposal to an appropriate storage facility.

Solid radwastes are accepted before being processed and packaged by mobile equipment for shipment off-site.

5.4 Risks to human health, cultural heritage sites, and the environment, including through the possibility of emergencies

Consideration of risks to human health, cultural heritage, and the environment is one of the key aspects of developing an EIA report.

Environmental risk is the likelihood of an event with adverse consequences for the environment and population health caused by the predicted negative impact of economic and other activities that pose a threat of natural or man-made emergencies.

5.4.1 Risks to population health and the environment

Risks to human health and the environment are assessed considering both radiation and non-radiation effects. The risks of non-carcinogenic effects are also accounted for.

The SPZ is organized around any NPP following the Ukrainian radiation safety legislation. In the SPZ, the population is prohibited from living, and restrictions are imposed on production activities that are not related to the nuclear facility and where radiation monitoring is carried out. Thus, neither exports nor agricultural activities are allowed in this area.

In addition, a supervised area is organized around the NPP, which is larger than the Exclusion Zone, and where radiation monitoring is also conducted for various indicators. The scope and frequency of such monitoring is determined by the SNRIU-approved NPP radiation monitoring regulations.

5.4.1.1 Assessment of public dose from natural radiation sources

The existing air pollution is well below the permissible concentrations.

Table 5.28 shows the content of radionuclides in surface waters of water bodies in 2021 [35], as well as the permissible concentration of radionuclides in potable water [23].

Table 5.28 – Radionuclide content in surface waters of water bodies, Bq/m^3

Radionuclide	Permissible concentrations in potable water	Cooling pond	Horyn River (to NPP)	Horyn River (control gate)
^{137}Cs	$1 \cdot 10^5$	9,59	11,100	9,280
^{134}Cs	$7 \cdot 10^4$	0,529	0,388	0,538
^{60}Co	$8 \cdot 10^4$	0,566	0,407	0,594
^{90}Sr	$1 \cdot 10^4$	6,91	5,010	4,280
^{3}H	$3 \cdot 10^7$	$6{,}86 \cdot 10^4$	$4{,}25 \cdot 10^3$	$8{,}30 \cdot 10^3$

The table shows that the concentration of radionuclides in surface water bodies is significantly below the permissible levels.

Based on the data from KhNPP, the content of ^{137}Cs and 90Sr in staple foods [56] was assessed in comparison with the permissible values of ^{137}Cs and ^{90}Sr [57] in these foods, shown in Table 5.29.

Table 5.29 – Average values of ^{137}Cs and ^{90}Sr concentration in basic food products, Bq/kg

Sample	Radionuclide concentration values		Normative indicator of permissible levels	
	^{90}Sr, Bq/kg	^{137}Cs, Bq/kg	^{90}Sr, Bq/kg	^{137}Cs, Bq/kg
Wheat	0,300 – 0,673	0,059 – 0,777	20	50

Sample	Radionuclide concentration values		Normative indicator of permissible levels	
	^{90}Sr, Bq/kg	**^{137}Cs, Bq/kg**	**^{90}Sr, Bq/kg**	**^{137}Cs, Bq/kg**
Rye	0,451 – 1,260	0,085 – 0,133	20	50
Milk	0,21	0,83	20	100
Fish	0,49	0,61	35	150
Potato	0,059 – 0,851	0,041 – 0,340	20	60
Cabbage	0,370	0,133	20	60

Natural radionuclides and their decay products, as well as cosmic radiation make the main contribution to the formation of dose loads on the population of the KhNPP monitoring area. At the same time, artificial radionuclides of global fallout and radionuclides of Chornobyl origin make a significantly smaller contribution to the radiation dose.

Based on the analysis, construction and accident-free commissioning of the new KhNPP units will not cause a significant increase in radionuclides in surface water and basic food products. In emergencies, no significant impact on the population and the environment outside the SPZ is expected, see also. 5.3.7 and 5.3.9.

5.4.1.2 Assessment of risks from radiation exposure to the public and the environment

According to [22], the concept of risk is introduced for both stochastic and deterministic effects.

The individual *(r)* and collective *(R)* risk of stochastic effects from exposure is determined accordingly:

$$r = r_E \cdot E, \qquad (5.1)$$
$$R = r_E \cdot S_E \qquad (5.2)$$

E, S_E - individual and collective effective doses;
r_E - risk factor for fatal and non-fatal cancer and serious hereditary effects.

The risk coefficient per unit of individual or collective dose for the population is assumed to be equal to r_E = = $7.3\cdot10^{-2}$ Sv^{-1}.

When exposed to doses that cause deterministic effects, it is assumed that the risk of severe consequences is equal to the probability of the consequence itself:

$$r = p(E) \qquad (5.3)$$
$$R = p(S_E) \cdot N \qquad (5.4)$$

$p(E), p(S_E)$ is the probability of events that generate doses E and S_E, respectively;
N is the number of the population exposed to radiation with equivalent doses E > 0.5 Sv.

Risk of deterministic effects

An accident at the AP1000 power unit is considered to be a beyond-design-basis loss of coolant accident (LOCA) with subsequent core meltdown. Although the analysis of the core reaction in the AP1000 reactor during a loss of coolant accident shows that its integrity is preserved, it is assumed that significant core degradation and meltdown occurs to assess the radiological consequences of the accident.

The radionuclide composition and activity of each radionuclide in the release to the environment in a beyond design basis accident was set in accordance with [81] (Table 5.30). The value of the effective release height was conservatively assumed $_{heff}$ = 1 m.

Table 5.30 – The expected release of activity into the environment in case of an beyond design basis accident at the AP1000 power unit

Nuclide	**Activity (Bq)**
Xe-133	2,86E+16
Xe-133m	2,85E+14
Cs-137	1,17E+13
I-131	1,61E+14
Te-131m	3,19E+12
Sr-90	6,18E+11
Ru-103	1,33E+12
La-140	1,23E+11
Ce-141	2,93E+11
Ba-140	1,23E+13

The ratio of activity in the release between different physico-chemical forms of ^{131}I was set according to [82] to 95% (aerosol): 4.85% (molecular) : 0.15% (organic).

The values of the integrated volumetric specific activity and surface specific activity of radionuclides were calculated using a standard Gaussian model of the distribution of impurities in the atmosphere (its description is given in [60]). The obtained values were used to estimate the effective and equivalent doses to the public for the period of 14 days after the accident. The effective dose to the public was calculated for each of the 6 reference ages defined in [22], including the following dose formation ways: inhalation of radionuclides, external exposure from the release cloud and external exposure from radionuclides falling on the soil surface. Equivalent doses to the thyroid gland and skin were calculated in a similar manner.

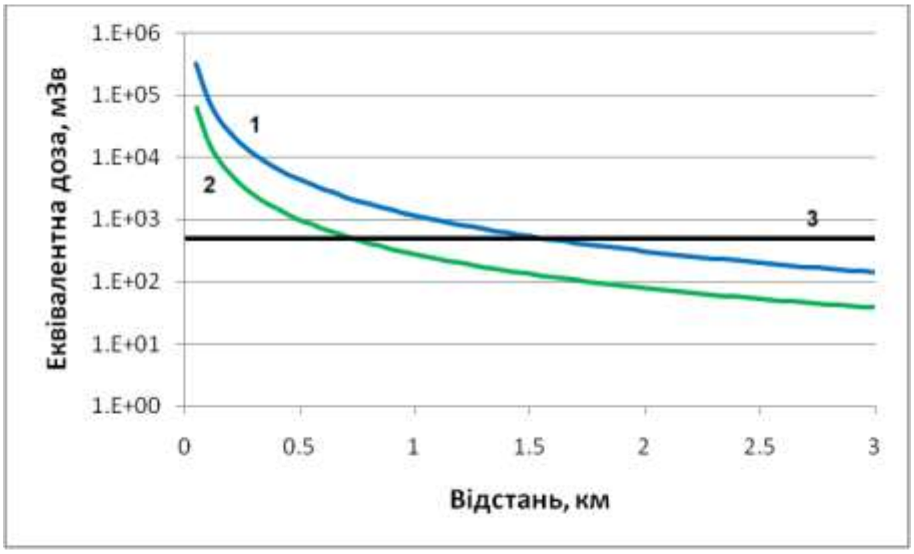


Figure 5.17 – The estimated values of equivalent doses to the thyroid gland (1) and skin (2); 3 - dose criterion of 500 mSv [22].

Figure 5.17 shows the results of calculations of the equivalent dose to the thyroid gland and skin for the critical age group "1 year" and the "worst" meteorological conditions of release propagation (wind speed of 1 m/s, atmospheric stability category *F*, no precipitation). The value of the roughness parameter of the underlying surface was set to 1 m in the modeling. Non-exceedance of the dose criterion of 0.5 Sv, established in [22], is ensured at distances of 750 m and more for skin exposure, and at distances of 1600 m and more for thyroid exposure. Since both of these values are within the sanitary protection zone, it can be concluded that in this case, the population N exposed to radiation with equivalent doses > 0.5 Sv is zero. Thus, according to formula (5.4), the collective risk of deterministic effects *R* is absent, and according to formula (5.3), the individual risk of deterministic effects *r* corresponds to the value of the frequency of the maximum accidental release and is 3.83E-08 events per reactor-year.

Risk of stochastic effects

The value of the risk of stochastic effects was calculated for the conditions of normal operation of the AP1000 power units. Air emissions from each of the two KhNPP units 5 and 6 are released through 2 ventilation pipes: the main ventilation pipe and the turbine building ventilation pipe of the plant [5]. The parameters of the 4 emission sources required for model calculations of atmospheric transfer of radionuclides are given in Table 5.31.

Table 5.31- Characteristics of radioactive release sources from the KhNPP Units 5 and 6 under normal operation

Release source	Unit 5 main ventilation pipe	Unit 5 TB ventilation pipe	Unit 6 main ventilation pipe	Unit 6 TB ventilation pipe
Effective height, m	81,6	39,8	81,6	39,8
Nuclear composition	Emission activity (Bq/year)			
H-3	1,8E+12	-	1,8E+12	-
C-14	2,7E+11	-	2,7E+11	-

Release source	Unit 5 main ventilation pipe	Unit 5 TB ventilation pipe	Unit 6 main ventilation pipe	Unit 6 TB ventilation pipe
Ar-41	4,8E+10	-	4,8E+10	-
Kr-85m	1,66E+10	7,80E+09	1,66E+10	7,80E+09
Kr-85	3,06E+12	2,60E+10	3,06E+12	2,60E+10
Kr-87	1,70E+10	2,20E+09	1,70E+10	2,20E+09
Kr-88	1,81E+10	8,50E+09	1,81E+10	8,50E+09
Xe-131m	1,31E+12	8,10E+10	1,31E+12	8,10E+10
Xe-133m	8,07E+10	3,50E+10	8,07E+10	3,50E+10
Xe-133	9,59E+11	2,90E+11	9,59E+11	2,90E+11
Xe-135m	1,30E+11	5,90E+10	1,30E+11	5,90E+10
Xe-135	1,73E+11	2,60E+11	1,73E+11	2,60E+11
Xe-138	5,90E+10	2,90E+10	5,90E+10	2,90E+10
I-131	2,06E+08	3,36E+06	2,06E+08	3,36E+06
I-133	3,45E+08	3,74E+06	3,45E+08	3,74E+06
Cr-51	1,20E+05	6,70E+04	1,20E+05	6,70E+04
Mn-54	-	1,10E+05	-	1,10E+05
Co-58	7,93E+05	7,80E+06	7,93E+05	7,80E+06
Co-60	1,90E+05	3,00E+06	1,90E+05	3,00E+06
Sr-89	3,28E+05	7,80E+05	3,28E+05	7,80E+05
Sr-90	1,10E+05	3,00E+05	1,10E+05	3,00E+05
Zr-95	3,70E+05	-	3,70E+05	-
Cs-134	2,00E+05	6,30E+05	2,00E+05	6,30E+05
Cs-137	2,70E+05	1,00E+06	2,70E+05	1,00E+06

The values of integrated volumetric specific activity and surface specific activity of radionuclides were calculated using a Gaussian model of impurities distribution in the atmosphere for continuous release, in which the dilution factor (or directly the volumetric activity of a radionuclide in the surface air) is calculated as an average for a period of 1 year, including the climatic average values of meteorological parameters repeatability. The repeatability values of meteorological parameters were calculated based on the data of KhNPP meteorological station measurements for 2013-2023 as elements of a three-dimensional matrix characterized by different values 1) wind direction (16 categories), 2) wind speed (8 categories) and 3) atmospheric stability category (6 categories).

The calculated values of radionuclide activity summed with the contributions of all 4 sources (Table 5.31) were used to estimate the effective dose to the population for a period of 1 year, and using formulas (5.1) and (5.2), the values of individual and collective risk of stochastic effects from exposure.

Figure 5.18 shows the values of the individual risk of stochastic effects for the population *r* calculated using formula (5.1) using the results of effective dose calculations for the critical age group “1 year” and average climatic conditions of release propagation with east-northeast wind, at which the calculated values of nuclide activity in air and fallout and the corresponding risks are the highest. The maximum value of individual risk $r = 3.23 \cdot 10^{-7}$ 1/year is achieved at a distance of about 800 m. Thus, for normal operation of two units (Nos. 5 and 6) with AP1000 reactors, the individual risk of stochastic effects for the population r is less than the neglected risk level of 10^{-6} 1/year [22] for all distances from the source, reference age groups and meteorological conditions of radioactive release in the atmosphere. Accordingly, it can be assumed that the value of the collective risk of stochastic effects R can also be neglected.

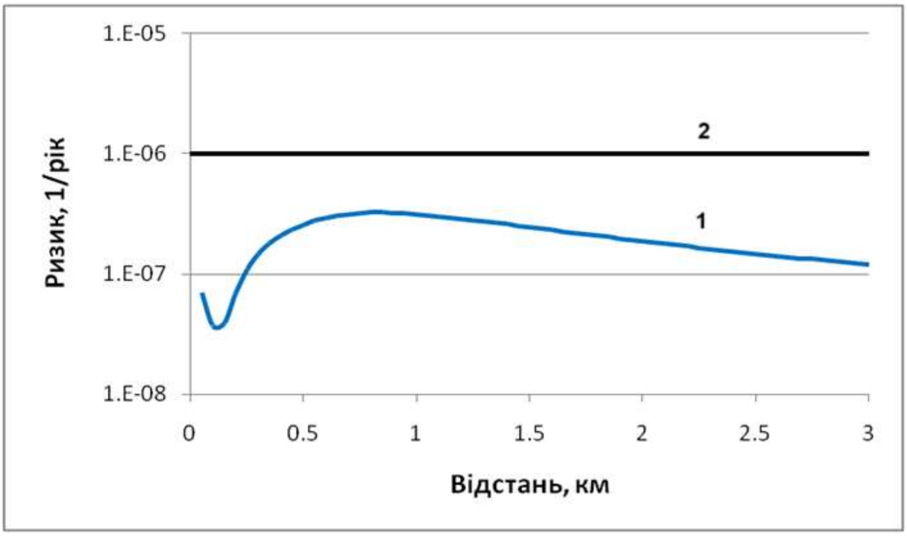


Figure 5.18 - Individual risk values for stochastic effects for the population in dependence from distance to the source (1) and level of neglected risk (2).

5.4.1.3 Assessment of the risk of the planned activity to public health

The risk of the planned activity's impact on public health from air pollution is assessed based on the calculations of the risk of non-carcinogenic and carcinogenic effects. Risk assessment is carried out under the following guidelines [17].

Characterization of the risk of non-carcinogenic effects under combined and complex effects of chemical compounds is based on calculating the hazard index (HI). The hazard index for the conditions of simultaneous intake of several substances by the same route (e.g., inhalation or oral) is calculated using the following formula:

$$HI = \sum HQ_i \qquad (5.5)$$

HQ_i – hazard quotients for individual substances, which are determined by:

$$HQ_i = C_i / RfC_i \qquad (5.6)$$

C_i – the estimated average annual concentration of the i substance, mg/m^3;

RfC_i – the reference (safe) concentration of the i substance, mg/m^3.

HQ_i = 1 – the limit value of the accepted risk.

The assessment of non-carcinogenic risk is carried out under the criteria given in Table 5.32.

Table 5.32 – Non-carcinogenic risk criteria

Risk characterization	**Hazard quotient (HQ)**
The risk of harmful effects is considered as negligibly small.	< 1
The threshold value, which does not require urgent measures, however, cannot be considered sufficiently acceptable.	1
The probability of developing harmful effects increases in proportion to the increase in HQ.	> 1

The hazard index of the planned activity was calculated as the sum of the hazard factors of individual substances contained in the emissions from the diesel generator (including background): nitrogen dioxide, sulfur dioxide, carbon monoxide, hydrocarbons C12-C19, and suspended solids. The results are shown in Table 5.33.

Table 5.33 – Calculation of non-carcinogenic effects

	Nitrogen dioxide	Sulfur dioxide	Carbon monoxide	Hydrocarbon limit C12-C19	Suspended solids, non-differentiated by structure
Maximum one-time concentration at the limit of the residential area, mg/m^3	0,224	0,064	0,418	0,413	0,064
Estimated average annual concentration, C_i mg/m^3,	0,00001	0,000004	0,00002	0,00002	0,000004
Reference (safe) concentration of the *i* - substance, RfC_i , mg/m^3	0,04	0,08	5,0	1	0,5
Hazard quotient, HQi	0,00025	0,00005	0,000004	0,00002	0,000002

$$HI = 0{,}00025 + 0{,}00005 + 0{,}000004 + 0{,}00002 + 0{,}000002 = 0{,}00033 < 1$$

According to Table B.1 of Annex B DBN A.2.2-1:2021 [17], the risk of non-carcinogenic effects is estimated to be extremely low.

The risk of developing carcinogenic effects is not determined due to the absence of carcinogenic substances in the emissions from diesel generators.

The social risk assessment of the planned activity is not determined because the emissions from the backup diesel generators do not contain carcinogenic substances.

The results of the risk assessment of the planned activities for the population's health prove that the commissioning of KhNPP Units 5 and 6 will not significantly affect the population's health. Moreover, it should be noted that the planned activity does not involve emissions of carcinogenic substances. Based on the results of the assessment, the impact of the planned activity on the social environment is characterized as environmentally acceptable.

5.4.2 Risks to Cultural Heritage Sites

Cultural heritage sites are located beyond the territory planned for the industrial site of KhNPP Units 5 and 6. Therefore, the construction and commissioning of the new power units does not pose any risks to cultural monuments.

5.5 The cumulative impact of other existing facilities, planned activities, and facilities for which a decision on the planned activity has been received, taking into account all existing environmental issues related to areas of special environmental protection significance that may be affected or where natural resources may be used

The KhNPP supervised area covers the territory of four districts of the Khmelnytskyy and Rivne regions. In the Khmelnytskyy region: the Shepetivka and Khmelnytskyy districts, in the Rivne region: the Rivne and Dubno districts.

[redacted]

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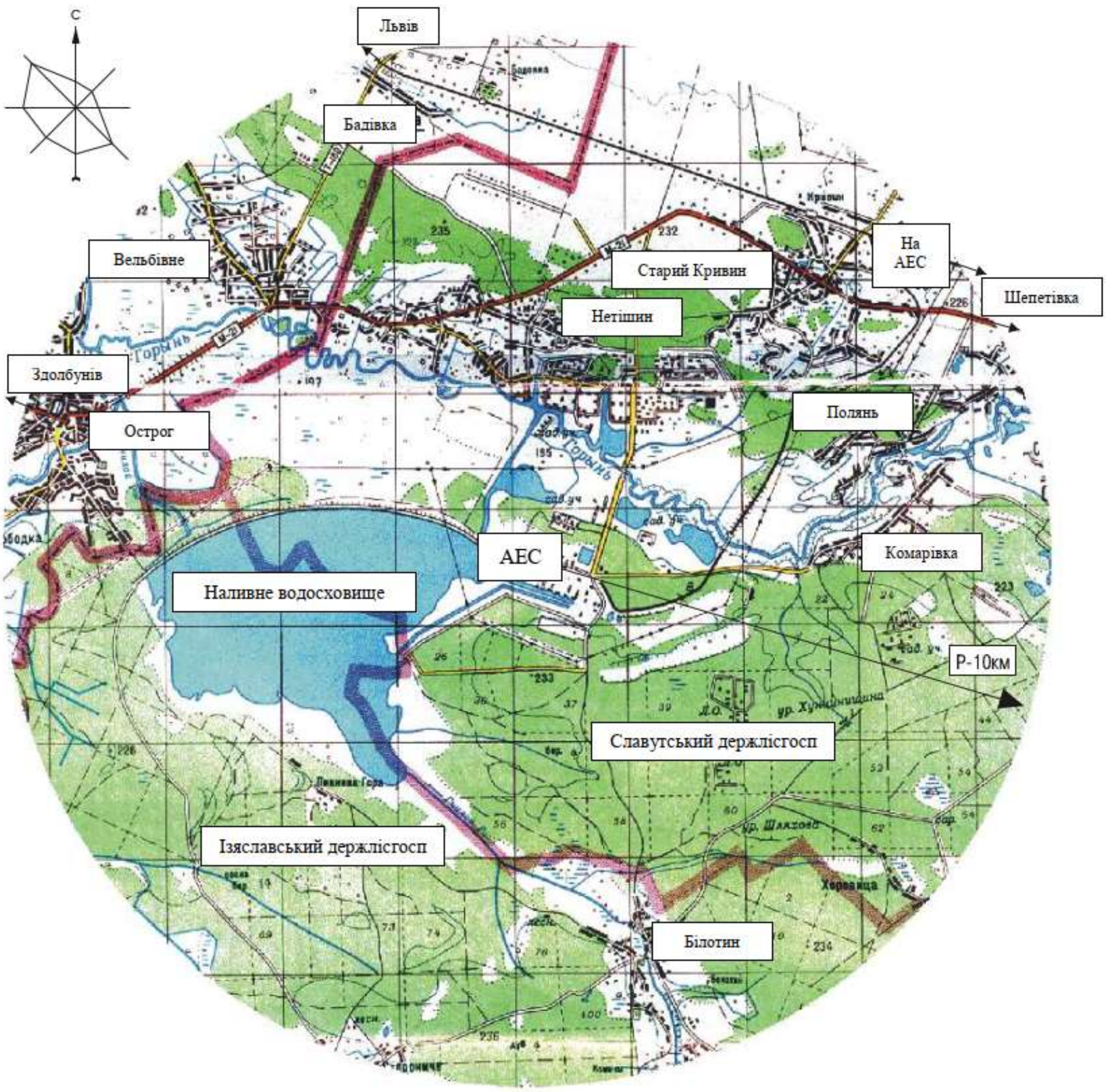

Figure 5.19 – Location of facilities in the KhNPP 10-km area

There are no large hydraulic facilities upstream and downstream of the Goryn and Viliya rivers in the 30-kilometer zone of the NPP. Reclamation drainage systems in the floodplains of these water sources do not affect the water supply to the NPP plant.

Industrial facilities within 30 kilometers of the NPP are concentrated mainly in the cities of Netishyn, Slavuta, Izyaslav, and Ostroh. These facilities are of local importance with a small production output. The industry of the neighboring towns is represented by the following enterprises:

– Slavuta town – a silicate products plant, a building faience plant, a woodworking plant, food industry enterprises (butter, fruit canning, brewery, etc.), local and consumer goods industry enterprises;

– Izyaslav town – a brick factory, a furniture factory, a musical instrument factory, a butter factory;

– Ostroh town – a brick factory, a drainage pipe factory, a woodworking plant, a furniture factory, a sugar factory, a fruit canning factory, a brewery, and a food processing plant.

The list of major enterprises with their locations is presented in Tables 5.34and 5.35.

Table 5.34 – List of enterprises in the Khmelnytskyy region

Location area	**Distance to NPP (km)**	**Name of the enterprise**
Izyaslav territorial community		
Izyaslav town (southeast)	24-28	1 “Kharchomash” plant
		2 Motor transport company (MTC) - 16840
		3 Heating network
		4 Fruit canning plant
		5 Sales base of bakery products (SBBP)
		6 Feed mill
		7 Bread factory
		8 Butter factory
		9 Repair and transportation enterprise
		10 Region Construction Ryagrobud
		11 Full production and commercial company (FPCC)
		12 Regional consumer socierty
		13 State forestry
		14 State institution№ 3
		15 Interdistrict base
		16 MH 324/31
		17 MH 324/58
		18 Factory "Octave"
		19 MTC OSS
		20 Agricultural chemical plant
		21 Water utility company
		22 Izyaslav Waste Processing Complex LLC
Velyka Radohoshch village (southwest)	20-21	23 Peat briquette plant
Pluzhne village (south)	14-15	24 Bread factory
		25 Brick factory
Kliubivka village (south)	26-27	26 Sugar factory.
Slavuta territorial community		
Slavuta town (east)	14-18	1 OJSC Silikat
		2 Oil depot
		3 Budfarfor plant
		4 Municipal enterprise "Vyrobnychnyk"
		5 Woodworking plant
		6 ATP-16845
		7 District management company
		8 Combine of public utilities
		9 Heating network

Location area	Distance to NPP (km)	Name of the enterprise
		10 Sewing factory
		11 ATP-2202
		12 Agricultural supply company
		13 Bread factory
		14 Chicory drying plant
		15 Bread products plant
		16 RTP
		17 Water Utility Company
		18 Firm "Progress"
		19 Brewery
		20 Repair and mechanical plant
		21 State forestry enterprise
		22 Cloth factory
		23 Plant "Estafeta"
		24 Furniture shop
		25 Paper mill
		26 Slavuta Roofing Plant LLC
		27 PJSC "Slavuta Glass Factory"
Tsvitokha village (south-east)	22-23	[redacted]
		29 RTP
Krupets village	10-12	30 "KHMELNYTSKEBUDENERGO" LTD
		31 PJSC "Slavuta malt plant"
Polyan village (north-east)	5-7	32 Sand quarry
		33 Paper mill
		34 Agrochemistry (Agricultural Chemicals)
Kryvyn village	5-7	35 Quarry of JSC "Volyn"
		36 OOO "ENERGOPIVDENZAKHIDMONTAZH"
Hannopil village	5-7	37 OJSC " Agricultural Chemicals"
		38 State Enterprise "Gannopol Distillery"
Ivanivka village	5-7	39 Feed mill
Stryhany village	5-7	40 Sand quarry
Romaniny village	5-7	41 Brick plant
Netishyn town	1-3	42 CJSC "Netishinharchprom"
		43 Atomenergoremont
		44 KHNPP Construction Department
		45 MU-7
		46 MU-13
		47 Khmelnytskyy Heat and Power Installation
		48 SU-3
		49 Khmelnytskyy ATP-16827
		50 Production and Trading Company "Dolphin"
		51 Atommontazhservice LLC
		52 LLC "Construction Industry KhNPP Construction Department"
		53 PE "Eximbud"
		54 Research and Production Commercial Enterprise Alfa LTD LLC
		55 LLC "Energy Complex KhNPP Construction Department "

Location area	Distance to NPP (km)	Name of the enterprise
		56 Simex LLC
		57 Ukrainian-Polish joint venture "Jurex-Ukraine"
		58 Collective Trade and Production Optical Enterprise "RITA"
		59 LLC "Production Enterprise "Turboelektromontazh"
		60 PE Company "Energogaz"
		61 Ukrainian-Polish joint venture in the form of a limited liability company "V.V.T."

Table 5.35 – List of enterprises in the Rivne region

Location area	Distance to NPP (km)	Name of the enterprise
Ostroh territorial community		
Ostroh town	8-10	1 Ostroh Brick Plant
		2 Ostroh Mineral Water Plant LLC
		3 OJSC Ostroh Furniture Factory
		4 Vilia factory
		5 Dairy plant
		6 Sugar factory
		7 Agriculture and construction company
	19-20	8 Fruit canning plant
		9 Ostroh Sugar Plant LLC
		10 Rivne Feed Mill LLC
		11 PJSC "Ostroh Grain Receiving Enterprise"
	4-6	12 CJSC "Agrotech"
	15-17	13 Private Production and Commercial Enterprise "Rembudmontazhservice"
	9-11	14 PJSC "Mohyla Plant of Building Materials"
	19-20	15 PE "Biogaztekhmontazh"
Hoshcha territorial community		
Hoshcha town (north)	30-32	16 Promin LLC
		17 Food products plant

The table shows that the closest to the NPP site enterprises are located as follows:

– 37 enterprises within a radius of 3-10 km. Of these, 20 are located in Netishyn and 7 in Ostroh;

– three economic facilities are in the village of Polyany; two are in the village of Kryvyn and the village of Hannopil; one is in the village of Stryhany, the village of Romany, and the village of Velbivno.

Under normal operation and in emergencies, dose loads on flora and fauna outside the SPZ will not lead to changes in their structure or other negative changes. The commissioning of Units 5 and 6, and the accident-free operation of KhNPP with six units (including planned Units 3 and 4) will not adversely affect the overall species diversity of invertebrates and insects (see also 5.2).

Following the commissioning of Units 5 and 6, no new technological processes are expected to be created that will result in the emission of any harmful substances into the atmosphere that are different from the existing ones, i.e. the launch of Units 5 and 6 will not have any negative impact on the SA facilities.

It is worth mentioning that Units 5 and 6 will not have any technological connections with Units 1-4, except for the technological wastewater systems, see also paragraph 5.3.3.

The performed dispersion measurements, taking into account the background air pollution and the influence of other air pollutants, showed no exceedances of the maximum permissible concentration standards, see also 1.5, 5.3, 5.4. The cumulative impact of the planned activity and neighboring polluting industrial enterprises is acceptable.

5.6 Impact of the planned activity on the climate, including the nature and scale of greenhouse gas emissions, and the sensitivity to climate change

The impact of KhNPP on the microclimate is determined by the performance of the cooling systems during the operation of six units, which include heat discharges, hydrothermal conditions of the cooling pond, cooling towers, and the nature of meteorological processes in the surface layer of the atmosphere.

Cooling systems can affect the microclimate of the air space directly above reservoirs and the environment in their boundaries.

The area of KhNPP impact will be local, namely: the impact of the cooling pond within 1.0 km, and the existing spray ponds – 0.3 km.

5.7 Technology and Substances Used

The environmental impacts caused by the technology and substances used are assessed considering the technology of hazardous chemicals and nuclear fuel management.

5.7.1 Handling chemicals and solutions

Chemicals that may impact the environment should be assessed using the Hazardous Substances Identification Methodology [58]. [redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

It is worth noting that the types, amounts, and quantities of chemicals consumed and the detailed list of chemicals for closed or open cooling systems depend on the site-specific WCR program, site water quality and treatment requirements, and the choice of site-specific equipment. Therefore, a detailed list will be compiled after the design and selection of site-specific equipment is completed.

Within the EIA report, the following hazardous substances are expected to be used in the technological process of Units 5 and 6:

- boric acid
- diesel fuel
- hydrogen
- lithium hydroxide;
- hydrazine
- zinc acetate;
- nitrogen.

Boric acid (H_3BO_3) is added to the reactor coolant to control reactivity. The Boric Acid Solution Tank (BAST) supplies borated water to the Reactor Coolant System (RCS) for replenishment after restarting operations to maintain the required boron content in the Reactor Coolant System (RCS) during power operation. The Chemical and Volume Control System (CVS) supplies boron-rich feed water to the Core Maintenance Tanks (CMTs), accumulators, the Inner Reactor Water Storage Tank (IRWST), and the spent fuel pool. The Boric Acid Solution Tank (BAST) is located in a separate bunded area with a concrete floor and walls of sufficient volume to prevent acid spills into the environment. Emissions from the boric acid solution preparation tank and chemical mixing tank will be discharged to the sump of the annex/auxiliary building (9.5 m^3). Discharge from the sump is carried out to the Waste Water system (WWS). During the Reactor Coolant System (RCS) loop draining and depressurization operations, the CVS receives water from the RCS. This water is transferred from the CVS to the liquid radioactive waste management system for treatment and discharge. There is a possibility of reactor coolant leakage through the reactor vessel flange O-rings. This wastewater is treated and discharged through the Liquid Radwaste System (WLS). There is a potential for reactor coolant to leak through the pressure compensator relief valves and the automatic pressure relief system (ADS) valves (saddle leakage). These leaks accumulate in collectors in the lower part of the distribution manifolds of the ADS valves. This wastewater is quantified, treated, and discharged through the Liquid Radwaste System (WLS). Thus, any potential emissions occur either through the Waste Water system (WWS) or through the liquid discharge point from the Liquid Radwaste System (WLS).

Diesel fuel is used for backup diesel generators, auxiliary diesel generators, and a diesel fire pump. The main components in the Standby Diesel Fuel Oil System (DOS) for diesel engines are located in separate, heated, fan-ventilated rooms installed on racks, and modular enclosures of transfer platforms on the site. The fuel transfer platform has a perimeter edge to hold spilled oil. All the underground fuel oil pipelines of the Standby Diesel Fuel Oil System (DOS) are protected and encased in a corrosion-resistant piping system to protect from oil leaks. In addition, the protective pipe has a monitoring and alarm system to detect leaks. Each fuel oil storage tank of the Standby Diesel Fuel Oil System (DOS) is located in a separate area with a reinforced concrete floor and walls, surrounded by a dam of sufficient volume to contain the entire contents of the tank in the case of an accidental leak or failure to prevent contamination of the underground aquifer. The purpose of the tank design is to localize the leak. Therefore, the only leakage point is the Waste Water System (WWS), as the tanks are discharged to the WWS. The WWS ensures that the oil is separated from the effluent from the sumps before it is discharged from the plant outfall.

Hydrogen gas (H_2) is added to the reactor coolant under pressure and maintained in solution to provide reducing conditions at normal operating temperatures to minimize general corrosion of primary circuit surfaces and fuel element vessel surfaces and reduce the risk of stress corrosion cracking (SCC) of sensitized stainless steels and nickel-based alloys. Hydrogen is added to maintain a reducing chemical environment and to create thermodynamically suitable oxide films on the surfaces of the Reactor Coolant System (RCS) that are similar to those that will be stable during operation. The hydrogen supply pipeline serving the Chemical and Volume Control System (CVS), as well as the pipelines of the Liquid Radwaste System (WLS) and the Gaseous Radwaste System (WGS), are postulated systems in which hydrogen is present during operation and in which the potential for leakage in the surrounding area is taken into account. Leakage points from other systems, including the Primary Sampling System (PSS) and auxiliary systems, were also investigated. The areas around the potential hydrogen leakage points have electrical classification zones defined under NFPA 70 (National Electrical Code). Gas release points are controlled as a part of the PU AP 1000's heating, ventilation, and air conditioning systems (HVAC) and do not generate any hazardous substances.

Lithium-7 hydroxide (^{7}LiOH) is added to the Reactor Coolant System (RCS) to create an alkaline atmosphere with the presence of boric acid at operating temperatures. 7LiOH is added as a concentrated solution from the chemical mixing tank in the CVS and if necessary mixed with demineralized water to be added regularly to the RCS. ^{7}LiOH is used to maintain an alkaline pH to minimize corrosion and the rate of corrosion product formation. The company will determine the amount of 7LiOH stored at the site in a warehouse.

Hydrazine (N_2H_4) is added to the reactor coolant when the reactor is restarted after a fuel reloading shutdown to remove dissolved oxygen after mechanical oxygen removal methods are completed. Hydrazine reacts with iron oxide and copper oxide to form protective oxide (passive) films. Hydrazine is added through the chemical mixing tank by the CVS. Hydrazine does not pose a threat to nuclear safety due to its infrequent use. In addition, employees involved in the work required to maintain safety functions do not need to be in areas where hydrazine may leak or be released (e.g., in the CVS pump station in the radioactive part of the annex building). Both the lithium hydroxide and a small portion of the hydrazine stockpile are stored in an annex building, which is a reinforced concrete structure of seismic resistance category I. It shares a common pedestal deck with the containment building and the shielded building. It protects the equipment and pipelines located in the building. The annex building provides a sufficient ventilation area from the main steam and feedwater pipeline shut-off valve compartments in the event of a postulated leak in the main steam or feedwater pipeline.

Zinc acetate is created and stored in a zinc injection equipment set that is part of the CVS to inject zinc acetate into the RCS. The addition of soluble zinc acetate to the reactor coolant causes zinc to incorporate into oxide films on the wetted surfaces of reactor coolant components, steam generator tubes, and RCS piping. It reduces the ongoing corrosion of austenitic stainless steel and nickel-based alloys. Zinc acetate is stored in a stainless steel zinc additive tank. The turbine compartment sump serves as a secondary containment for the zinc addition tank.

Nitrogen has no toxic effects under atmospheric pressure. The nitrogen injection equipment is located outdoors. The rest of the pipelines located indoors are of all-welded construction with valves without seals. The set of equipment for hydrogen injection is located outdoors. Other pipelines located indoors are of all-welded construction with valves without seals.

The storage places, hazard class, mass of hazardous substances, and class of the arresters are shown in Table 5.37.

Table 5.37 – Identification of hazardous substances

Production item	Name of hazardous substance/weight, t	Class or individual name of the hazardous substance	[redacted]	Class
Power unit No. 5 within the protected zone				
Annex building	Zinc acetate solution / 1.32 Hydrazine solution / 0.10 Lithium hydroxide solution / 0.02	H3 RANDOM TOXICITY Hydrazine 2-naphthylamine H3 RANDOM TOXICITY	[redacted] [redacted] [redacted]	-
Building of the turbine room and building of the first compartment of the turbine room	Zinc acetate solution / 1.32 Hydrazine solution / 1.00	Hydrazine 2-naphthylamine H3 RANDOM TOXICITY	[redacted] [redacted]	3
Diesel generator building	Diesel fuel № 2D / 13,34	Oil products and alternative fuels	[redacted]	-
Diesel fuel storage tank (DOS-MT-01A) and diesel fuel pumping unit (DOS-MS-01A)	Diesel fuel № 2D / 313,28	Oil products and alternative fuels	[redacted]	3
Diesel fuel storage tank (DOS-MT-01B) and diesel fuel pumping unit (DOS-MS-01B)	Diesel fuel № 2D/ 313,28	Oil products and alternative fuels	[redacted]	3
Boric acid tank	Boric acid solution / 306.13	E1 Category 1	[redacted]	1
Power unit No. 6 within the protected zone				
Auxiliary building	Zinc acetate solution / 1.32 Hydrazine solution / 0.10 Lithium hydroxide solution / 0.02	H3 RANDOM TOXICITY Hydrazine 2-naphthylamine H3 RANDOM TOXICITY	[redacted] [redacted] [redacted]	-
Building of the turbine room and building of the first compartment of the turbine room	Zinc acetate solution / 1.32 Hydrazine solution / 1.00	Hydrazine 2-naphthylamine H3 RANDOM TOXICITY	[redacted] [redacted]	3
Diesel generator building	Diesel fuel № 2D / 13,34	Oil products and alternative fuels	[redacted]	-

Production item	Name of hazardous substance/weight, t	Class or individual name of the hazardous substance	[redacted]	Class
Diesel fuel storage tank (DOS-MT-01A) and diesel fuel pumping unit (DOS-MS-01A)	Diesel fuel № 2D / 313,28	Oil products and alternative fuels	[redacted]	3
Diesel fuel storage tank (DOS-MT-01B) and diesel fuel pumping unit (DOS-MS-01B)	Diesel fuel № 2D / 313,28	Oil products and alternative fuels	[redacted]	3
Boric acid tank	Boric acid solution / 306.13	E1 Category 1	[redacted]	1
Permanent items within the protected zone				
Nitrogen-oxygen station	Liquid nitrogen / 10.50 Liquid hydrogen / 0.40	E1 Category 1 Hydrogen	[redacted] [redacted]	3
Permanent NPP facilities outside the protected zone				
Fire Protection System (FPS) diesel tank	Diesel fuel № 2D / 0,79	Oil products and alternative fuels	[redacted]	-

According to the materials provided by Westinghouse Electric Company, certain production units were identified as high-risk objects:

- The turbine building and the first bay of the turbine building of unit 5 were identified as Class 3 high-risk objects;
- The diesel fuel storage tank (DOS-MT-01A) and diesel fuel pumping unit (DOS-MS-01A) of unit 5 were identified as high-risk objects of Class 3;
- The diesel fuel storage tank (DOS-MT-01B) and diesel fuel pumping unit (DOS-MS-01B) of unit 5 are identified as high-risk objects of Class 3;
- The boric acid tank of unit 5 is identified as a high-risk object of Class 1;
- The turbine building and the first bay of the turbine building of unit 6 is identified as Class 3 high-risk objects;
- The diesel fuel storage tank (DOS-MT-01A) and diesel fuel pumping unit (DOS-MS-01A) of unit 6 are identified as a high-risk object of Class 3;
- The diesel fuel storage tank (DOS-MT-01B) and diesel fuel pumping unit (DOS-MS-01B) of unit 6 are identified as a high-risk object of Class 3;
- The boric acid tank of unit 6 is identified as a high-risk object of Class 1;
- The nitrogen-oxygen station is identified as a high-risk object of Class 3.

5.7.2 Nuclear Fuel Handling

The following stages of nuclear fuel management are envisaged within the planned activities

– storage of new nuclear fuel;
– use of nuclear fuel in nuclear reactors;
– transportation of new and spent nuclear fuel, radioactive materials, and waste;
– storage of spent nuclear fuel, radioactive materials, and waste.

The Fuel Handling and Refueling System (FHS) ensure safe nuclear fuel management. The main function of the Fuel Handling and Refueling System (FHS) is to move and store new and irradiated fuel within the power unit. The FHS system maintains fuel assemblies and active components in a subcritical state during handling and storage under both normal and emergency conditions. In addition, the FHS system is designed to ensure that equipment of seismic resistance category I function after a safe shutdown of the power unit during an MRS. Subcriticality during fuel transfer and storage is ensured by the geometrically safe configuration of the equipment involved in the transfer.

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[redacted]

[redacted]

Currently, the design scheme for spent fuel handling based on Holtec International technology is being implemented for Ukrainian NPPs. [redacted]

[redacted]

[redacted]

The storage site area is designed with the possibility of expansion considering the new generating and/or replacement construction facilities.

6 A DESCRIPTION OF THE FORECASTING METHODS USED TO ASSESS ENVIRONMENTAL IMPACTS AND THE ASSUMPTIONS UNDERLYING SUCH FORECASTING, AS WELL AS THE USED ENVIRONMENTAL DATA

To assess the dynamics of environmental indicators, impacts were assessed throughout the entire range of activities related to the work performed at the KhNPP industrial site.

The environmental impact assessment considered the aspects of the activity that may affect the state of resources and components of the natural environment, as well as the consequences associated with the impacts.

To determine the quantitative parameters of possible impacts, calculation methods, and expert assessments based on the results of engineering surveys at the project site were used.

The assessment of radiation factors takes into account the radioactive decay of radionuclides of existing environmental contamination, as well as additional potential contamination as a result of the planned activity.

In cases where there is no reliable initial data required to assess the environmental impact of the planned activity, a conservative approach is used. In particular, the calculations were performed under approved industry standards and regulatory requirements. [redacted]

In addition, appropriate software tools approved by the SNRIU were used to calculate the possible movement of radioactive contamination in the event of hypothetical maximum design basis accidents.

All available materials characterizing the current state of environmental components in the KhNPP area, monitoring data, results of engineering and other studies of previous years, cartographic materials, and other information were used as sources of information for the EIA.

Forecasting the dynamics of environmental indicators was performed using the EOL 2000 software, an automated system for calculating the dispersion of harmful substances emissions, which is included in the list of programs recommended by the Ministry of Environment of Ukraine. The calculation module of the system is implemented under OND-86 [61], the Methodology for Calculating the Concentrations of Harmful Substances in the air contained in the enterprises' emissions.

The specific information sources used in the preparation of the EIA materials are mentioned in the text as references and are provided in the section "List of References".

7 A DESCRIPTION OF THE MEASURES ENVISAGED TO PREVENT, PRECLUDE, AVOID, REDUCE, ELIMINATE A SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACT, INCLUDING COMPENSATORY MEASURES (IF POSSIBLE)

The AP1000 plant has been designed with environmental concerns as a priority. The safety of the public and the power plant workers, as well as the environmental impact has been addressed as follows:

- operational releases and discharges were minimized by design features;
- strict targets for personnel radiation exposure were set and satisfied. The targets are aimed at ensuring maximum employee safety and are implemented in accordance with ALARA principles. The targets are implemented through modern design solutions, high-tech monitoring systems, training programs and strict adherence to international safety standards;
- total radwaste volumes were minimized compared to reactors of previous generations by implementing technological and engineering solutions that increase the efficiency of nuclear fuel use, reduce the amount of waste generated during reactor operation, and optimize waste treatment and storage systems;
- improved safety performance by the introduction of passive safety systems, automation of technological processes and optimization of the number of operating personnel;
- other hazardous waste volumes (non-radioactive) were minimized.

The AP1000 plant safety approach has been specifically designed to maximize the plant robustness against catastrophic events resulting in extensive loss of infrastructure and a common-cause, complete loss of electrical power – both onsite and offsite. Specifically, the AP1000 plant is unique in that the plant response to a complete station blackout is considered as a design basis event and is embedded in the licensing basis.

This fundamental approach is at the basis of the AP1000 robustness against extreme external events.

7.1 Description of technical solutions to prevent accidents and localize releases of hazardous substances, ensure fire and explosion safety

The AP1000 is designed to prevent abnormal operation by utilizing its own safety margin and physical features (e.g., larger water volumes and reserves, negative power and temperature coefficients of reactivity).

To reduce the probability of deviations from normal operation that could lead to emergency situations, non-safety-related active systems are provided. These highly reliable active systems are the first level of protection against more likely events, as they are automatically activated and prevent unnecessary operation of passive systems important for safety.

To mitigate design basis accidents, the AP1000 plant is designed with passive safety features as a second level of protection. The passive safety systems do not require operator actions or AC power. These systems use only natural forces, such as gravity, natural circulation, and compressed gas to make the systems work. Simple valves actuate passive safety systems automatically. The valves are energized and held in the closed position under normal operation. An emergency signal or loss of power is required to trigger these valves in an emergency.

Fire safety of KhNPP Units 5 and 6 is ensured by fire prevention and fire protection subsystems, including organizational and technical measures. The specificity of KhNPP fire safety is that the fire safety systems of the facility are targeted and should primarily ensure radiation and nuclear safety of the facility.

The designed fire safety system for KhNPP Units 5 and 6 performs fire prevention and fire protection functions.

Preventing the formation of a flammable environment is ensured by a combination of the following measures:

– maximizing the use of non-combustible and not easily combustible substances and materials;
– limiting the mass of combustible substances and materials that are compactly located, placing them in the safest way;
– isolation of flammable environment (allocation of fire compartments and sections);
– installation of fire hazardous equipment in isolated rooms (fire compartments and sections);
– maximum isolation and automation of the technological process with spent nuclear fuel;
– use of devices to protect production equipment with flammable substances from damage and accidents;
– installation of cutoff, shutdown and other devices (including on ventilation system air ducts).

Preventing the formation of ignition sources in a flammable environment is achieved by a combination of the following measures:

– use of electrical equipment that meets the conditions of operation in explosive and fire hazardous areas in accordance with the Electrical Installation Rules;
– use of fast-acting means of protective disconnection of possible sources of ignition;
– compliance with electrostatic safety requirements;
– lightning protection of buildings and structures;
– eliminating conditions for thermal, chemical and/or microbiological spontaneous combustion of flammable substances.

Fire protection is achieved by a combination of the following measures:

- use of fire extinguishing means and appropriate types of fire fighting equipment;
- application of fire alarm systems and automatic fire extinguishing systems;
- use of non-combustible building structures and materials with standardized fire hazard indicators;
- use of space-planning solutions and devices that limit the spread of fire, such as:
  - division of the building into fire compartments and sections;
  - installation of fire barriers;
  - refractory elements in the equipment;
  - emergency shutdown of equipment, etc.;
- ensuring timely warning and evacuation of personnel through space-planning solutions and technical means;
- use of collective and individual protection means for people (personnel, fire units) against fire hazards and radiation exposure;
- use of technical means of smoke protection.

7.2 Justification for the acceptability of the design solution package

Westinghouse's AP1000 technology is the only Generation III+ reactor technology licensed by the U.S. Nuclear Regulatory Commission and in several European and Asian countries. The advantage of AP1000 reactors is a very high installed capacity utilization rate of 93% and an extended fuel cycle of 18 months. The AP1000 plant is a two-loop pressurized water reactor (PWR) that uses a simplified, innovative and effective approach to safety. The AP1000 design offers clear advantages, including high safety, economic competitiveness, and improved and more efficient operation.

The AP1000 reactor design is distinguished by its passive safety systems, record short fuel overload time, and, therefore, high efficiency. In addition, such a powerful reactor occupies a small area.

The safety of NPPs with the AP1000 reactor is ensured by a system of technological and organizational means:

- use of the internal self-protection properties of the reactor unit;
- application of the defence-in-depth concept;
- use of safety systems designed using a single failure principle, diversity, redundancy and physical separation;
- use of approved engineering and technical practices;
- compliance with nuclear and radiation safety regulations, as well as compliance with the requirements set forth in the AP1000 basic design;
- maintaining and improving the safety culture;
- use of the quality management system at all stages of the nuclear facility life cycle;
- ensuring appropriate training and qualification of personnel;
- use of operational experience;

The AP1000 plant safety is ensured by the consistent implementation of a defence in depth strategy based on the following:

- preventing deviations from normal operation;
- detecting deviations from normal operation and providing means to prevent such deviations that may lead to emergency conditions;
- providing engineering safety measures to control and mitigate emergency conditions. In addition, the prevention and mitigation of severe accidents is considered through the development and use of probabilistic risk assessment.

The AP1000 design combines proven design concepts and operational experience from existing PWR plants. It is applied to a defined set of functional requirements in the simplest and most efficient way possible.

Compliance with environmental requirements shall be ensured in accordance with the established restrictions: environmental, sanitary and epidemiological, urban planning and fire protection. The limits are set according to a number of criteria:

- internal and external exposure of personnel and the public;
- maximum permissible emissions and discharges to the environment;
- the amount of chemical emissions of harmful substances into the atmosphere;
- concentration of harmful substances in the surface layer of the atmosphere;
- volumes of special water use and discharges;
- area of the sanitary protection area and supervised area.

During the siting, design, construction, operation, lifetime extension and decommissioning of power units, the requirements of legislative acts and applicable environmental regulations are met, i.e., environmental safety (the state of environmental protection against disruption of its ecological balance) shall be ensured.

The rational use of natural resources, compliance with the established requirements for environmental pollution, and compliance with existing agreements will be ensured by implementing the comprehensive measures envisaged by the design of units 5 and 6, which cover all aspects of environmental compliance:

- measures to conserve resources (conservation and rational use of land, water, energy, and fuel resources, reuse of resources);
- protective measures:
  - architectural, construction and planning solutions;
  - measures to reduce radiation impact on the environment;
  - measures to reduce non-radiation impact on the environment;
- restoration measures:
  - technical and biological reclamation;
  - normalization of the state of certain environmental components;
- compensation measures:
  - compensation for inherent damage during normal operation of the power unit;
  - assessment of the necessary costs to compensate for damage to the public and the environment in the event of an accident;
- security measures (monitoring systems):

- radiation monitoring system at the NPP site and adjacent territory;
- surface and groundwater monitoring systems;
- monitoring biocenoses and populations of surface water (bioindicators of thermal impact, eutrophication and radionuclide contamination);
- system for monitoring geological processes and soil conditions;
- system for monitoring the condition of the foundations of buildings and structures;
- warning system in the NPP supervised area.

Liquid or solid radioactive waste management and storage is carried out in accordance with the requirements of the General Safety Provisions for Radioactive Waste Management Prior to Disposal.

To detect possible leaks of liquid radioactive media on the NPP territory, the observation wells equipped with water sampling tools for monitoring are provided.

The NPP is a source of environmental pollution, the radioactive impact of which is manifested only in the event of beyond design basis accidents.

7.3 Protection of the environment from ionizing radiation

During plant operation, the following measures and devices ensure environmental protection against ionizing radiation:

- localization barriers in accordance with the defence in depth principle;
- creation of closed loops with radioactive media;
- arrangement of primary pressurized systems within the containment;
- creation of intermediate cooling water circuits;
- division of production rooms into restricted and normally occupied areas;
- division of ventilation systems of restricted and normally occupied areas;
- creation of an organized collection and treatment of radioactive leaks;
- creation of an organized collection of liquid and solid radioactive waste;
- storage and processing of waste in a special building;
- maintaining radiation and climatic conditions in production rooms by means of ventilation systems;
- accident localization system.

Protective measures against the release of radioactive substances into the atmosphere, surface and groundwater, soil and food chains are ensured as follows:

- a special containment system that prevents the spread of radioactive substances into the environment;
- an air purification and removal system that provides for the following basic measures:
  - the exhaust air containing radioactive isotopes is purified using aerosol and iodine filters;

– separate measurements are performed to determine the presence of inert gases, aerosols and iodine;

– the ventilation system maintains the pressure in the containment area below atmospheric pressure, which ensures that in the event of any leakage from the primary circuit, air from the containment area passes through the filters with constant monitoring of its activity;

– cleaning of process blowdowns is carried out on filters where most of the radioactive isotopes of xenon and krypton decay;

– organized air emission from the restricted area premises of the nuclear island and the radioactive waste management building (carried out through ventilation pipes that ensure the necessary dispersion of emitted radionuclides in the atmospheric air to concentrations below permissible levels);

- establishment of sanitary and protection area;
- emission control system in each ventilation pipe, which is carried out continuously using a centralized system, as well as individual devices;
- control of the concentration of radioactive iodine aerosols before and after filters of ventilation systems.

The Containment Air Filtration System (VFS) [62] provides the following functions to limit the exposure of plant personnel and the general public to airborne radioactivity:

- the VFS purges the containment atmosphere of airborne contamination during normal operation to an acceptable radiation level;
- the VFS purges the containment atmosphere to reduce potential airborne contamination during cold shutdown for personnel protection;
- the VFS treats the containment exhaust air to maintain normal gaseous radiological releases at safe levels when combined with gaseous discharges from other sources;
- the VFS monitors the radioactive effluents discharged to the environment through the plant vent;
- the plant vent minimizes the re-entry of effluents into the HVAC fresh air intakes.

The Gaseous Radwaste System (WGS) receives, processes, and discharges the radioactive waste gases received within acceptable off-site release limits during normal modes of plant operation including power generation, shutdown and refueling [63]. The WGS is a once-through ambient temperature activated carbon delay system.

The WGS is designed to eliminate sources of hydrogen ignition. Discharge to the VFS is downstream of the Radiologically Controlled Area Ventilation System (VAS) exhaust fans to provide additional protection against hydrogen ignition.

The Radwaste Building HVAC System function is to maintain suitable environmental conditions for equipment and personnel working in the area. The specific functions of the system are:

– provide conditioned air to all work areas to maintain acceptable temperatures for equipment and personnel working in the areas;

– ensure that air movement is from clean to potentially contaminated areas to minimize the spread of airborne contaminants;

– collect the vented discharges from all potentially contaminated mobile equipment;

– radiation monitoring by the Radiation Monitoring System (RMS) of all potentially contaminated exhaust air prior to release to the plant vent;

– maintain the Radwaste Building at a negative pressure with respect to outdoors to prevent unmonitored releases from the Radwaste Building;

– provide once-through ventilation of the Radwaste Building with no recirculation of potentially contaminated air.

To protect groundwater from contamination, units 5 and 6 have a liquid radwaste system (WLS) designed to monitor, collect, process, treat, store and dispose the liquid radwastes generated during normal operation.

To prevent a water-borne activity discharge, the containment isolation valves, piping and electrical penetrations, hatches, and the containment are installed with the following safety functions:

- automatic isolation of pipelines crossing the containment is necessary to ensure the containment integrity;
- leakage of the containment, penetrations and isolation valves is less than the design leakage at the design containment pressure, which meets the requirements for leakage tests [64].

The WLS performs the following safety-related functions:

– automatic isolation of WLS lines that penetrate the Containment Building;

– overpressure protection of containment penetrations.

The WLS provides these non-safety related functions:

– to receive and process Reactor Coolant System (RCS) effluent;

– to receive and process radioactive equipment drains, including those from the WLS;

– to receive and process radioactive floor drains, including those from the WLS;

– to receive and accumulate radioactive hand-wash and shower-drain wastes from the Radioactive Waste Drain System (WRS);

– to receive and accumulate radioactive chemical wastes from the WLS;

– to receive and process water from the spent fuel handling subsystem and the Solid Radwaste System;

– to receive and process water from relief-valve discharges into the containment, including those from the Normal Residual Heat Removal System (RNS), Chemical and Volume Control System (CVS), and Passive Core Cooling System (PXS);

– to transfer any of the chemically contaminated influents to the WLS to a mobile equipment processing facility in the Radwaste Building. After treatment by mobile equipment, the WLS may receive the treated water for additional processing or discharge;

– to maintain a separation between incompatible waste streams.

Radiation protection of the operating personnel and contamination aversion of the environment in the SRW system is ensured by:

- special equipment for SRW handling (containers, vehicles, etc.);
- mechanical means for transfering operations;
- radiation monitoring and decontamination equipment.

All SRW transport and processing operations are performed with radiation monitoring to ensure radiation safety of the plant personnel.

All shields designed to protect against the release of radionuclides into the environment are monitored by the NPP's RM system.

7.4 Measures to reduce non-radiation environmental impact

A nuclear power plant with AP1000 provides features and capabilities to minimize emissions and related environmental impacts. NPP emissions can be divided into two categories: liquid and gaseous emissions.

All chemical emissions into the atmosphere are periodic and do not lead to a violation of the regulatory state of the atmosphere surface layers and ensure the lowest possible level of impact. Thus, the design does not provide for special measures to reduce air pollutant emissions.

The following measures will be taken to prevent or reduce the flow of pollutants into the aquatic environment, as well as to protect surface waters from depletion during the construction and operation of the facility:

- the NPP has a reverse process water supply system designed to minimize the environmental impact on surface water bodies of public use;
- it is a designed equipment cooling system of power units 5 and 6 with cooling towers at the NPP. It allows to reduce the volume of water taken from the reservoir and use one only for feeding the Service Water System (SWS), Circulating Water System (CWS) and cooling tower blowdown;
- all NPP wastewater after treatment is directed to the cooling pond and is not discharged directly into public water bodies;
- the NPP cooling pond is a regulating reservoir that allows water intake from the Goryn River only during high-water periods and, accordingly, does not affect the water management situation in the Goryn River basin;
- all NPP reclaimed water entering the cooling pond are subject to hydrochemical control;
- in case of exceeding the level of mineralization and concentration of biogenic elements in the cooling pond, it shall be purged within the limits of their maximum permissible concentrations (MPC) established by sanitary standards;
- to comply with the temperature conditions in the control point stipulated by the sanitary standards by diluting the blowdown water, which is controlled by appropriate water temperature measurements;

- to monitor the hydrobiological state of the KhNPP technical and ecological system, to study the conditions of existence of aquatic communities, their structure and quantitative indicators in the background water bodies (Hnilyi Rih River, Horyn River);
- the laboratory of the KhNPP subdivision monitors the chemical composition and water temperature at sampling points in the cooling pond, inlet and outlet channels;
- compliance with the requirements of the current legislation on the protection and rational use of surface water.

In addition, the following measures will be taken to prevent or reduce the flow of pollutants into the water environment:

- use of water for drinking purposes should be carried out only upon confirmation of compliance of water quality with the requirements [20];
- keeping regular records of water withdrawn in the logs of the established form, its quality and water level depth in the wells;
- maintaining water meters for water accounting, crane devices for water sampling for laboratory analysis, compliance with the requirements of the sanitary mode of the groundwater protection areas [65];
- monitoring of groundwater regime (level, temperature, chemical composition);
- compliance with the requirements of the current legislation on the protection and rational use of groundwater.

The noise impact from sources located on the industrial site on facilities outside the NPP sanitary protection area is within normal limits.

Chemicals used in the AP1000 plant are stored on the nuclear island, Turbine Island, and in the yard.

The chemicals are used for a variety of purposes and are applied to the primary side, secondary side, passive cooling systems, closed cooling water systems, and other AP1000 applications [59].

Many of these chemicals are stored in Chemical Storage Area in the Turbine Building. To prevent any leakages from the Turbine Building to the environment, the area of potential releases are diked with sufficient volume to contain the leaked volume of the chemical. For chemicals stored in the Service Water System (SWS) Chemical Treatment Building, there are individual prefabricated cubicles with individual containments to separate chemicals and their vapors to avoid chemical interactions [59].

The Chemical and Volume Control System (CVS) provides the means for adding chemicals to the RCS.

The boric acid storage tank (BAST) supplies borated water to the RCS. The BAST is contained in a separate concrete floored and walled diked area with sufficient volume to prevent spilling the acid to the environment. The Annex/Auxiliary Building Sump will manage releases from the Boric Acid Batching Tank and Chemical Mixing Tank (9.5 m^3 of volume). Discharge of the sump is to the Waste Water System (WWS) [59].

Therefore, any potential discharges are either through the WWS or the WLS liquid discharge release point.

Diesel Oil Fuel is used for standby diesel generators, ancillary diesel generators, and the diesel driven fire protection pump. Diesel fuel is stored on the AP1000 plant site.

The Standby Diesel Fuel Oil System (DOS) design conforms to the requirements [59]. The major components in the DOS for the diesel engines are enclosed in separate, heated, fan ventilated, skid mounted, modularized transfer skids enclosures in the yard. The fuel transfer skid has a lip around the perimeter to retain diesel fuel spills. The skid has four floor drains to catch fuel oil spills. The diesel fuel from the drains is routed to the WWS for its separation and processing [59].

All buried DOS diesel fuel transfer piping is protected and enclosed within a corrosion resistant containment spill protection piping system. The protection pipe has a leak detection monitoring and alarm system [59, 66].

Each DOS Diesel Fuel Storage Tank is contained in a separate reinforced concrete floored and walled diked area with sufficient volume to contain the entire tank contents of an accidental leak or failure in order to prevent contamination of the underground aquifer. Each diesel fuel tank area includes a sump area for water collection and drainage to the WWS. The dike is designed to be capable of capturing the maximum probable precipitation rainfall for testing of the rainwater contained in the dike before discharge [59].

For each tank, the design objective is to contain the leak. Therefore, the only release point is via the WWS as the sumps are discharged to the WWS. The WWS provides separation of diesel fuel from the sump discharges before release from the plant outfall [59].

The equipment and floor drainage systems collect liquid wastes from equipment and floor drains during normal operation, startup, shutdown, and refueling [67]. The liquid wastes are then transferred to appropriate processing and disposal systems.

Equipment and floor drainage is segregated according to the type of waste. Liquid wastes are classified and segregated for collection as follows:

- radioactive liquid waste
- nonradioactive liquid waste
- chemical and detergent liquid waste
- oily liquid waste

Nonradioactive and Potentially Radioactive Waste Drains

The waste water system collects nonradioactive waste from floor and equipment drains in auxiliary, annex, turbine, and diesel generator building sumps or tanks. Selected nonradioactive liquid wastes and tanks are monitored for radioactivity to determine the liquid wastes have not been inadvertently contaminated. If contaminated, the wastes are diverted to the liquid radwaste system for processing and ultimate disposal.

Chemical Waste Drains

The radioactive waste drain system collects chemical wastes from the auxiliary building chemical laboratory and decontamination solution drains from the annex building and directs these wastes to the chemical waste tank of the liquid radwaste system.

Detergent Waste Drains

The laundry and respirator cleaning functions that generate detergent wastes are performed offsite. Detergent wastes from hot sinks and showers are routed to the chemical waste tank.

Oily Waste Drains

The waste water system collects nonradioactive, oily, liquid waste in drain tanks and sumps. Drain tank and sump liquid wastes are pumped through an oil separator prior to further processing. The oil is collected in a tank for disposal.

Sampling for oil in the waste holdup tank of the liquid radwaste system is provided to detect oil contamination before the ion exchanger resins are damaged. Oily water is pumped from the tank through an oil adsorbing bag filter before further processing. The spent bag filters are transferred to drums and stored in the radwaste building.

7.5 Comprehensive measures to reduce negative impact on the air environment

The project provides for the following measures to prevent negative impact on the air environment and reduce pollutant emissions into the atmosphere:

– preventive measures – planning, standardization, regulation, design of construction and reconstruction of factories and other facilities that impact or may impact the air quality, establishment of a sanitary protection zone, sanitary-hygienic expertise, governmental accounting, monitoring, etc.;

– implementation of measures to prevent and reduce air pollution by transport emissions and other mobile vehicles and facilities and their physical factors impact. They include development and implementation of a set of measures to reduce emissions, neutralize harmful substances and physical impact during the design, manufacture, commissioning and repair of transport and other vehicles and facilities; conversion of transport and other vehicles and facilities into less toxic fuels; improving the maintenance of transportation routes; improving fuel transportation and storage technologies;

– implementation of legal measures – regulating the implementation of preventive measures against its contamination by industrial, household and other releases. It is determined that to warehouse, place, store or transport the industrial and household release that is a source of air contamination with pollutants and substances with an unpleasant smell or other harmful effects, is allowed only with a special authorization in the territories designated by local executive authorities and local self-government bodies, in compliance with environmental safety standards and subsequent utilization or disposal. It is prohibited to incinerate such wastes on the enterprise territory, except when it is carried out using special facilities under the requirements established by the legislation on atmospheric air protection. The owners or the authorized bodies are obliged to ensure the processing, utilization and timely release transportation that pollutes the air to enterprises that use it as raw materials or to specially allocated places or facilities;

– implementation of security measures – preventing, reducing and achieving safe levels of industrial and other noise. They should be ensured by creating and implementing low-noise machines and mechanisms; improving the transport design and other mobile vehicles, facilities and their operating conditions, as well as maintaining railways, roads, pavement, etc. in proper condition;

– implementation of preventive measures – regulating the conditions for designing, building and reconstructing an enterprise. They are carried out with obligatory compliance with environmental safety standards, government sanitary requirements and rules at the facilities planned for this purpose, as well as taking into account the accumulation and pollution transformation in the atmosphere, its transboundary transfer, and the specifics of climatic conditions;

– approval of development projects for construction and reconstruction of enterprises and other facilities, that impact or may impact the atmospheric air is carried out by a specially authorized executive body for urban planning and architecture, under the conclusions of environmental, sanitary and other executive authorities or local self-government bodies in accordance with their powers as defined by law. The construction and commissioning of new and reconstructed enterprises and other facilities is prohibited if it does not meet the requirements for air protection prescribed by law;

– use of equipment with high environmental characteristics and systems for emissions purification from harmful components, application of the control measurement devices and automatic system for reliable protection of operating equipment, control over the density of all connections.

During the equipment operation, a set of organizational and technical measures is envisaged to reduce pollutant emissions into the air:

– compliance of technological regulations and fire safety requirements;
– maintaining complete technical readiness of equipment and pipeline integrity;
– maintaining equipment in proper operating condition;
– the systematic valves tightness monitoring, fittings and pipeline connections;
– compliance of the prescribed standards of permissible limit release for contaminants into the air (performed by specialized services using the instruments equipped in the company's laboratory);
– regulating pollutant emission into the atmosphere during periods of adverse meteorological conditions (AMC).

7.6 Remediation measures

7.6.1 Technical and biological reclamation

The land of the State Forestry Fund and marginal agricultural land were allocated for the construction of the KhNPP. Land was alienated for the KhNPP construction. The reclamation activities were completed by the time unit 1 was commissioned.

Soil degradation processes associated with the construction of NPP units are common only in the industrial site area. Their presence in the KhNPP SA is practically not related to the plant operation.

Given the absence of additional environmental contamination with radionuclides during normal operation of the plant, special agrotechnical measures with changes in the structure of agricultural land use, re-profiling of agricultural sectors and changes in technological processing of products are considered inappropriate.

The need for special measures may be caused only by exceeding the established levels of radionuclide contamination of agricultural products, which may exceed the dose limit established for the public. According to the assessment, the additional contribution to contamination of various agricultural products with long-lived radionuclides due to gas and aerosol emissions is lower than the existing contamination, which, in turn, is significantly lower than the established permissible levels.

In the considered emergency situations, contamination of certain territories is possible at levels that will determine the agricultural products produced on these lands as not meeting the established permissible levels. In this case, countermeasures may be applied, the decision to take which is based on an analysis of the actual situation. The procedure for applying countermeasures is regulated by DGN 6.6.1.-6.5.001-98. Countermeasures are used not to reduce the impact on the soil, but to reduce the dose load on the population.

It is advisable to use mushrooms, as well as pine, blueberries, mosses and lichens (for each of the tiers) as bioindicators of contamination, for which there is a sufficient database and the corresponding dependencies have been established.

7.6.2 Normalization of vegetation, fauna and nature reserves

Anthropogenic impacts vary in scale and impact under the current KhNPP operating mode. The main factors that change and reduce the resilience of plant communities are the following: plowing, felling, grazing, haymaking, recreation, land reclamation, construction, quarrying (removal of soil and geological rocks), artificial plantations that do not meet environmental conditions, fires, etc.

A comprehensive assessment of the impact of all these factors shows significant changes in vegetation cover and destruction of ecosystems.

The commissioning of new power units, further development of infrastructure, and an increase in the number of service personnel will lead to a certain increase in the impact on natural complexes and vegetation, but it is possible to limit it by creating new protected areas, monitoring and control.

The KhNPP SA contains 47 nature reserve fund objects with different protection degrees, the area of which is more than 3000 hectares. This is slightly more than 1% of the area territory, which is four times lower than the national indicator. Protected objects belong to four categories: nature reserves (of national and local importance), natural monuments (of national and local importance), protected tracts, and park and garden art monuments. Of the 47 nature reserve fund objects, 7 are of national importance, and the remaining 40 are of local importance.

Forest management should adhere to the optimal ratio of natural and transformed community types, which will stabilize the situation in the context of the normal operation of new power units.

According to the Decree of the President of Ukraine, a national nature park "Male Polissia" with an area of 8762.7 hectares is being created in Slavuta and Iziaslav districts of Khmelnytskyy region.

The boundaries of the national park are conditionally laid out by river valleys and the KhNPP cooling pond. In the north - the Goryn River and the cooling pond; in the east - the Goryn River; in the northwest - the Vilia River; in the south - the tributaries of the Goryn River and the Vilia River. Most of the southern and southeastern part of the nearer supervised area will be included in this National Park. The creation of the park will help preserve the unique natural resources of the region.

There is every reason to believe that the regional structure of natural ecosystems will be preserved.

7.7 Compensation measures

The legislation of Ukraine provides for economic measures to stimulate activities aimed at reducing the environmental impact, namely:

- limits on the use of natural resources and pollutant emission standards;
- setting environmental tax rates for environmental pollution and the use of natural resources;
- compensation in accordance with the established procedure for damages caused to the environment as a result of violation of environmental legislation.

The above payments, which are regularly made by KhNPP during the operational period, go to the state and local budgets and can be used to finance measures related to environmental protection and damage compensation, depending on the budget allocation at the state or regional level.

Compensation measures in the social sphere include the following aspects:

- increase in electricity generation for the needs of the population, utilities and industrial enterprises;
- new jobs for construction and installation personnel and engineering and technical personnel, additional jobs for the population both during the construction of the NPP and during operation;

- resettlement of additional construction and installation personnel and then operational personnel near the NPP under construction will stimulate the need to expand the scope of social services that also cover the local population.

Fish farming of herbivorous fish has been organized in the cooling pond area to prevent its siltation.

The additional levels of contamination of the soil under normal operation of the plant are tens of thousands of times lower than the existing background contamination. Given the fact that radionuclides enter the soil in ultra-micro quantities, they cannot affect soil fertility in any way. Their content in soils is much lower than the content of nutrients and they cannot compete with them when it comes to plant growth. The radionuclides in soils also do not affect the quality of the products and yields. Therefore, under normal operation of the plant, it is not advisable to take special agrotechnical measures aimed at reducing the impact on the soil. Thus, no damage will be caused by contamination of land and agricultural products under normal operating conditions of KhNPP Units 5 and 6.

Atmospheric air and land resources will not experience anthropogenic load from the operation of KhNPP Units 5 and 6.

8 DESCRIPTION OF THE EXPECTED SIGNIFICANT ADVERSE ENVIRONMENTAL ACTIVITY IMPACT CAUSED BY THE PROJECT'S VULNERABILITY TO DISASTER RISKS, MEASURES TO PREVENT OR MITIGATE THE DISASTER IMPACT ON THE ENVIRONMENT AND EMERGENCY RESPONSE MEASURES

Following the IAEA recommendations set out in the document "Basic Safety Principles for Nuclear Power Plants" INSAG 12, the goals and obligations of Energoatom to ensure and maintain the safety of nuclear facilities are defined in the Safety Policy Statement of Energoatom, which is available on the official website of the company.

Protecting people and the environment from radiation exposure during the construction, commissioning, operation, and decommissioning of nuclear facilities is the highest priority of Energoatom's activities.

Energoatom is entirely responsible for the nuclear and radiation safety of nuclear facilities at all life cycle stages and gives unconditional priority to safety over other goals.

The main objectives of Energoatom are to maintain and improve the design safety level of nuclear facilities based on the obligations under the Convention on Nuclear Safety, the results of scientific and technical research and development, operational experience, as well as the implementation of a new effective program for the protection of nuclear facilities from hazardous impacts, including ones caused by military aggression.

Energoatom ensures continuous monitoring and analysis of the safety of nuclear facilities.

Energoatom maintains constant communication with the public, informing them about the safety status and activities to improve safety.

8.1 AP1000 design

The AP1000 plant has been designed with environmental requirements as a priority. The public safety and power plant employees, as well as the environmental impact, are addressed in this way:

- Minimized Operational emissions and discharges through design features.
- Set and met strict targets for personnel radiation exposure. These targets are aimed at ensuring maximum employee safety and are implemented in accordance with the ALARA principles. The targets are implemented through modern design solutions, high-tech monitoring systems, training programs and strict adherence to international safety standards.
- The reduced total amount of radioactive waste compared to previous generations of reactors.
- Other minimized hazardous waste (non-radioactive).

AP1000's approach to safety has been specifically designed to maximize the nuclear power plant's resistance to disaster events that result in major infrastructure damage and total loss of power from a common cause, both on and off-site. In particular, the AP1000 plant is unique in that a complete power outage is considered a design event and is built into the design. The fundamental approach that underpins the AP1000's resistance to extreme external events (such as Fukushima): the AP1000 was designed with passive safety systems to eliminate reliance on additional support systems, thereby creating a safer design and more independent:

1. In the case of a power outage, critical Structures, Systems, and Components (SSCs) automatically achieve a fail-safe configuration without the need for operator action or AC/DC power.

2. The AP1000's passive approach to safety reduces the importance of the AC power supply and cooling by providing long recovery periods from events, that would result in a prolonged plant outage and/or prolonged loss of connection to the final heat sink.

3. The structures, systems, and components (SSCs) critical to bringing the reactor to a safe shutdown state are protected within a steel containment and surrounded by a robust reinforced concrete composite shield. The CS building is designed following the latest US NRC, EUR, and WENRA regulations to withstand commercial aircraft impact.

The facilities of KhNPP Units 5 and 6 are based on the design configuration of the reference NPP. The reference NPP is the Vogtle NPP with two AP1000 units 3 &4 located in Burke County near Waynesboro, Georgia in the southeastern United States. The design life of the AP1000 power unit is 60 years.

The American AP1000 technology is the only Generation III+ reactor technology that has received a license for construction and operation from the U.S. Nuclear Regulatory Commission (U.S. NRC).

Today, NPPs with AP1000 reactor units are safely and reliably operated in China and the United States (6 units in total):

– Sanmen NPP Unit 1 in China began commercial operation in September 2018. It became the first power unit with AP1000, which was built and commissioned using this technology for the first time.
– Haiyang-1 and Sanmen-2 were commissioned in November 2018. The Haiyang-2 power unit began commercial operation in January 2019.
– In the United States, two Vogtle NPP units were commissioned - No. 3 (in July 2023) and No. 4 (in April 2024).

The launch, commissioning, and operation of AP1000 units demonstrated the effectiveness of the inherent design features of passive safety systems. Moreover, tests of AP1000 power units proved the availability of sufficient reliability reserves and high power generation performance.

The AP1000 design has been developed under a set of US codes and standards, the vast majority of which are recognized as international best practices and are recognized in EU countries. Therefore, to ensure the implementation of the AP1000 project, the operating organization is already coordinating with the regulatory authority the regulatory framework that will be used for design, fabrication, installation, normative regulation plan (NRP), and licensing. This task consists of two fields:

– acceptance of construction and general industrial standards of the United States in the form of State Standards, ISO, and Departmental Building Codes (DBC);

– resolving the issue of applying NUREG, ANS, ANSI, and ASME norms,) rules and standards and using them in licensing and nuclear and radiation safety reviews.

Licensing of certain stages of the nuclear facility life cycle (construction and commissioning, operation, and decommissioning) will be carried out following the national legislation.

8.2 Probabilistic Safety Assessment

The probabilistic safety analysis (PSA) for AP1000 reactor units was performed in accordance with ASME/ANSI standards approved by the NRC. The PSA models are recognized as meeting the NRC PSA safety objectives and relevant regulatory guidance. PSA models focus on the magnitude and outcomes of internal initial events, internal flood, internal fire, seismic hazards, and other external hazards. The PSA also describes the defenth in depth model during shutdown and the process of maintaining the proper condition.

Probabilistic safety analysis for power units is a comprehensive analysis that includes full-scale Level 1 and Level 2 “at power” PSA.

Level 1 analysis includes:

– assessment of internal initial events;
– analysis of the event tree and success criteria;
– analysis of plant systems using fault tree models;
– analysis of common cause failures and human reliability;
– data analysis;
– quantitative calculation of the CDF.

Level 2 analysis includes:

– assessment of severe accident phenomena and fission product source conditions;
– modeling of the containment event tree and associated success criteria;
– analysis of hydrogen combustion and mixing;
– quantitative calculation of the CDF.

The PSA results indicate that the AP1000 design meets the higher expectations and goals for the next generation of passive pressurized water reactors (PWRs).

The NF severe damage frequency in the core and maximum accidental release frequency (MARF) for internal events during power operation (excluding seismic events, fires, and floods) are 3,94E-07 one-reactor events per year and 3,83E-08 one-reactor events per year (according to NP 306.2.245-2024, such criteria should not exceed 1E-6 per reactor per year and 1E-7 per power unit per year). These frequencies are at least two orders of magnitude lower than for typically operated pressurized water reactors. The risk reduction is attributed to many plant design features, with the dominant reduction coming from highly reliable and redundant passive safety systems that address both reactor operation and shutdown risks. These passive systems are much less dependent on operator actions and auxiliary systems than the factory systems at currently operating plants.

Conservative, limit estimates of fires and floods show that the reactor core damage risk due to these events is small compared to the reactor core damage risk due to events related to power line accidents and outages.

A summary of the PSA`s conclusions on the AP1000 construction:

- The AP1000 design benefits from the high level of redundancy and diversity of passive safety systems. Passive systems have proven highly reliable; the design is simple, requiring a limited number of components to function.
- The AP1000 is less reliant on non-safety-related systems than modern plants or advanced evolutionary light water reactors.
- Non-safety support systems (AC power, cooling water for components, process water, and air for instrumentation) play a limited role in the plant's risk profile because passive safety systems do not require cooling water or AC power.
- The AP1000 is less reliant on human actions than modern plants or advanced light water reactors in the process of evolution.
- The core damage frequency and the limited accidental release frequency are low, despite the conservative assumptions made when defining the success criteria for passive systems.
- Individual systems failures or components are not too important due to the redundancy and diversity of safety-related systems.
- Passive safety systems are available in all shutdown modes. Scheduled maintenance of passive functions is only performed during shutdown modes when the function is not important for risk. In addition, scheduled maintenance of the non-safety-related advanced protection functions used during shutdown is performed during power-up.
- The passive cooling construction of the AP1000's containment vessel is very reliable. Air cooling is of great importance and can prevent containment destruction, although the construction has other defense lines to cool the containment, such as fan coolers and passive water cooling of the vessel.
- The potential for containment bypass is reduced due to fewer pinholes that could lead to fission product leakage.
- The lower part of the reactor vessel has no through-holes, which eliminates through-hole failure as a potential cause of reactor vessel failure. Preventing the movement of molten core fragments into the containment eliminates several severe accidents, such as fuel-coolant interaction outside the reactor vessel and core-concrete interaction, which could threaten the integrity of the containment. Therefore, AP1000, by

preventing the movement of core debris into the containment, significantly reduces the containment failure probability.

- The potential for fires and flooding to spread to safety-related equipment is significantly reduced by the AP1000 design.

The PSA results for internal events that initiate the emergency at the power plant demonstrate that the AP1000 containment construction is reliable in preventing releases following a severe accident and that the risk to the public from severe accidents for the AP1000 is very low. The frequency of the limited accidental release (containment failure rate) at AP1000 can be divided into two types of failures:

1) the defective containment, in which the containment integrity is either compromised due to the initiating event or has never been achieved since the beginning of the accident;

2) containment failure caused by high-energy phenomena of a severe accident. The sum of these failures is the total frequency of the limited accident release.

The quantitative assessment results of the event tree in the containment structure for the frequency of the limited accidental release are important:

- the total frequency of the limited accidental release for the AP1000 is 1.95E-08 events per year. This is approximately 8 percent of the reactor containment damage frequency for internal initial power-up events. The ability of the containment to prevent releases (i.e., containment effectiveness) is 92 percent.
- the Level 3 analysis shows that the risk to the public is small and within acceptable limits.

The PRA's results in accordance with the AP1000 Design Control Document for Units 5 and 6, namely the nuclear fuel severe damage frequency in the core and the frequency of accidental releases, are presented in Table 8.1. The results of the PSA models demonstrate that the ones and results meet the safety objectives of the NRC PRA. In addition, for comparison, Table 8.1 shows the assessment of the fulfillment of the safety criteria for KhNPP Units 1 and 2.

Table 8.1 – Results of probabilistic risk assessment of AP1000 and WWER-1000 for internal events

	Core damage frequency per reactor per year	**Limited accidental release frequency per reactor per year**
Power unit No. 5 (AP 1000)	3,94E-07	3,83E-08
Power unit No. 6 (AP 1000)	3,94E-07	3,83E-08
Power unit No. 1 (WWER -1000)	4,08E-06	1,62E-06
Power unit No. 2 (WWER -1000)	4,12E-06	9,10E-07

Based on the summary results of the Probabilistic Risk Assessment of the AP1000 unit, it can be concluded that the core damage frequency and the frequency of the limited accidental release of the AP1000 unit meet the safety criteria for NPP units by the Basic Safety Principles for Nuclear Power Plants.

8.3 Maximum design basis accident. Beyond design basis accident (design extension conditions)

Power unit condition categories are defined in accordance with ANSI N18.2, Nuclear Safety Criteria for the Design of Stationary PWR Plants, which distinguish between four different reactor plant conditions depending on their frequency of occurrence and the potential impact of their consequences on the public.

There are four categories:

- State I - Normal operation and transients
- State II - Medium frequency failures
- State III - Infrequent failures
- State IV - Limit failures

The main principle underlying the ratio of design requirements to each condition is that the most frequent conditions should have the lowest potential risks associated with the release of radioactive substances, and those extreme situations that pose the greatest risks to the public should be the least likely to occur.

The maximum design basis and beyond design basis accidents are characterized by events of state IV.

State IV events are faults that are not expected but are postulated because their consequences include the potential to release significant amounts of radioactive material. These faults represent design limit cases. State IV faults shall not cause the release of fission products to the environment, resulting in doses to personnel and the public exceeding regulatory values. A single Condition IV event should not cause an indirect loss of essential functions of systems required to eliminate the malfunction, including emergency core cooling systems and containment. The following faults are classified in this category:

- steam pipeline failure (major);
- feedwater system pipeline break;
- GCS shaft jamming (blocked rotor);
- the HPF shaft breakage;
- a range of accidents with the release of the SCS body;
- steam generator tube rupture;
- LOCA'resulting of some alleged ruptures of the first circuit pipelines (large rupture);
- fuel handling accidents.

Based on the results of the analysis of relevant accidents in the category – the State IV events, it was determined that the most serious radiological consequences arising from a loss of coolant accident due to a series of suspected ruptures in the primary pipelines (Loss of Coolant Accident - LOCA).

A LOCA is the result of a pipe rupture at the pressure limit of the reactor coolant system. A large pipe rupture is defined as a rupture with a total cross-sectional area equal to or greater than 1.0 ft2 (0.3 m2). This event is considered a State IV (Limit Failure) event because it is not expected to occur during the plant life cycle, but is postulated as a conservative design basis.

Even though the analysis of the AP1000 core during a loss-of-coolant accident (LOCA) shows that the integrity of the core is preserved, it is assumed that major core degradation and melting occurred to assess the radiological consequences of the accident. A core melt accident with a large loss of coolant (LOCA) is the most severe accident scenario considered in the framework of beyond design basis accidents.

The accident conditions model is based on NUREG-1465 [68] and Regulatory Guide 1.183 [69]. The releases from a core melt accident with a large loss of coolant (LOCA) result in design basis accidents.

A design basis accident is an accident for which the design defines initial events and final states and provides for safety systems that ensure, taking into account the principle of a single failure of the safety system or one additional personnel error, limiting its consequences to the established limits.

Maximum design basis accident is a design basis accident with the most severe radiation consequences.

Design extension conditions are conditions caused by initial events not considered as part of a design basis accident, in particular, the expected probability of occurrence of which is lower than that taken into account for design basis accidents, or the course (development) of which is accompanied by additional failures of safety systems or human errors compared to design basis accidents. Design extension conditions are divided into two categories: category A, which includes design extension conditions without severe nuclear fuel damage, and category B, which includes accidents with severe damage to nuclear fuel (severe accidents).

Radiation accidents of this class result in the release of radioactive substances into the environment and contamination of the natural environment, including agricultural land. The degree of contamination of the territory adjacent to the plant depends primarily on the amount of radionuclides released into the environment and the nature of their dispersion in the atmosphere. Unfavorable weather conditions are those under which there is minimal dispersion of radioactive substances in the atmosphere. Under such conditions, contamination of a small area with very large density gradients occurs.

The sources of radioactive substances entering agroecosystems in case of accidents are primarily determined by the radionuclide composition of the release, the structure of agricultural land near the plant, and the season.

In the case of an accident, the following radioactive mixture of fission products is released into the environment: radioactive noble gases (RNG), radioisotopes of iodine,

^{137}Cs, ^{90}Sr. RBGs do not participate in migration through agrobiocenoses due to their inertness. Short-lived radioisotopes of iodine play the main role in the contamination of agricultural products at the early stage of the accident (several months). It is at the early stage of the accident that the peculiarities of the behavior of accidentally released radionuclides in agrobiocenoses are manifested. At further stages of the accident, long-lived radionuclides 137Cs and 90Sr will play a leading role in the product contamination.

The maximum contamination of agricultural products may occur in the case of an accident during the growing season. Most of the radionuclides falling from the atmosphere during the passage of a cloud are retained on the surface of plants, while the rest fall directly on the soil cover. During harvesting or grazing on contaminated pastures, radionuclides (a certain amount of those deposited on the soil surface) are transferred to agricultural products. The pasture-animal-milk chain is a particularly important way for iodine radioisotopes to migrate at the early accident stage. If the radioactive fallout occurs during the grazing period, iodine radionuclides are quickly included in trophic migration chains when animals consume pasture vegetation contaminated by aerial means. The first weeks after the accident are particularly acute in terms of radiation. The duration of the period of predominantly foliar contamination is determined by the first growing season after the accident.

During the next growing season after the accident, the main mechanism of radionuclides migration through agricultural ways is the root uptake of radionuclides from the soil by plants. In the case of such a design basis accident, these radionuclides will be long-lived 137Cs and 90Sr, and the duration of this period may cover tens of years. Root uptake of radionuclides into plants is significantly less than aerial contamination of plants due to the sorption of radioactive substances by soil.

All major types of agricultural land are represented in the land use structure around KhNPP. Therefore, the main migration path of radioactive fallout in agrobiocenoses in the event of hypothetical accidents will be determined by their initial dispersion in the atmosphere (wind direction, atmospheric condition, precipitation).

The critical source of radionuclides in agricultural products during probable accidents will be meadows and pastures located in the floodplain of the Goryn River. Therefore, the critical pathway for radionuclide migration both in the early phase of the accident and in the subsequent phases will be the chain “pastures-animals-livestock products-human”.

The value of the total release corresponding to the maximum design basis accident in compliance with the document [70] is given in Table 8.2 (Bq).

Table 8.2 - Expected total release of radionuclide composition to the environment under the design extension conditions at the AP1000 power unit (Bq) [70].

Nuclide	0-2 hours	2-8 hours	8-24 hours	24-96 hours	96-720 hours
Xe-133	2.17E+14	1.173E+15	4.33E+15	7.69E+15	1.52E+16
Xe-133m	1.19E+12	9.41E+12	2.44E+13	4.94E+13	2.01E+14
Cs-137	3.03E+12	8.13E+12	5.07E+11	2.59E+09	2.40E+10

I-131	3.34E+13	9.27E+13	9.50E+12	6.24E+12	1.87E+13
Te-131m	7.48E+11	2.32E+12	1.26E+11	2.22E+08	7.40E+07
Sr-90	1.37E+11	4.51E+11	2.82E+10	1.48E+08	1.33E+09
Ru-103	2.96E+11	9.71E+11	6.03E+10	2.96E+08	2.15E+09
La-140	2.84E+10	8.94E+10	5.03E+09	1.48E+07	3.70E+06
Ce-141	6.54E+10	2.14E+11	1.33E+10	7.03E+07	4.48E+08
Ba-140	2.76E+12	9.01E+12	5.54E+11	2.96E+09	1.15E+10

8.4 Dose load assessment of an accident at the AP1000 unit

The dose load assessment in emergency situations and emergencies is a key task since the entire modern methodology for ensuring the radiation safety of nuclear power facilities is based on the standardization of population exposure individual doses.

8.4.1 Design basis accident at the KhNPP Units 5-6 with AP1000 reactors

In case of design basis accidents, in accordance with subpara. 7.1-7.2 [55], public exposure doses on the SPZ boundary and beyond should not exceed the values of unconditional justification levels given in Table D.7.1 of NRBU-97, namely:

a) effective dose:

– children - 10 mSv;

– adults - 20 mSv;

b) thyroid dose:

– children - 100 mSv;

– adults - 300 mSv;

c) skin dose:

– children - 300 mSv;

– adults - 500 mSv.

Non-exceedance of radiation doses in case of design basis accidents and abnormal operation should be ensured:

- for all reference ages specified in NRBU-97;

- for all distances equal to or exceeding the distance from the places of possible releases to the SPZ boundaries.

The modeling of release propagation from KhNPP AP1000 Units 5-6 was performed for the design basis LOCA scenario (release activity according to Table 8.2). The calculations of contamination parameters and radiation doses were performed for stationary meteorological conditions at points on the plume axis with a step of 50 m up to a maximum distance of 3000 m from the source.

8.4.1.1 Effective dose

The results of calculations of effective dose values for all six reference groups of the population for the atmospheric stability category D (neutral conditions (equilibrium stratification) according to the Paskvill-Gifford classification) in the range of distances 500 – 1500 m are shown in Fig. 8.1. The wind speed was set equal to 1 м/s^{-1}, the intensity of rainfall was 10.7 mm h^{-1}. According to the results, the critical age group for such an accident is the reference group "10 years".

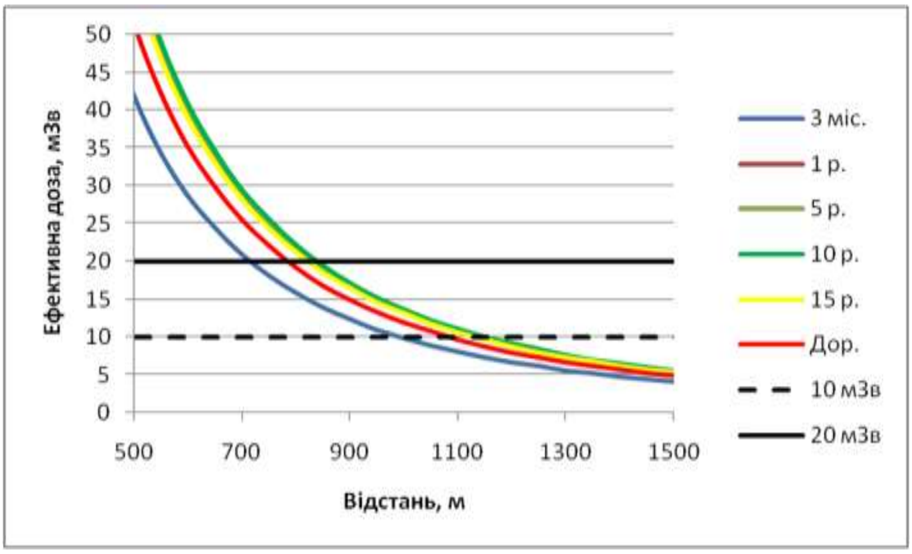


Figure 8.1 - Dependence of the calculated effective dose value for different reference ages on the distance for the atmospheric stability category D

The horizontal lines indicate dose rates of 10 mSv for children and 20 mSv for adults in design basis accidents

The results of calculations of the effective exposure dose of the reference group "10 years" for all stability categories are shown in Fig. 8.2 For the stability category F (moderately stable atmosphere, according to the Paskvill-Gifford classification), the dose limit for children is not exceeded at a distance of 1750 m from the release source.

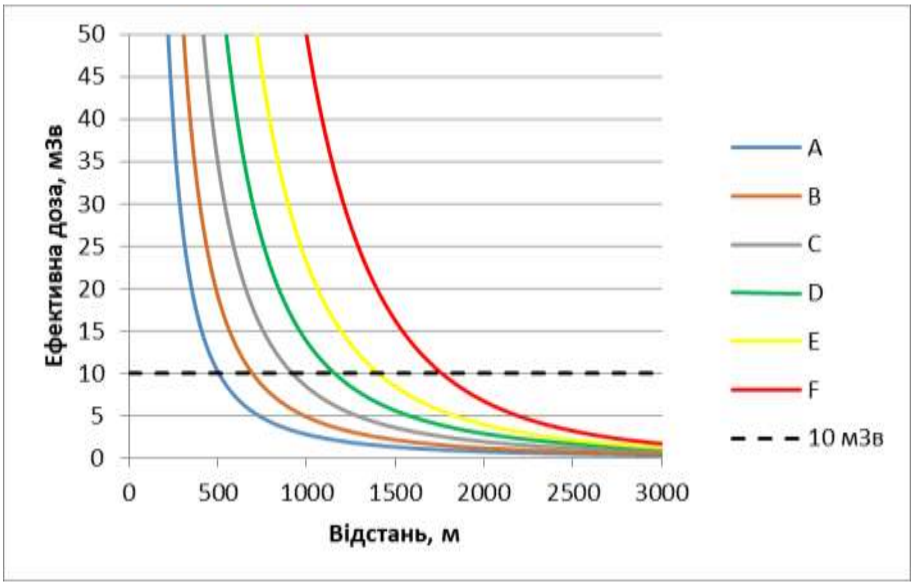


Figure 8.2 – Dependence of the calculated value of the effective dose of the reference age “10 years” on the distance for different categories of atmospheric stability

The horizontal line indicates the dose rate of 10 mSv for children in design basis accidents

The set of conditions for release propagation in the event of a design basis accident at the AP1000 unit, under which the maximum effective dose values are achieved, is the wind speed of 1 м/s^{-1}, the atmospheric stability category F (moderately stable atmosphere) and the value of the underlying surface roughness parameter z0 = 0.01 m (type of surface microrelief - mowed and low grass up to 15 cm). The critical population group is the age category “10 years”.

Thus, in the case of the considered design basis LOCA at the AP1000 unit, the criterion of not exceeding the dose limit is ensured under all considered meteorological conditions and for all age groups at distances ≥ 1750 m from the release source.

Table 8.3 shows the results of calculations of the effective dose for individual nuclides and dose pathways for the age category “10 years”, atmospheric stability category F (moderately stable atmosphere) and roughness parameter 0.01 m at a distance of 1750 m from the source, which ensures that the dose criterion for children of 10 mSv is not exceeded. According to the SOU NNEGC [55], the exposure pathway through consumption of contaminated products was not considered for accidental releases. The calculated value of the effective dose *Eeff* = 9.3 mSv consists of the contributions of the “air” component *Eair* (inhalation pathway and external exposure from activity in the air) and external exposure from fallout on the earth's surface *Esrf*, the relative contribution of which to the effective dose is 69 % and 31 %, respectively.

Table 8.3 - Contribution of individual nuclides to the calculated dose values due to inhalation of radionuclides and external exposure from the cloud *Eair* for the age category “10 years” in the case of a design basis accident at the AP1000 power unit, external exposure from fallout on the soil surface *Esrf* and total effective dose *Eeff* at a distance of 1750 m from the source

Nuclide	**Emission, Bq**	***Eair*, mSv**	***Esrf*, mSv**	***Eeff*, mSv**

I-131 (aer)	3.17E+13	3.81E+00	2.22E+00	6.03E+00
I-131 (mol.)	1.62E+12	2.59E-03	4.31E-03	6.90E-03
I-131 (org.)	5.01E+10	3.71E-02	6.31E-04	3.77E-02
Xe-133m	1.19E+12	1.76E-04	0.00E+00	1.76E-04
Xe-133	2.17E+14	3.51E-02	0.00E+00	3.51E-02
Sr-90	1.37E+11	3.70E-01	2.97E-03	3.73E-01
Ru-103	2.96E+11	2.85E-02	2.56E-02	5.41E-02
Cs-137	3.03E+12	2.04E+00	3.28E-01	2.37E+00
Ba-140	2.76E+12	6.77E-02	9.69E-02	1.65E-01
La-140	2.84E+10	5.01E-04	1.18E-02	1.23E-02
Ce-141	6.54E+10	6.93E-03	8.84E-04	7.81E-03
Te-131m	7.48E+11	4.97E-03	1.95E-01	2.00E-01
Sum		**6.41**	**2.89**	**9.30**

8.4.1.2 Equivalent skin dose

Equivalent skin doses to the public were calculated in the event of a design basis LOCA at the AP1000 unit. Fig. 8.3 shows the dependence of the equivalent skin dose on the distance to the source for different categories of atmospheric stability at a wind speed of 1 m/s^{-1} and a roughness parameter value of 0.01 m. Under the given conditions of atmospheric distribution of the release, the calculated values of the equivalent skin dose are the same for all reference groups of the population.

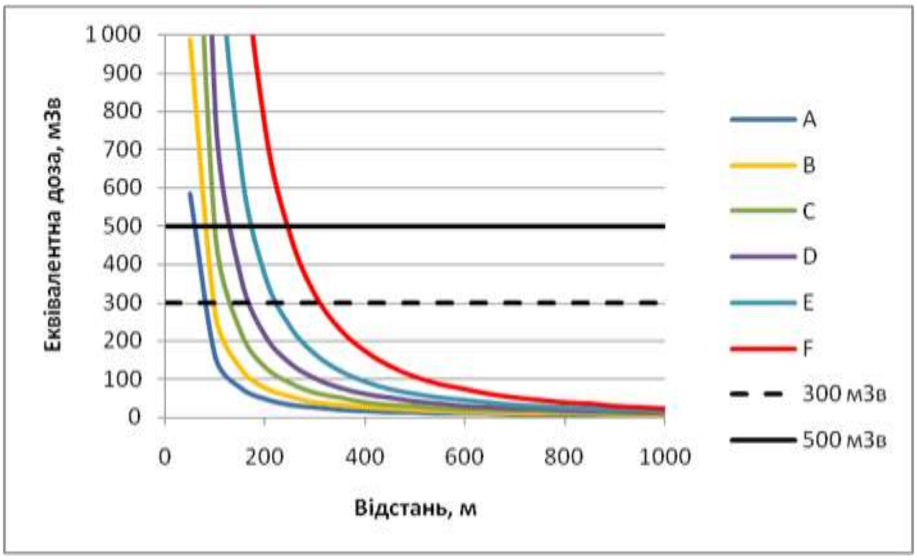


Figure 8.3 – Dependence of the calculated value of the equivalent skin dose on the distance for different categories of atmospheric stability

The horizontal lines indicate dose rates of 300 mSv for children and 500 mSv for adults in case of accidental releases

As follows from the calculation results, in the event of a design basis LOCA at the AP1000 unit, the non-exceedance of skin dose rate exposure for all considered meteorological conditions is ensured at distances of ≥ 350 m from the release source for children and ≥ 250 m from the release source for adults.

8.4.1.3 Equivalent thyroid dose

The equivalent thyroid doses for the public in the event of a maximum design basis accident at the AP1000 unit were calculated. Fig. 8.4 shows the dependence of the equivalent thyroid dose on the distance to the source for different categories of atmospheric stability at a wind speed of 1 м/s^{-1} and a roughness parameter value of 1 m, and Fig. 8.5 shows the dose-distance dependence for different reference ages and atmospheric stability category F (moderately stable atmosphere). The critical population group is the reference age of “1 year”.

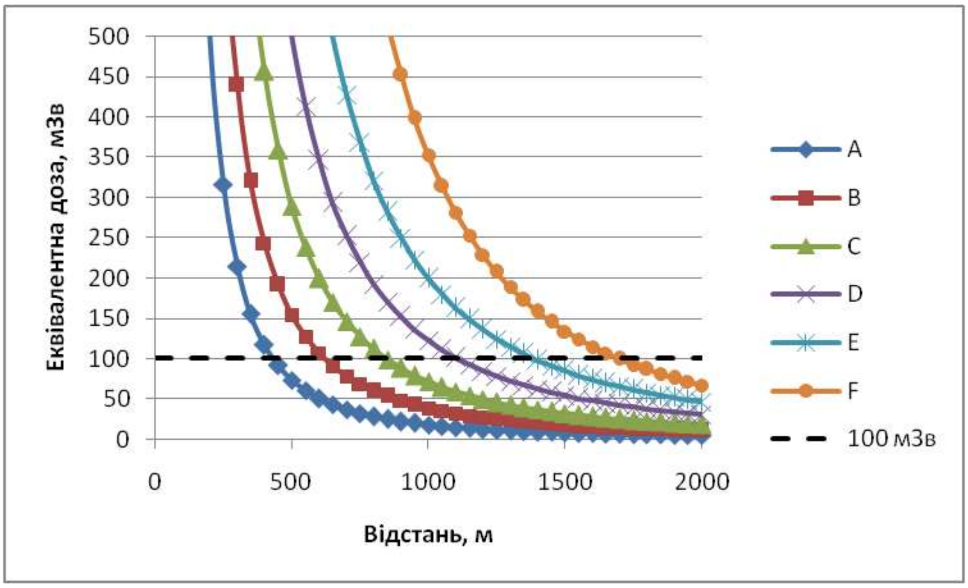


Figure 8.4 – Dependence of the calculated equivalent thyroid dose value on the distance for different categories of atmospheric stability and the reference age category “1 year”

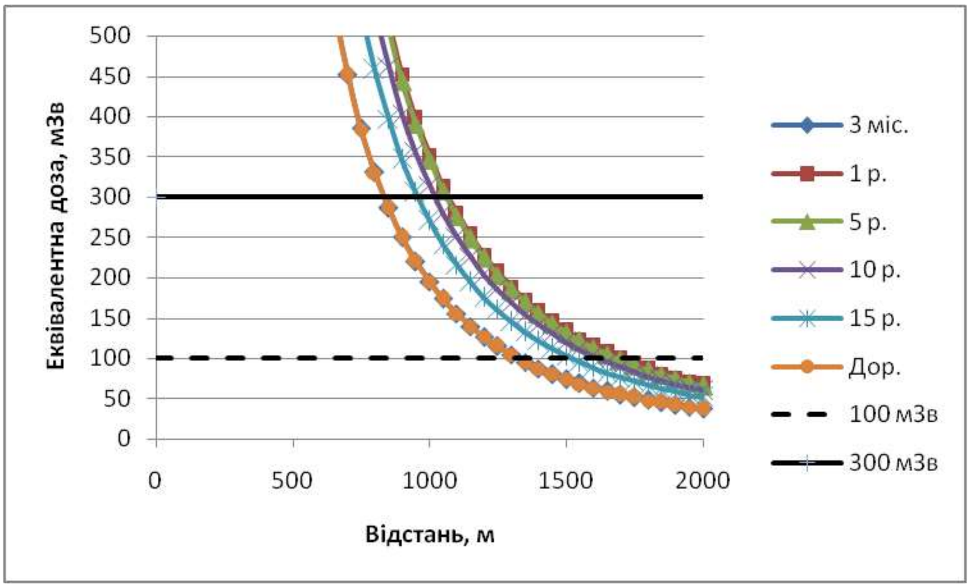


Figure 8.5 – Dependence of the calculated equivalent thyroid dose value on the distance for different reference ages and atmospheric stability category F

Thus, in the event of a design basis LOCA at the AP1000 unit, the non-exceedance of thyroid dose rate for all considered meteorological conditions is ensured at a distances of ≥ 1700 m from the release source for children and ≥ 850 m from the release source for adults.

The model calculations for the release scenarios for a design basis LOCA at the AP1000 unit resulted in the following:

1. In the case of the considered design-basis LOCA at the AP1000 unit, the non-exceedance limit criterion for the effective dose is ensured under all considered meteorological conditions and for all age groups at a distances of ≥ 1750 m from the release source.
2. In the event of a design basis accident with loss of coolant at a power unit with an AP1000 reactor, the dose limit for skin exposure for all considered meteorological conditions is ensured at distances ≥ 350 m from the release source for children and ≥ 250 m from the release source for adults.
3. In the event of a design basis LOCA at the AP1000 unit, the non-exceedance of thyroid dose rate for all considered meteorological conditions is ensured at the distances of ≥ 1700 m from the release source for children and ≥ 850 m from the release source for adults.
4. The SPZ boundary for KhNPP AP1000 Units 5-6 (1700 m) practically does not exceed the existing KhNPP SPZ (2700 m radius), except for its western part. In this area, the SPZ boundary of the AP1000 units 5 and 6 exceeds the existing one in the western direction by no more than 250 meters. Most of this additional area falls on the water surface of the KhNPP cooling pond.
5. The KhNPP SPZ sizes ensure that the established dose criteria are not exceeded for all reference age groups and in the entire range of meteorological conditions for the propagation of radioactive releases in the atmosphere and characteristics of the underlying surface.

8.4.2 Beyond Design Basis Accident at the KhNPP AP1000 Units 5-6

Calculations of contamination characteristics and radiation doses were performed for stationary meteorological conditions at points on the plume axis with a step of 100 m up to a maximum distance of 30 km from the source.

8.4.2.1 Effective dose

Effective doses to the public were calculated for different age groups. In accordance with the requirements of [60], all the results presented below were obtained by modeling the spread of radionuclides in the atmosphere with a value of the wet removal constant $\Lambda = 2\ h^{-1}$, which corresponds to the intensity of rainfall $J = 21.4\ mm\ h^{-1}$.

Based on the results of model calculations, it was found that in the event of a *beyond design basis accident (design extension conditions) at the AP1000 unit*, the non-exceedance of dose criterion for the effective dose to the public for beyond design basis accidents (50 mSv) is provided under all considered meteorological conditions and for all age groups at the distances of ≥ 3500 m from the release source.

The set of conditions for release propagation at the BDBA (design extension conditions) under which the maximum effective dose values are achieved, is wind speed

1 м/s^{-1} at a height of 10 m, atmospheric stability category F, rainfall intensity 21.4 mm h^{-1}, and the value of the roughness parameter of the underlying surface z_0 = 1 m. The critical population group is the age category "1 year".

Table 8.4 shows the results of calculations of the effective radiation dose for two age categories "1 year" and "Adults" in case of an BDBA at one of the KhNPP AP1000 Units 5-6 at a distance of 3500 m from the release source. The main way of forming the effective radiation dose is external human exposure from fallout on the soil surface (68% for children of 1 year and 76% for adults).

Table 8.4 – Contribution of individual nuclides to the calculated dose values due to inhalation of radionuclides and external exposure from the cloud *Eair*, external exposure from deposition on the soil surface *Esrf* and total effective dose *Eeff* for two age categories "1 year" and "Adults" in case of a BDBA (design extension conditions) at AP1000 unit

Nuclide	**Emission, Bq**	**1 year**			**Adults**		
		***Eair*, mSv**	***Esrf*, mSv**	***Eair*, mSv**	***Esrf*, mSv**	***Eair*, mSv**	***Esrf*, mSv**
I-131 (aer.)	1,53E+14	1,10E+01	2,65E+01	3,75E+01	5,06E+00	2,65E+01	3,16E+01
I-131 (mol.)	7,79E+12	1,48E-01	6,71E-01	8,18E-01	7,60E-02	6,71E-01	7,47E-01
I-131 (org.)	2,41E+11	1,31E-01	7,16E-03	1,38E-01	6,79E-02	7,16E-03	7,50E-02
Xe-133m	2,85E+14	2,66E-02	0,00E+00	2,66E-02	2,66E-02	0,00E+00	2,66E-02
Xe-133	2,86E+16	2,92E+00	0,00E+00	2,92E+00	2,92E+00	0,00E+00	2,92E+00
Sr-90	6,18E+11	2,62E-01	3,31E-02	2,95E-01	4,46E-01	3,31E-02	4,79E-01
Ru-103	1,33E+12	1,41E-02	2,84E-01	2,99E-01	1,79E-02	2,84E-01	3,02E-01
Cs-137	1,17E+13	1,24E+00	3,13E+00	4,37E+00	2,03E+00	3,13E+00	5,16E+00
Ce-141	2,93E+11	3,66E-03	9,79E-03	1,35E-02	4,93E-03	9,79E-03	1,47E-02
La-140	1,23E+11	1,05E-03	1,26E-01	1,27E-01	8,14E-04	1,26E-01	1,27E-01
Ba-140	1,23E+13	2,83E-01	1,07E+00	1,35E+00	3,19E-01	1,07E+00	1,39E+00
Te-131m	3,19E+12	2,85E-02	2,04E+00	2,07E+00	1,50E-02	2,04E+00	2,06E+00
Sum		**16,1**	**33,9**	**49,9**	**11,0**	**33,9**	**44,9**

8.4.2.2 Equivalent skin dose

Equivalent skin doses were calculated for the public in the event of an BDBA (design extension conditions) at the AP1000 unit. Fig. 8.6 shows the dependence of equivalent skin dose on the distance to the source for different categories of atmospheric stability at wind speed 1 m/s^{-1} and roughness parameter value 1 m. Under the given conditions of atmospheric propagation of the release, the calculated values of the equivalent skin dose are the same for all reference groups of the population.

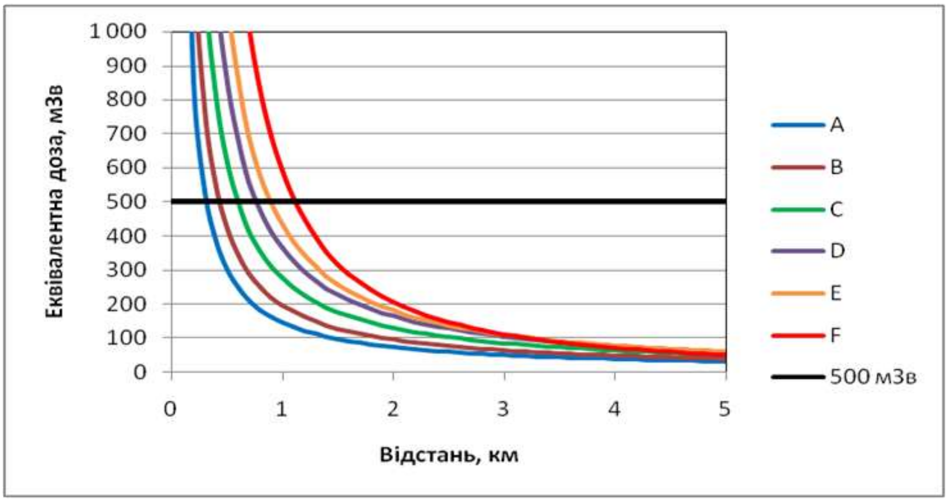


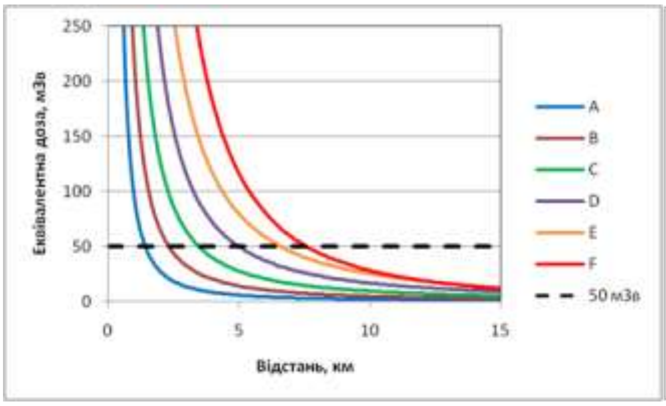
Figure 8.6 – Dependence of the calculated equivalent skin dose value on the distance for different categories of atmospheric stability

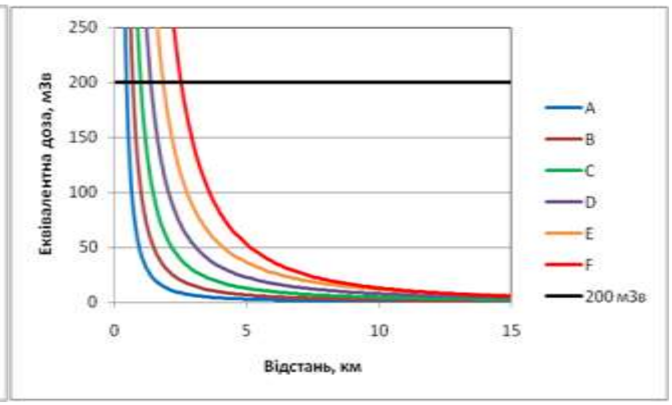
The horizontal line indicates the dose criterion of 500 mSv for all reference age categories in case of accidental releases

According to the calculations, in the event of a BDBA at the AP1000 unit, the dose criterion for skin exposure for all considered meteorological conditions and types of bedding surface is not exceeded at the distances of ≥ 1200 m from the release source for all reference age categories.

8.4.2.3 Equivalent thyroid dose

Calculations of equivalent thyroid doses were performed for the population in case of a BDBA at the AP1000 unit. Fig. 8.7 shows the dependence of equivalent thyroid dose on the distance to the source for different categories of atmospheric stability at wind speed 1 м/s^{-1} and roughness parameter value of 1 m, and Fig. 8.8 shows the dependence of dose on distance for different reference age groups and atmospheric stability category F. The critical population group is the reference age "1 year", and for all age groups the maximum dose values are obtained for stability category F.





(a) *(b)*

Figure 8.7 – Dependence of the calculated equivalent thyroid dose value on the distance for different stability categories and reference age categories "1 year" *(a)* and "Adults" *(b)*

The horizontal lines show the values of the dose criteria of 50 mSv for the "1 year" category and 200 mSv for the "Adults" category

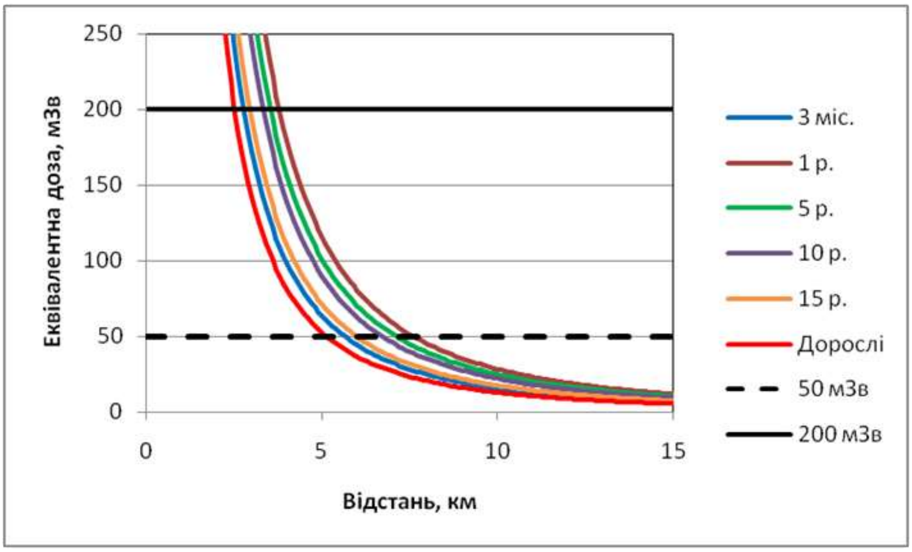


Figure 8.8 – Dependence of the calculated equivalent thyroid dose value on the distance for different reference ages and atmospheric stability category F.

Thus, in the event of a BDBA (design extension conditions) at the AP1000 unit, the dose criteria for thyroid exposure are not exceeded under all considered meteorological conditions and for all reference age categories at the distances of ≥ 7600 m from the release source.

As a result of model calculations for the considered release scenario in case of a BDBA at the AP1000 units, the following results were obtained:

1. The critical population group is the age group "1 year". Non-exceedance of the criteria for the introduction of urgent countermeasures (lower limits of justification) for the *effective dose* under all considered meteorological conditions, all types of bedding surface and for all reference age groups is ensured at the distances of ≥ 3500 m from the release source.
2. Non-exceedance of the dose criterion for *skin exposure* for all considered meteorological conditions and types of underlying surface is ensured at the distances of ≥ 1200 m from the release source for all reference age groups.
3. Non-exceedance of the dose criteria for *thyroid exposure* is ensured for all considered meteorological conditions and for all reference age categories at the distances of ≥ 7600 m from the release source.
4. The main way of forming the effective dose is external human exposure from fallout on the soil surface (68% for children of 1 year and 76% for adults). The largest contribution to the effective dose for the critical age group "1 year" is ^{131}I – 77%.
5. The defined SA boundary for the AP1000 units fully fits into the current KhNPP SA with a radius of 30 km.

8.5 The Ensuring Safety Principles of the NPP

The design of the AP1000 unit was developed in accordance with the requirements of the U.S. legislation 10 CFR 20 "Standards for Protection Against Radiation" [71], internationally recognized standards (ASTME, ASME, etc.) and in accordance with the requirements of international institutions (IAEA, EUR and WENRA). One of the features of the AP1000 plant is the use of passive safety systems, which makes the power unit less dependent on external power supply in case of emergencies.

The AP1000 design is a combination of proven design concepts. In addition, is the result of the experience of operating existing PWR/WWR plants, applied to a defined set of functional requirements most simply and efficiently possible.

The principles of ensuring nuclear and radiation safety of Westinghouse Electric Company LLC AP1000 power units are based on:

- requirements established by the US nuclear safety codes, norms, and standards for the specifics of the power units under development and do not contradict the relevant nuclear safety rules and regulations in force in Ukraine;
- modern safety philosophy and principles developed by the global nuclear community and enshrined in the IAEA safety standards and ICRP publications;
- application of well-known deterministic methods, supplemented by probabilistic methods using appropriate numerical targets and analysis for detailed safety assessment;
- using proven components and technologies in the design of the AP1000;
- utilization of innovative safety features and capabilities in the AP1000 design;
- use of modular construction technology;
- simplification of the AP1000 design in comparison with WWER facilities operated in Ukraine;
- minimizing the impact of internal and external hazards and human errors;
- use of an advanced digital interface and human-machine interface.

The general safety objective is to ensure the personnel protection, the population, and the environment from unacceptable radiation exposure during the commissioning, operation, and decommissioning of a nuclear facility.

The general objective is achieved by safety management at all stages of the NPP nuclear facility life cycle and in all operational conditions through the implementation of radiological and technical safety objectives.

The operating organization continuously implements and keeps up-to-date the regulatory documents/standards of the enterprise that establish general provisions according to which the organizational culture is formed, maintained, and developed to ensure safety to protect personnel, the public, and the environment from unacceptable radiation exposure during the activities implementation in the field of nuclear energy use. These regulatory documents comply with the current regulatory requirements, take into account the IAEA recommendations, and experience in implementing a safety culture in the operating organization.

The above documents are mandatory for all operating organization personnel and should be included in the relevant regulatory documents, job descriptions, other company production documents, briefing programs, training materials for company personnel, etc. Understanding of and compliance with the requirements of these documents is verified during self-assessments, safety culture audits, knowledge testing, and personnel certification.

By the law, the licensee (operating organization) must ensure compliance with the terms and conditions of the activity, which are defined in the license conditions or specified directly in the license when it is issued. The license conditions are usually developed by the licensing authority and approved by the Cabinet of Ministers of Ukraine. The current legislation provides for administrative liability for violation of the conditions for conducting the licensed type of activity and sets out the grounds for the licensing authority to refuse to issue a license, suspend it, or revoke it.

In its activities, the licensee should follow the basic principles of the state policy in the field of nuclear energy use and radiation protection, which are:

- priority of protecting people and the environment from ionizing radiation;
- ensuring the minimum level of radioactive waste generation during the use of nuclear energy;
- prohibition of any activity in the field of nuclear energy use that results in a reasonably foreseeable greater negative impact on future generations than that allowed for the current generation;
- ensuring safety in the use of nuclear energy;
- openness and accessibility of information related to the use of nuclear energy;
- providing compensation for damage caused by radiation exposure;
- creation of a legal and financial mechanism for socio-economic compensation of the risk for the population living in the observation zones;
- creation of special social infrastructure in the observation zones;
- ensuring measures for the socio-economic interest of local executive authorities and local self-government bodies on the territory of which nuclear facilities and facilities intended for radioactive waste management are located;
- establishing liability for violation of the legal safety regime in the field of nuclear energy use;
- separation of state administration functions in the field of nuclear energy use and state regulation of nuclear and radiation safety;
- separation of functions of state administration in the field of nuclear energy use and direct economic activity in the field of nuclear energy use;
- distribution of duties, rights and responsibilities among all subjects of legal relations in the field of nuclear energy use;
- regulation, licensing and supervision in the field of nuclear energy use;
- creation of a legal and financial mechanism of liability of the operating organization to citizens and business entities for nuclear damage caused;
- establishing a legal and financial mechanism for the licensee's liability to citizens and business entities for damage caused in the event of a radiation accident;
- disposal and long-term storage of radioactive waste at the expense of waste producers;

- participation of citizens and their associations in the formation of state policy in the field of nuclear energy use;
- prohibition of any activity related to ionizing radiation, if the benefits of such activity are less than the possible harm caused by it;
- compliance with the limits of exposure doses to personnel and the public established by the rules and regulations on nuclear and radiation safety;
- establishing the lowest indicators of individual doses, number of exposed persons, and probability of exposure from any specific radiation source under the rules and regulations on radiation safety, taking into account economic and social conditions of the state;
- implementation of international treaties, development of international cooperation in the field of peaceful uses of nuclear energy, and strengthening of the international regime of safety and radiation protection of the population;
- separation of state administration in the field of nuclear energy use and radioactive waste disposal.

The radiological safety objective is to ensure that the limits of radiation exposure to personnel, the public, and 10 CFR 20 “Standards for Protection Against Radiation” [71], as well as those established by the RSSU [22], limits of radiation exposure to personnel, the population and the environment during normal operation, violations of normal operation and design accidents, as well as limiting radiation exposure in the event of a severe accident. At the same time, it is necessary to ensure that the specified radiation exposure is at the lowest possible level, taking into account economic and social factors, and the achieved level of science and technology.

According to the established standards, the following categories of persons exposed to radiation (personnel and the population) are established:

- Category A (personnel) - persons who permanently or temporarily work directly with sources of ionizing radiation.
- Category B (personnel) - persons who are not directly involved in work with sources of ionizing radiation, but due to the location of workplaces in the premises and industrial sites of facilities with radiation and nuclear technologies, they may receive additional exposure
- Category C - the entire population.

Thus, each category of persons has its dose limits and permissible levels, which are given in Table 8.5.

Table 8.5 – Dose limits (mSv per year)

Dose limits	**Person exposure category**		
	A	**B**	**C**
Annual effective dose	20*	2	1
The annual equivalent dose in:			
The lens of the eye	150	15	15
Skin	500	50	50

Hands and feet	500	50	-

Note *: average for any consecutive 5 years, but not more than 50 mSv in a single year.

Following the radiological safety objective, it is necessary to:

- ensure that, in normal operation, radiation exposure at the plant and doses resulting from any release of radioactive material from the facility are kept as low as reasonably achievable and below the established limits;
- ensure that for all accidents considered in the design of the plant, the radiological consequences, if any, are negligible;
- reduce the likelihood of off-site events and their associated radiological consequences to avoid the need for extensive countermeasures and to enable the authorities to simplify off-site emergency planning.

The design of the AP1000 plant includes features that keep radiation exposure to personnel at a reasonably achievable level (ALARA principle) at all stages of the nuclear facility life cycle.

The main principles of radiation safety in accordance with the ALARA, which are provided for in the design of the AP1000 plant, are as follows:

- structures, systems and components are designed to be reliable and maintainable, thereby effectively reducing maintenance requirements for radioactive components;
- structures, systems and components are designed in a way to reduce radiation exposure, which allows for operation, maintenance and inspection of equipment within the minimum design radiation field;
- structures, systems and components are designed to ensure the optimal layout and access conditions to reduce the time for repair and dismantling, thereby effectively reducing the time spent in the radiation exposure zone during operation, maintenance and inspections;
- structures, systems and components are designed in such a way as to ensure remote and semi-remote operation, maintenance and inspections, thereby effectively reducing the time spent in the radiation exposure zone.

For radiation protection, the entire territory of the NPP with an AP1000 unit, where personnel may be present, is classified following the defined radiation zones by the requirements and definitions [71] and is based primarily on the expected personnel access. All areas of the plant are classified into radiation-safe areas and areas with limited access (strict regime areas) subject to radiological control. The designation of radiation zones and corresponding radiation levels of NPPs with AP1000 units according to [71] are given in Table 8.6.

Restricted zones (strict regime zones) following [71] are, in turn, divided into radiation hazardous zones, zones with high radiation levels, zones of radioactive air pollution, zones of surface radioactive pollution and zones of radioactive materials. During the operation of the plant, the requirements for mandatory designation of zones will be established by the radiation safety personnel based on the actual radiation levels as specified in paragraph 1902 [71]. The requirements for access to each piece of plant equipment, instrumentation, or control devices used at the plant will be considered when establishing the design radiation level in this zone.

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]		
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

The safety of NPPs with the AP1000 reactor is ensured by a system of technological and organizational means through:

- use of the internal self-protection properties of the reactor unit;
- application of the principle of deeply shielded protection;
- use of safety systems designed using the principle of a single failure, diversity, redundancy, and physical separation;
- use of approved engineering and technical practices;
- Compliance with nuclear and radiation safety rules and regulations, as well as compliance with the requirements outlined in the AP1000 basic design;
- maintaining and improving the safety culture;
- use of the quality management system at all stages of the nuclear facility life cycle;
- ensuring appropriate training and qualification of personnel;
- taking into account operational experience, in particular, AP 600;

- availability of necessary operational documentation.

The principles of ensuring NPP safety are divided into fundamental and general organizational and technical principles.

The fundamental principles include:

- ensuring a safety culture;
- responsibility of the OO (Operating Organization);
- state regulation of safety;
- implementation of the defense-in-depth strategy.
- General organizational and technical principles include:
- application of proven engineering and technical practices;
- quality management;
- self-assessment of NPP safety;
- security analysis;
- departmental supervision;
- independent inspections;
- consideration of the human factor;
- ensuring radiation safety;
- consideration of operational experience;
- scientific and technical support.

The safety of the AP1000 installation is ensured by the consistent implementation of a translaty defended protection strategy based on

- prevention of deviations from normal operation;
- detection of deviations from normal operation and provision of means to prevent such deviations that may lead to emergency conditions;
- provision of engineering safety features to control and mitigate emergency conditions. In addition, the prevention and mitigation of severe accidents is considered through the development and use of probabilistic risk assessment and supporting analysis results.

The AP1000's ability to prevent abnormal operation is based on its safety margin and physical characteristics (e.g., larger water volumes and reserves, negative power and temperature coefficients).

8.6 Measures to protect the population and the environment

Measures to protect the population and the environment include the general procedure for determining emergency and urgent protective countermeasures for the population, informing and providing recommendations on the protection of the population to executive authorities, the state nuclear and radiation safety regulatory authority, and other interested organizations.

The population radiation protection in the context of an emergency is based on a system of radiation protection measures (countermeasures), which usually interfere with normal human activity, as well as with normal social, economic and cultural functioning of the territories.

Intervention is a type of human activity that is always aimed at reducing and preventing uncontrolled and unpredictable exposure or the probability of exposure in situations of emergency exposure.

Countermeasure types

All protective countermeasures used in the event of a radiation accident are divided into direct and indirect ones.

Direct countermeasures include countermeasures, the implementation of which leads to the prevention or reduction of individual and/or collective doses of the population's accidental exposure

Indirect countermeasures include all types of countermeasures that do not prevent individual and collective doses to the public but reduce (compensate) the amount of health damage associated with this accidental exposure.

Indirect countermeasures, in particular, include those aimed at improving the life quality of the population exposed to accidental exposure: introduction of socio-economic and medical benefits and monetary compensation, improvement of nutrition, etc.

The emergency plan developed for each NPP provides the scope of monitoring of radiation indicators of environmental objects in the exclusion (observation) zone, as well as information on the location of sampling sites for environmental objects, sites for monitoring dose rate, and integrated dose on the ground in the NPP observation area, locations of stationary radiation monitoring facilities (air filter of facilities, integrated dosimeters, etc.).

Protection of the public and the environment in the event of an accident at KhNPP is ensured by implementing the following key measures of the KhNPP's Emergency Preparedness and Response Systems.

- enhanced monitoring of radiation indicators of environmental objects and public exposure in the Zone
- forecasting of radiation doses to the population in the Zone;
- informing central and local executive authorities and local self-government bodies about the results of monitoring and radiation dose forecasting;
- provision of recommendations to central and local executive authorities and local self-government bodies on countermeasures to protect the population.

The monitoring of radiation indicators performed to protect the population and the environment includes:

- continuous monitoring of gas and aerosol emissions through vent pipes using stationary measuring instruments;
- radiation control over the release of radioactive substances into the environment, the state of the radiation situation in the SPZ and OZ and radioactive contamination of environmental objects;

- the scale assessment and the significance of accidental releases and discharges to the environment, and forecasts of public exposure doses.

The scale assessment and the significance of accidental releases and discharges to the environment are performed under the methodology [72].

Based on the results of the forecast of public exposure doses, protective countermeasures for the public are determined based on the levels of intervention and action levels established in [22].

The decision to take protective countermeasures is made not only by taking into account the current state of the radiation situation but is primarily based on the forecast of its development in connection with expected accidental releases and discharges, as well as using hydrometeorological forecasts.

The Radiation Situation Monitoring Group (RSMG) is responsible for forecasting public exposure doses and developing recommendations for public protection. Before the emergency groups and brigades (EG&B) are assembled, the shift personnel of the Radiation Safety Shop (RSS) develop recommendations for public protection for transmission to local executive authorities.

The results of assessments and forecasts and recommendations on protective countermeasures for the public are immediately transmitted to the headquarters of the emergency manager (HEMO). Before the meeting of the headquarters of the EMO, the information is reported to the NPP shift supervisor (NPP SS).

Analysis and clarification or verification of monitoring results, forecasts, and protective measures recommended for the population is carried out by the HEOS Headquarters on behalf of the HEOS. Recommendations on public protection for transfer to external organizations are approved by the HEOS (NPP SS (Shift Supervisor of the NPP) before the HEOS takes over its responsibilities).

The results of monitoring of radiation indicators, forecasts of radiation situations, public exposure doses, and recommended protective countermeasures for the public are immediately communicated to the Executive Committee of the Netishyn City Council and the Mayor of Netishyn, Energoatom Commission on Emergency Situations and other interested organizations.

During the accident, assessments and forecasts of radiation situation in the supervised area and public exposure doses are periodically repeated or performed immediately in case of significant changes in the hydrometeorological situation in the accident area.

8.7 Emergency preparedness and emergency response in the event of a radiation emergency

According to the IAEA Safety Glossary, emergency preparedness is the ability to take measures that effectively mitigate the consequences of an emergency for human health and safety, quality of life, property, or the environment.

Emergency response is defined by the IAEA as the implementation of measures aimed at mitigating the consequences of an emergency for human health and safety, quality of life, property, and the environment. It can also provide a basis for restoring normal social and economic activities.

Facilities that use radioactive materials (RM) and other ionizing radiation sources (IRS) in their practical activities are classified according to the category of potential radiation hazard to the public and the environment in the design (normal) mode and the event of a radiation emergency. Five categories of such facilities are defined. Emergency planning in case of a radiation emergency is carried out by these categories:

Category I – facilities (nuclear power plants) for which hazardous events on the site, including events with a low probability of occurrence, may lead to severe deterministic medical off-site effects.

Category II – facilities (some types of research reactors or enterprises for the production of sealed radiation sources, etc.) for which hazardous accidents at the industrial site may lead to an increase in off-site doses to the public, which justifies urgent countermeasures.

Category III – facilities (industrial radiation facilities, enterprises storing spent nuclear fuel or collecting and disposing of low-level waste, etc.) for which hazardous accidents at the site may lead to increased radiation doses or contamination, which justifies urgent protective actions at the site.

Category IV – activities that may lead to a radiation emergency that justifies the application of urgent countermeasures in an unexpected location. These activities include transportation and other authorized activities related to mobile objects (such as industrial radiographic radiation sources, nuclear-powered satellites or radiothermal generators), as well as unauthorized activities (such as activities with illegally obtained radiation sources). Hazard category IV represents the minimum hazard level applicable to the entire country territory;

Category V – activities that do not involve the use of radiation sources under normal conditions, but there is a significant probability of radioactive contamination of agricultural products to levels that require an immediate ban on the use of products as a result of an accident at facilities of radiation hazard categories I or II, including such facilities in other countries.

Radiation hazard categories I and II include power and research nuclear facilities, where radiation emergencies may result in deterministic and stochastic effects on personnel and the public, which requires planning of preventive and urgent protective actions such facilities off-site.

NPP safety is achieved through the consistent implementation of certain special measures at five levels of the defense-in-depth strategy, which is a set of consistent physical barriers to the spread of radioactive substances and ionizing radiation together with technical means and organizational measures aimed at preventing deviations from normal operating conditions, preventing emergencies and limiting their consequences.

Emergency preparedness and response is the last of the five levels of defense-in-depth strategy implementation which provides for:

- the establishment of a sanitary protection zone and supervised area around the NPP;
- availability of emergency plans, emergency response plans, the effectiveness and implementation readiness which are periodically checked during emergency training and activities;
- construction of radiation shelters and Incident and Emergency Centers.

The NPP Incident and Emergency Center and the Emergency Preparedness and Response System of the Operating Organization (EPR) to emergencies and accidents at Ukrainian NPPs ensure implementation of measures of this level at NPPs, as the most radiation-hazardous facilities.

According to [73], the NPP Incident and Emergency Center is an infrastructure facility in the operating organization's emergency preparedness and response system that includes a set of specially equipped premises, equipment, information, and communication systems and is intended to manage the response to nuclear and radiation emergencies and other accidents at the NPP site and within its sanitary protection zone and to coordinate interaction with external organizations to ensure radiation protection of personnel

The Emergency Preparedness and Response System of the Operating Organization (EPR) is an organizational structure of an operating organization and operates following the IAEA recommendations, requirements of the nuclear legislation of Ukraine, norms, rules, and standards on nuclear and radiation safety, as well as legislation in the civil protection field.

The operating organization has a basic document that establishes the principles of organization of the operating organization's EPR, defines its goals, objectives, composition, operation procedure, distribution of powers and responsibilities between structural units and officials of the operating organization regarding emergency planning, preparedness, and response, interaction with third-party bodies, enterprises, and organizations. This document is developed and approved by the operating organization and coordinated with the Ministry of Energy, Ministry of Health, SNRIU, and State Emergency Service of Ukraine.

The operating organization's EPR performs its functions as part of the Unified State Civil Protection System (USCPS), which ensures state policy implementation in the civil protection field in Ukraine.

Interaction of central executive authorities, functional and territorial subsystems, and the operating organization within the preparedness and emergency response system for radiation and radiation-nuclear emergencies is carried out through the USCPS.

The scheme of interaction between the functional system of nuclear and radiation safety within the USCPS and the international obligations of Ukraine is shown in Fig. 8.9.

The authorities of the territorial subsystem of the USCPS (local executive authorities and local self-administration bodies) shall ensure, respectively

– notification of the population about protective measures;
– informing the population about the radiation situation;
– making decisions on iodine prophylaxis and the population evacuation;
– implementation of other measures within the competence and of the bodies' authorities under nuclear legislation.

In the event of a nuclear or radiation emergency at operating NPPs in Ukraine, central and local authorities should, by applicable law, make decisions and act based on relevant departmental and territorial plans, considering recommendations of the NPP and the operating organization, as well as other authorized bodies.

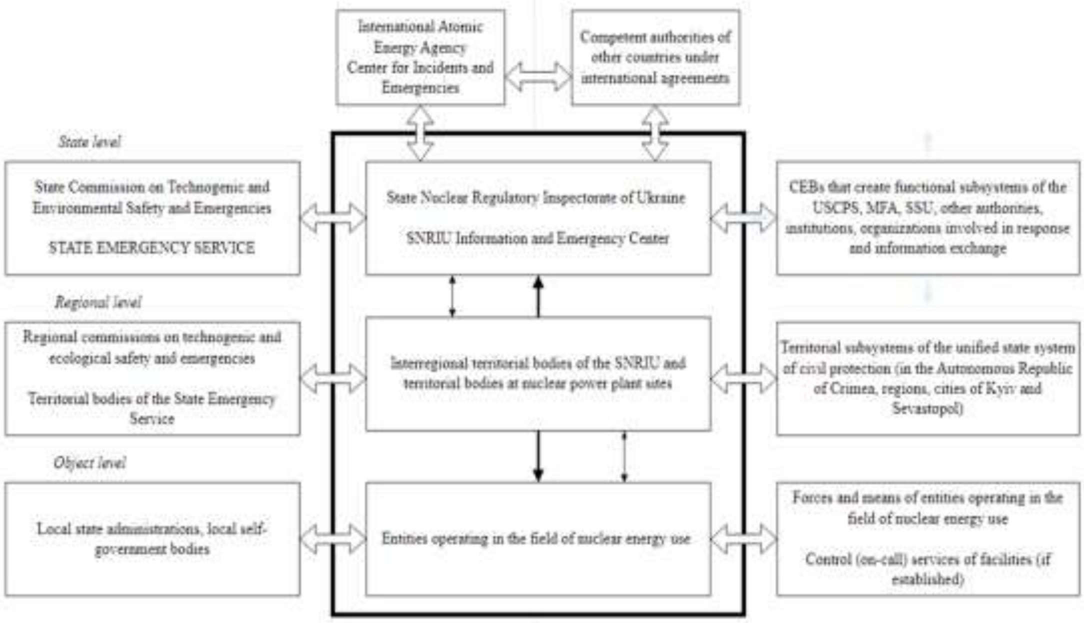


Figure 8.9 – Scheme of interaction of the functional system of nuclear and radiation safety

According to the requirements of the current legislative and regulatory acts in the civil protection field, all operating NPPs in Ukraine have identified high-risk facilities and approved lists of facilities to be equipped with automated systems for early detection of emergency hazards and notification of personnel in case of emergency. The operating organization has implemented automated systems for early warning of emergencies and notification of personnel in case of emergencies at each separate NPP unit and established control over their implementation.

8.7.1 Radiation monitoring

At any operating NPP, in normal operation (as well as at all stages of occurrence and elimination of consequences of a possible nuclear or radiological emergency and in the post-accident period), continuous monitoring of gas and aerosol emissions through vent pipes and liquid discharges, radiation situation in the premises, on the plant site and in the observation area is carried out (provided) following the Regulations on Radiation Monitoring during Operation of NPP Facilities. It ensures the accident detection of signs based on the readings of measuring instruments, alarm devices, relay protection devices, and automatics that have been triggered. In most cases, it is possible to detect signs of a radiation accident and declare the appropriate accident class even before radioactive substances leave the NPP site.

In addition to laboratory monitoring methods, each NPP operates an automated radiation monitoring system (ARMS) consisting of automated monitoring stations. Supervision is carried out continuously in an automatic mode, which allows receiving information from the control posts, conducting systematic data analysis, and performing a forecast of the radiation situation for all settlements in the 30-kilometer zone around the NPP.

To provide the public with the most accurate information and protect the population on time, the Ministry of Environmental Protection and Natural Resources together with the data owners: Energoatom, the Ministry of Health of Ukraine, the State Emergency Service of Ukraine, the Ukrainian Hydrometeorological Center, local authorities and business entities, have collected all relevant data on a single map of radiation background in Ukraine [74]. It shows measurements from monitoring points located throughout the country. Specialists, even in the most hazardous settlements, collect the data daily automatically or manually. Today, there are 514 measurement points throughout the country.

Summary information on the radiation situation at industrial sites and in the supervised areas of NPP branches is published on the official website.

8.7.2 International commitments on early notification of a nuclear accident

In the event of a potential or actual emergency on the territory of Ukraine, according to the Procedure for Classification of Emergencies by their Levels [75], the State Emergency Response Plan [76] is put into effect.

Based on the IAEA recommendations and requirements, the following classes of accidents are established: emergency preparedness - industrial accident - site accident - municipal accident. They correspond to hazard warning - emergency at the facility - emergency on the site - general emergency.

In particular, in the event of a utility accident (the largest one) at an NPP, they are immediately implemented:

– emergency plan of the site, i.e. NPP;
– emergency plan of the operating organization;

– response plans of local and regional territorial subsystems of the Unified State Civil Protection System, whose territory belongs to the NPP supervised area;
– response plans of relevant functional subsystems;
– radiation accident response plan.

The plan is intended for:

– prompt response of governmental authorities and civil protection forces, prevention of loss of life, material losses reduction, and organization of priority life support for the victims;
– organizing management, interaction and informing of the governing authorities and civil protection forces involved in disaster relief;
– determining the sequence and scope of organizational and practical measures to respond to an emergency and eliminate its consequences, deadlines, responsible executors, and resources required for this purpose.

The plan is implemented by:

– informing and notifying about the risk or occurrence of an emergency;
– transferring governing bodies and civil protection forces to the high alert mode and emergency mode;
– actions of governing bodies and civil protection forces in the high alert mode and emergency mode;
– management during the elimination of the consequences of an emergency;
– involvement of civil protection forces and conducting emergency rescue and other urgent works;
– interaction between governing authorities and civil protection forces;
– organization of the main types of support during rescue and other emergency operations and elimination of the consequences of an emergency.

Since 1986, Ukraine has ratified the IAEA Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency by a decree of the Presidium of the Verkhovna Rada.

The SNRIU is authorized to act as a single national point of contact according to the IAEA Convention on Early Notification of Nuclear Accidents, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and the Convention on the Physical Protection of Nuclear Material, and Nuclear Facilities; to exchange internationally operational information on nuclear events within the International Nuclear Event Scale (INES).

The Convention on Early Notification of a Nuclear Accident applies in the event of any accident involving the operation of a nuclear facility, the activities of a State Party, or persons or entities under its jurisdiction or control, which results in a release of radioactive substances or may result in a release of radioactive substances and which has resulted in or may result in an international transboundary release that, in terms of radiation safety, could be important to other States. According to the Convention, a State Party in whose territory a nuclear accident has occurred shall immediately notify the IAEA, as well as (directly or through the IAEA) those States that have been or may be exposed to radiation, indicating the nature of the accident, the time when it occurred, and its exact location. Each State Party shall notify the IAEA and other States Parties of its competent authorities responsible for accident response, notification, and information relating to the accident.

The SNRIU provides the Ukrainian Hydrometeorological Center (UkrHMC) of the State Emergency Service with information on the source and (if available) composition of the radioactive release for modeling atmospheric transport of radioactive substances based on numerical weather forecasts using the Real-time On-line DecisiOn Support system (RODOS) and ensuring information exchange within the World Meteorological Organization. The UkrHMC provides SNRIU with available meteorological information for assessing and forecasting the development of emergencies, including risks of transboundary impact. At the state level, the SNRIU notifies the IAEA and competent authorities of other states, as well as the media through the SNRIU Information and Incident and Emergency Center.

9 IDENTIFICATION OF ALL DIFFICULTIES (TECHNICAL DEFICIENCIES, LACK OF SUFFICIENT TECHNICAL MEANS OR KNOWLEDGE) IDENTIFIED IN THE PREPARATION PROCESS OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

There are no difficulties in the preparation process of the environmental impact assessment report for the construction of KhNPP Units 5 and 6. The available technical means and knowledge are sufficient.

10 ALL COMMENTS AND SUGGESTIONS RECEIVED BY THE AUTHORIZED CENTRAL BODY AFTER THE PUBLISHED NOTIFICATION OF THE PLANNED ACTIVITY, AND A TABLE WITH INFORMATION ON FULL CONSIDERATION, PARTIAL ONE OR JUSTIFICATION FOR COMMENTS REJECTION AND SUGGESTIONS RECEIVED DURING THE PUBLIC DISCUSSION

All comments and suggestions received by the authorized central body after the publication of the Notification of the planned activity and information on consideration and incorporation are presented in Table 10.1, see also Appendix A.

The conditions of the Ministry of Environmental Protection and Natural Resources for the scope of studies and level of information details to be included in the EIA Report and information on consideration are presented in Table 10.2, see also Appendix B.

All comments and suggestions received from the Polish authorities on the scope of environmental impact assessment documentation and information on consideration and incorporation are presented in Table 10.3, see also Appendix K.

Table 10.1 – All comments and suggestions received by the authorized central body after the publication of the Notification of planned activities and responses to them

No.	Content of the comment or suggestion	Information on review and consideration
The public organization letter “Ecoclub” “Ecodia” “Khmelnytskyy Energy Cluster” dated 12.04.2024 №73		
1	Analysis of the reactor unit selection, including: - justification and selection procedure for the Westinghouse Electric Company's AP 1000 reactor; - justification of the possibility of selecting an alternative reactor unit, including the environmental impact determination of the alternative unit operation; - information on consideration of other technical alternatives to generate the appropriate amount of electricity, including the option of refusing to construct KhNPP Units 5 and 6 and using renewable energy sources to generate the same amount of electricity.	Considered Information is provided in Section 2 of the EIA Report.
2	Site selection for KhNPP 5 and 6 units: justification and procedure for site selection for KhNPP 5 and 6 units siting; - justification of the possibility of selecting an alternative location (site) for KhNPP 5 and 6 units; - list and results of studies conducted to determine the suitability of the selected territory (site) for the construction of KhNPP Units 5 and 6.	Considered Information is provided in Section 2 of the EIA Report.
3	Design characteristics, including: -information on the development stage or design stage at which the object of the planned activity is, if available - project documentation adopted at this stage; - information on the pre-project stage (pre-investment) works; - dates of the completion of all design stages.	Considered Information is provided in paragraph 5.1 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
4	Description of a permissible alternative, its feasibility and effectiveness, its advantages and disadvantages in terms of technical and economic indicators (including, if available, a feasibility study), environmental safety, and consumption of natural resources per unit of output.	Not considered The EIA Report discusses the territorial alternative in Section 2 of the EIA Report.
5	Detail the planned activity place and location of the main objects of the material and technical base (including buildings and structures, engineering and transport networks, and other graphic materials as part of design and planning decisions, which show the buildings' layouts and structures) of the planned activity on the following materials: -on the general plan of the territory and/or detailed plan of the territory; -on orthophotomaps (satellite images) of high resolution; -on the scheme (plan). We propose to display the following information on the mapping materials: -consumed land resources; -30-kilometer zone of KhNPP; -the industrial site boundaries; -location and parameters of buildings, roads, and other facilities; -location of sources of pollutant emissions; -location of the nearby residential development to the object of the planned activity. We also emphasize that the cartographic materials attached to the Report in electronic format should maintain high resolution and quality.	Partially considered The information is partially provided in paragraphs 1.1 and 1.4.1 of the EIA Report.
6	Description of preparatory and construction works, their duration; content, fixed assets, and technologies of works related to the removal of green or other plants, engineering preparation, and land protection, change of relief, drainage of surface wastewater and groundwater; planned temporary structures, transport, and engineering networks.	Considered The information is provided in paragraph 1.3 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
7	Description of the planned activity, namely: -production processes that are the content of the planned activity; in addition, it is recommended that the process description or equipment include the projected production capacity, maximum consumption of raw materials or other materials per hour, and other parameters of production capacity; -annual demand for raw materials, fuel and fuels, other materials, and water (in appropriate units); -annual water demand for unit cooling in the following combinations: a) KhNPP Units 5, 6 b) KhNPP Units 1, 2 and 5, 6 c) KhNPP Units 1, 2, 3, 4, 5, 6 -the planned activity lifetime ; -characteristics of the nuclear fuel cycle with its description; -compliance of the planned KhNPP Units 5, and 6 with the operational and safety requirements defined by the International Atomic Energy Agency and the Western European Nuclear Regulatory Association (WENRA); -organizational, technical and technological solutions for environmental protection and rational use of natural resources adopted by the planned activity and for which costs are provided, as well as restoration and compensation measures (if applicable).	Partially considered Information on production processes is provided in paragraph 1.4 of the EIA Report. Information on the annual demand for raw materials and water for cooling the units is provided in paragraphs 1.4.3 and 1.4.4 of the EIA Report. Information on the unit's lifetime is provided in paragraph 1.4.2 of the EIA Report. Information on the nuclear fuel cycle characteristics is partially provided in paragraph 5.7.2 (nuclear fuel use) of the EIA Report. Information on the compliance of the planned KhNPP Units 5 and 6 with the operational requirements is provided in paragraph 8.6 of the EIA Report. Information on organizational, technical, and technological solutions is partially provided in Section 7 of the EIA Report.
8	Characteristics of the technological equipment to be constructed, reconstructed, re-equipped or dismantled (replaced) in connection with the planned activity, which is: - pollutant generation source; - the source of the significant impact of physical factors (noise, infra- or ultrasound that spreads beyond the production buildings and the industrial site, significant electromagnetic radiation	Considered Information on the sources of pollutants is provided in paragraph 1.5 of the EIA Report. Information on sources of significant impact of physical factors is provided in paragraph 5.3 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
	following state sanitary norms and rules for the protection of the population from the effects of electromagnetic radiation, ionizing radiation, etc.;) -accumulators of pollutants, solid and liquid waste; -belongs to the objects subject to EIA according to the Law.	Information on pollutants is provided in paragraph 1.5. Information on belonging to the objects subject to EIA according to the Law is provided in Section 1 of the EIA Report.
9	The assessment (characterization) of the impact on environmental components is proposed to be considered according to the following options: -Considering the impact of the operation of KhNPP Units 1 and 2 and planned KhNPP Units 5 and 6; -considering the impact of the operation of KhNPP Units 1-4 (KhNPP Units 3, 4 following the EIA Conclusion, registration number of the case 2018111232231) and planned KhNPP Units 5, 6.	Considered Information is provided in paragraph 5.5 of the EIA Report
10	Description of the waste, including its name or code by the state classifications, the annual volume of waste (and, if available, the specific generation rate adopted for the object of the planned activity), one of disposal at own waste sites, the volume of recycling and transfer to other organizations for recycling or placement (disposal).	Considered Information is provided in paragraph 1.5.2.3 of the EIA Report.
11	Characterization of water use and water disposal in terms of the type of these systems, volumes per year, the quality composition of wastewater and other wastewater in terms of natural physical, chemical, and chemical indicators of water and the content of pollutants, and the equipment of wastewater treatment facilities. Water use and water intake should be characterized in terms of the type of water supply system, type of source(s), name and type of water body - the supply source, water quality category, water intake volume per year by water supply source, and uneven consumption by month.	Considered Information is provided in paragraphs 1.4.3, 1.4.4, 5.2.2, and 5.3.3 of the EIA Report.
12	Provide in the EIA report the calculation of the water balance for the Goryn River, considering the operation of 6 KhNPP units (No. 1-6) and 4 KhNPP units (No. 1-2, 5-6), with due regard to their lifetime and the trend of changes in the Goryn River water level due to climate change, and accounting for existing and projected economic activities within the Goryn River basin.	Partially considered The information is partially provided in paragraph 1.4.5.1 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
		More detailed information will be provided at the project stage.
13	Provide hydrothermal calculations of the cooling water reservoir for the period of operation of 6 KhNPP units (No. 1-6) and 4 KhNPP units (No. 1-2, 5-6), considering their lifetime.	Considered The information is provided in paragraph 5.3.2 of the EIA Report.
14	Characterization of land plots for areas allocated or to be allocated (withdrawn) for the planned activity, land plots (recommended list - by cadastral numbers), category and purpose for the planned and existing states, restrictions on the use of land for the existing and planned state following land management documentation, measures for engineering preparation and protection of land, terms, scope and technologies for reclamation of disturbed land, management of fertile soil layer on the land to be disturbed.	Considered The information is provided in paragraph 1.4.1 of the EIA Report.
15	Characterization of changes in the micro- or macroclimatic conditions of the area due to the planned activity, for example, in temperature, air humidity, freezing of soil or water, fog, or the probability of artificial fog formation over a residential area, etc. Additionally, assess the vulnerability of the planned activity as a whole or its processes or facilities to the adverse effects of climate change, such as an increase in average temperatures, unevenness of river flow, a drop in their water content, etc.	Considered Information is provided in paragraphs 5.6, and 5.3.2 of the EIA Report.
16	The impact characteristics of Units 5 and 6 on flora and fauna. The cumulative impact assessment of flora and fauna from the simultaneous operation of six KhNPP units, including:	Considered
	-identification of bioindicators for environmental assessments;	Information is provided in paragraph 7.5.1 of the EIA Report.
	-identification of zoo-indicators for environmental assessments;	Information is provided in paragraph 7.5.1 of the EIA Report.
	-assessment of changes in forest composition; plant and animal populations;	Information is provided in paragraph 5.2 of the EIA Report.
	-assessment of possible destruction of animal populations, destruction of ecosystems, partial or complete elimination of habitats;	Information is provided in paragraph 5.2 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
	-assessment of changes in the composition of aquatic plant and animal populations.	Information is provided in paragraph 5.2 of the EIA Report.
17	Emission characteristics: a list of stationary sources with an indication of their type, including stationary sites where mobile sources of emissions (construction and installation equipment, trucks, mobile devices, and installations, except for hand tools) are regularly (daily) operated.	Considered Information is provided in paragraph 1.5 of the EIA Report
18	The chemical emissions characteristics: a list of chemical emissions to the atmosphere and the surrounding water environment (sources and quantitative characteristics of discharges).	Considered Information is provided in paragraph 1.5.2 of the EIA Report.
19	Characteristics of the impact on the population, including the rate of cancer in the population (considering the sex and age) in the nearest settlements in comparison with the average rate in Ukraine and calculations: -risk of non-carcinogenic effects; -risk of carcinogenic effects; -the social risk of the planned activity.	Considered Information is provided in paragraph 5.4 of the EIA Report.
20	If there are territories or objects of the NRF, Ecological Network on the territory of the planned activity, within the sanitary protection zone, or on the territory of natural environment objects directly affected by the planned activity, assess the impact of the planned activity on natural complexes and objects, in particular flora and fauna, their communities and habitats (including protected ones), and provide measures to minimize such impact by compensatory measures.	Considered Information is provided in paragraphs 5.2 and 7.6 of the EIA Report.
21	Description ("characteristics") of spent nuclear fuel and radioactive waste management, including the quantity, storage site, and storage period. Also, provide alternative options for spent nuclear fuel and radioactive waste handling from the planned one.	Considered Information is provided in paragraphs 5.7.2.4, 5.3.10, and 1.5.1 of the EIA Report.
22	Description (characterization) of the radioactive materials transportation, including nuclear fuel, spent nuclear fuel, and radwaste (RW), including:	Partially considered Information is partially provided in paragraph 5.7.2 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
	-assessment of radiation impact during transportation of all types of radioactive materials to and from Khmelnytskyy NPP; -determination of the degree of environmental risk during transportation of all types of radioactive materials to and from Khmelnytskyy NPP under normal transportation conditions; -assessment of consequences for the population and the environment during transportation of all types of radioactive materials to and from Khmelnytskyy NPP under normal transportation conditions; -assessment of possible accident risks during transportation of all types of radioactive materials to and from Khmelnytskyy NPP with breakdown by types of transport used (rail, road, etc.) -assessment of environmental and economic damage in case of an accident during transportation and costs for its compensation under all scenarios; -assessment of environmental and economic costs of overcoming the consequences of transportation accidents under all scenarios.	Detailed information will be at the "project" stage.
23	Characterize the environmental impact during emergencies: -to consider accident scenarios at one of KhNPP Units 5-6 and at two units at once, including those caused by the impact of military operations; -to consider scenarios of different types of weapons hitting the vital life support points, destruction of the turbine hall or cooling system of KhNPP Units 5 and 6; -to consider the scenario of an accident with the crash of a large passenger aircraft similar to a Boeing 777/Boeing 737 with full fuel tanks on the nodal points of KhNPP Units 5 and 6;	Partially considered Accident scenarios are considered in the Preliminary Safety Analysis Report (PSAR).
	-maximum design and beyond design basis accidents (with their description);	Information is provided in Section 8 of the EIA Report.
	-meteorological situations that were considered in such assessments, the extent of impact on environmental components;	The information is provided in paragraphs 5.3.8, 5.3.9 of the EIA Report.
	-impact area in case of emergencies;	Information is provided in paragraphs. 5.3.8, 5.3.9 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
	-list of pollutants and their potential release mass in case of emergency;	Information is provided in paragraphs 1.5, 5.3.8, and 5.3.9 of the EIA Report.
	-number of people potentially affected in the impact area in case of emergencies;	Information is provided in Section 2 of the EIA Report.
	-potential economic losses from emergencies; -measures to prevent, minimize, and eliminate such consequences.	Information on economic losses from accidents and the measures envisaged are partially presented in Section 8, and detailed information will be provided in the Preliminary Safety Analysis Report (PSAR).
24	Description of the socio-economic impact and forecasting of the difference between the price of electricity generated per unit of fuel and the market price of a unit of fuel and the storage price and further disposal of a spent nuclear fuel unit at present and every five years during the power units' lifetime.	Considered Information is provided in paragraph 4.10 (socio-economic factors) of the EIA Report.
25	Provide information related to decommissioning, liquidation (dismantling) of the facility, cessation of planned activities, focusing on dismantling, removal of waste and hazardous chemicals, and land reclamation.	Partially considered Information is partially provided in paragraphs 5.1 and 7.5.1 of the EIA Report.
26	The EIA report should include: - Preliminary Safety Analysis Report (PSAR); - Ageing Management Program; - A report on the inspection of the condition of the existing structures of the cooling pond dam.	Not considered The PSAR and Ageing Management Program will be implemented at the design stage. Information on the need to construct a dam is provided in paragraphs 1.4 and 1.5.1.2.
The Ministry of Environmental Protection and Natural Resources letter with comments and suggestions from the public on the planned activities dated 17.04.2024 No. 21/21-03/1681-24:		
Letter of the Executive Committee of Netishyn City Council dated 04.04.2024 No. 01/01-18-1272/2024		
1	We suggest the Notification should be revised in Section 4 Social and Economic Impact of the planned activity as follows: "The socio-economic justification for the planned activities is to strengthen the energy	Partially considered The project will comply with all legal and organizational frameworks for environmental

<table>
<tr><th>No.</th><th>Content of the comment or suggestion</th><th>Information on review and consideration</th></tr>
<tr><td></td><td>independence of the state and provide the population and industry with electricity and heat. The project implementation is of national importance and involves a large number of local contractors, which will create new jobs, and increase production capacity utilization and economic development of the country.</td><td rowspan="2">impact assessment following the requirements of the Law of Ukraine “On Environmental Impact Assessment” dated 23.05.2017 No. 2059-VIII.

It should be noted that in connection with the entry into force on 29.12.2023 of the Law of Ukraine dated 13.07.2023 No. 3227-IX “On Amendments to Certain Laws of Ukraine on Improving and Digitalizing the Environmental Impact Assessment Procedure”, the environmental impact assessment procedure will now be implemented through a new Unified EIA Register on the Unified Environmental Platform of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Ecology) “EcoSystem”. The documentation to be posted there will be open, considering the peculiarities of martial law.

The planned activities notification under the project “Construction of power units No. 5, 6 with the AP1000 reactor unit at the Khmelnytskyy NPP site” has been published on the EcoSystem platform in the Unified EIA Register and is not subject to change.

Within 12 working days from the date of notice publication, the public could submit comments and suggestions to the Ministry of Ecology on the planned activities, the research scope, and the level of detail of information to be included in the EIA Report.</td></tr>
<tr><td>2</td><td>In the process of activities implementation, it is planned to:

1) spend at least 10 percent of the cost of the power unit construction project on the social development of the region.

2) ensure full implementation of Article 12 of the Law of Ukraine “On the Use of Nuclear Energy and Radiation Safety”, in particular:

-preserving benefits for payment for consumed electricity for the population permanently residing in the 30-kilometer zone of nuclear power plants;

-allocating to a special fund of the local budget socio-economic compensation for the risk of the population living in the observation zone;

-creation and maintenance of special social infrastructure facilities, including protective structures designed to shelter and protect people, equipment, and property from radiation exposure in the event of a radiation accident.

33) provision of the specialized medical institution status located on the community territory where the nuclear facility is, with appropriate financial support;

4)personal income tax payment by business entities performing work on the completion of new power units at the Khmelnytskyy NPP site to the community budget where the nuclear facility is.”</td></tr>
</table>

No.	Content of the comment or suggestion	Information on review and consideration
		Subsequently, the Announcement of the public discussion and the EIA Report will be posted on the EcoSystem platform in the EIA Register. The duration of the public discussion is at least 25 working days dated the official publication of the Announcement and the EIA Report. At the public discussion stage of the EIA report, the public is allowed to participate in public hearings and provide any comments and suggestions on the environmental impact assessment report and the planned activities.
Letter from Ulashanivka village council dated 04.04.2024 No. 06-59/87		
1	In Section 4 of the notification, the last sentence should be revised to read as follows: "In the activity implementation planned to spend at least 10 percent (up to 10 percent in the published version) of the construction project cost on the social development of the region", since the development and economic growth of the caustic region, provision of business guarantees and its insurance should be ensured first and foremost.	Partially considered The project will comply with all legal and organizational frameworks for environmental impact assessment following the requirements of the Law of Ukraine "On Environmental Impact Assessment" No. 2059-VIII dated 23.05.2017. It is important to note that due to the entry into force on 29.12.2023 of the Law of Ukraine No. 3227-IX dated 13.07.2023 "On Amendments to Certain Laws of Ukraine on Improving and Digitalizing the Environmental Impact Assessment Procedure", the environmental impact assessment procedure will now be implemented through a new Unified EIA Register on the Unified Environmental Platform of the Ministry of Environmental Protection and Natural Resources of Ukraine (the Ministry of Ecology), EcoSystem. The posted
2	It is worth noting that, in addition to the positive effects of the construction of such a facility, it is also necessary to specify its negative consequences for the population of the 30-kilometer risk zone, the threat to the health of this category of people, the threat to the environment and ecology, and the increased risks for investors, enterprises, and production. Section 4 of the notification should be expanded with paragraph 2 as follows: Decisions to build new power units will also have the following negative consequences: - a threat to the environment, which is a potential water resources shortage, because Ukrainian NPPs have repeatedly faced the problem of a lack of water for reactor cooling. Fresh water is used to cool them. Most of the regions of Ukraine have insufficient water resources: 0.14-0.72 thousand cubic meters per person per year. In Europe, the average figure per person is 4.56 thousand mSv/year. In 2016 and 2017, Khmelnytskyy NPP additionally pumped water from the	

No.	Content of the comment or suggestion	Information on review and consideration
	Goryn River to cool two power units. Despite this, KhNPP plans to build two additional units. This will affect the river's ecosystem; - a threat to the public health of the 30-kilometer risk zone of Khmelnytskyy NPP. Increasing number of people suffering from cancer, cardiovascular diseases, etc.; - climate change. According to the 2021 Analysis of the Impact of Climate Change on Water Resources. Ukraine', most river basins will experience a decrease in average annual runoff this century. The average annual temperature in Ukraine is projected to increase by 0.8-1.10 C. The redistribution of precipitation throughout the year will also increase: there will be more precipitation in the cold season, and less in the warm season when the need for cooling of nuclear power plants increases; -safety factors - construction safety of the AP 1000 technology, Westinghouse Electric Company claims that due to simplified systems, AP 1000 reactors are cheaper to build, operate, and maintain (due to lower piping safety, fewer cables and pumps, and a smaller overall building footprint). However, according to the U.S. Nuclear Regulatory Commission's report on the safety assessment of the AP 1000 reactor, the reactor shield would not resist a direct aircraft hit, which is the most important in martial law; - economic factors include the risks of cost overspending and delayed construction under martial law. Please be aware that before the new nuclear reactor construction it is necessary to study the sufficiency of water resources and the impact on other facilities. It is also essential to consider climate change forecasts in each region where construction is planned (increased emissions and average annual temperature, atypical weather changes during seasons such as droughts or floods, changes in air and water quality, etc.) Considering the above, we urge you to follow the above suggestions and comments, ensure compliance with the legal guarantees of the population of the risk zone, and prevent neglect of their rights and interests, as for several years in a row there have been trends of non-compliance with the provisions of Articles 12-1, 12-2 of the Law of Ukraine “On the Use of Nuclear Energy and Radiation Safety”, suspension of its scope from 2019 to 2024 by the Laws of	documentation will be open, considering the peculiarities of martial law. The notification on the planned activities under the project “Construction of power units No. 5, 6 with the AP1000 reactor unit at the Khmelnytskyy NPP site” has been published on the EcoSystem platform in the Unified EIA Register and is not subject to change. Within 12 working days from the date of notice publication, the public could submit comments and suggestions to the Ministry of Ecology on the planned activities, the research scope, and the level of detail of information to be included in the EIA Report. Subsequently, the Announcement of the public discussion and the EIA Report will be posted on the EcoSystem platform in the EIA Register. The duration of the public discussion is at least 25 working days dated the official publication of the Announcement and the EIA Report. At the public discussion stage of the EIA report, the public is allowed to participate in public hearings and provide any comments and suggestions to the EIA report and the planned activities. Information on the sufficiency of water resources is provided in paragraph 1.4.4 of the EIA Report. Information on threats to public health is provided in paragraph 5.4 of the EIA Report.

No.	Content of the comment or suggestion	Information on review and consideration
	Ukraine, which contradicts the requirements of Article 22 of the Constitution of Ukraine; non-return of electricity benefits for consumers, etc. In addition, the location of an object of national importance in the region should provide guarantees for business and its insurance, and attract investors for the territorial community development.	Paragraph 5.6 of the EIA Report provides information on climate change forecasts. Information on safety factors is provided in Sections 7 and 8 of the EIA Report.
Letter of Pluzhne village council dated 04.04.2024 №03-33/365/2024		
1	In Section 4 of the notification, the last sentence should be revised to read as follows: "In the activity implementation it is planned to spend at least 10 percent (up to 10 percent in the published version) of the construction project cost on the social development of the region", since the development and economic growth of the caustic region, provision of business guarantees and its insurance should be ensured first and foremost.	Partially considered The project will comply with all legal and organizational frameworks for environmental impact assessment following the requirements of the Law of Ukraine "On Environmental Impact Assessment" dated 23.05.2017 No. 2059-VIII. It should be noted that in connection with the entry into force on 29.12.2023 of the Law of Ukraine dated 13.07.2023 No. 3227-IX "On Amendments to Certain Laws of Ukraine on Improving and Digitalizing the Environmental Impact Assessment Procedure", the environmental impact assessment procedure will now be implemented through a new Unified EIA Register on the Unified Environmental Platform of the Ministry of Environmental Protection and Natural Resources of Ukraine (the Ministry of Ecology) "EcoSystem". The documentation to be posted there will be open, considering the peculiarities of martial law. The notification on the planned activities under the project "Construction of Power Units 5, 6 with the AP 1000 Reactor Unit at the Khmelnytskyy NPP Site" was published on the EcoSystem platform in the Unified EIA Register and is not subject to
2	It is worth noting that besides the positive consequences of the construction of such a facility, it is also necessary to specify its negative consequences for the population of the 30-kilometer risk zone, the threat to the health of this category of people, the threat to the environment and ecology, and the increased risks for investors, enterprises, and production, Section 4 of the notification should be supplemented with paragraph 2 as follows: The decision to build new power units will also have the following negative consequences: - a threat to the environment is a potential water resource shortage, as Ukrainian NPPs have repeatedly faced the problem of a lack of water for reactor cooling. Fresh water is used to cool them. Most of the regions of Ukraine have insufficient water resources: 0.14-0.72 thousand cubic meters per person per year. In Europe, the average per capita figure is 4.56 thousand mSv/year. In 2016 and 2017, Khmelnytskyy NPP additionally pumped water from the Goryn River to cool two power units. Despite this, KhNPP plans to build two additional units. This will affect the river's ecosystem; - a threat to the population health in the 30-kilometer risk zone of the Khmelnytskyy NPP. Increase in the number of people suffering from cancer, cardiovascular diseases, etc.; - climate change. According to the 2021 Analysis of the Impact of Climate Change on Water Resources. Ukraine', most river basins will experience a decrease in average annual runoff this	

No.	Content of the comment or suggestion	Information on review and consideration
	century. The average annual temperature in Ukraine is projected to increase by 0.8-1.10 C. The redistribution of precipitation throughout the year will also increase: there will be more precipitation in the cold season, and less in the warm season when the need for cooling of nuclear power plants increases; - safety factors - construction safety of the AP 1000 technology, Westinghouse Electric Company claims that due to simplified systems, AP 1000 reactors are cheaper to build, operate, and maintain (due to lower piping safety, fewer cables and pumps, and a smaller overall building footprint). However, according to the U.S. Nuclear Regulatory Commission's report on the safety assessment of the AP 1000 reactor, the reactor shield would not resist a direct aircraft hit, which is the most important in martial law; - economic factors, including the risks of cost overspending and delayed construction under martial law. Please be aware that before the construction of new nuclear reactors, it is necessary to study the sufficiency of water resources and the impact of other facilities. It is also essential to consider climate change forecasts in each region where construction is planned (increased emissions and average annual temperature, atypical weather changes during seasons such as droughts or floods, changes in air and water quality, etc.) Given the above, we urge you to take into account the above proposals and comments, ensure compliance with the legal guarantees of the population of the risk zone, and prevent neglect of their rights and interests, as for several years in a row there have been trends of non-compliance with the provisions of Articles 12-1, 12-2 of the Law of Ukraine “On the Use of Nuclear Energy and Radiation Safety”, suspension of its scope from 2019 to 2024 by the Laws of Ukraine, which contradicts the requirements of Article 22 of the Constitution of Ukraine; non-return of electricity benefits for consumers, etc. In addition, the location of an object of national importance in the region should provide guarantees for business and its insurance, and attract investors for the territorial community development. Besides, according to a preliminary public opinion poll, the public is extremely concerned and against the 5-6 power unit construction at the Khmelnytskyy NPP site due to the systematic failure to comply with the above legal requirements and disregard for their legitimate rights and interests.	change. Within 12 working days from the date of publication of the notice, the public had the right to provide the Ministry of Environment with comments and suggestions on the planned activities, the scope of studies, and the level of detail of information to be included in the EIA Report. Subsequently, the Announcement on the start of public discussion and the EIA Report will be posted on the EcoSystem platform in the EIA Register. The public discussion duration is at least 25 working days dated the official publication of the Announcement and the EIA Report. At the stage of public discussion of the EIA report, the public is allowed to participate in public hearings and provide any comments and suggestions to the environmental impact assessment report and the planned activities. Information on water resource sufficiency is provided in paragraph 1.4.4 of the EIA Report. Information on threats to public health is provided in paragraph 5.4 of the EIA Report. Paragraph 5.6 of the EIA Report provides information on climate change forecasts. Information on safety factors is provided in

No.	Content of the comment or suggestion	Information on review and consideration
		Sections 7 and 8 of the EIA Report.
	Letter of the Iziaslav City Council of Shepetivka District, Khmelnytskyy Region, dated 04.04.2024 No. 1013/03-14	
1	In Section 4 of the notification, the last sentence should be revised to read as follows: "In the course of carrying out the activity, it is planned to spend at least 10 percent (up to 10 percent in the published version) of the construction project cost on the social development of the region", since the development and economic growth of the caustic region, provision of business guarantees and its insurance should be ensured first and foremost.	Partially considered The project will comply with all legal and organizational frameworks for environmental impact assessment following the requirements of the Law of Ukraine "On Environmental Impact Assessment" dated 23.05.2017 No. 2059-VIII. It should be noted that in connection with the entry into force on 29.12.2023 of the Law of Ukraine dated 13.07.2023 No. 3227-IX "On Amendments to Certain Laws of Ukraine on Improving and Digitalizing the Environmental Impact Assessment Procedure", the environmental impact assessment procedure will now be implemented through a new Unified EIA Register on the Unified Environmental Platform of the Ministry of Environmental Protection and Natural Resources of Ukraine (the Ministry of Ecology) "EcoSystem". The documentation to be posted there will be open, considering the peculiarities of martial law. The notification on the planned activities under the project "Construction of Power Units 5, 6 with the AP 1000 Reactor Unit at the Khmelnytskyy NPP Site" was published on the EcoSystem platform in the Unified EIA Register and is not subject to change. Within 12 working days from the date of publication of the notice, the public had the right to
2	It is worth noting that besides the positive consequences of the construction of such a facility, it is also necessary to specify its negative consequences for the population of the 30-kilometer risk zone, the threat to the health of this category of people, the threat to the environment and ecology, and the increased risks for investors, enterprises, and production. Section 4 of the notification should be supplemented with paragraph 2 as follows: The decision to build new power units will also have the following negative consequences: - a threat to the environment is a potential water resource shortage, as Ukrainian NPPs have repeatedly faced the problem of a lack of water for reactor cooling. Fresh water is used to cool them. Most of the regions of Ukraine have insufficient water resources: 0.14-0.72 thousand cubic meters per person per year. In Europe, the average per capita figure is 4.56 thousand mSv/year. In 2016 and 2017, Khmelnytskyy NPP additionally pumped water from the Goryn River to cool two power units. Despite this, KhNPP plans to build two additional units. This will affect the river's ecosystem; - a threat to the population health in the 30-kilometer risk zone of the Khmelnytskyy NPP. Increase in the number of people suffering from cancer, cardiovascular diseases, etc. - climate change. According to the 2021 Analysis of the Impact of Climate Change on Water Resources. Ukraine', most river basins will experience a decrease in average annual runoff this century. The average annual temperature in Ukraine is projected to increase by 0.8-1.10 C. The redistribution of precipitation throughout the year will also increase: there will be more precipitation in the cold season, and less in the warm season when the need for cooling of nuclear power plants increases;	

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	- safety factors - construction safety of the AP 1000 technology, Westinghouse Electric Company claims that due to simplified systems, AP 1000 reactors are cheaper to build, operate, and maintain (due to lower piping safety, fewer cables and pumps, and a smaller overall building footprint). However, according to the U.S. Nuclear Regulatory Commission's report on the safety assessment of the AP 1000 reactor, the reactor shield would not resist a direct aircraft hit, which is the most important in martial law; - economic factors, including the risks of cost overspending and delayed construction under martial law. Please be aware that before the construction of new nuclear reactors, it is necessary to study the sufficiency of water resources and the impact of other facilities. It is also essential to consider climate change forecasts in each region where construction is planned (increased emissions and average annual temperature, atypical weather changes during seasons such as droughts or floods, changes in air and water quality, etc.).	provide the Ministry of Environment with comments and suggestions on the planned activities, the scope of studies, and the level of detail of information to be included in the EIA Report. Subsequently, the Announcement on the start of public discussion and the EIA Report will be posted on the EcoSystem platform in the EIA Register. The public discussion duration is at least 25 working days dated the official publication of the Announcement and the EIA Report. At the stage of public discussion of the EIA report, the public is allowed to participate in public hearings and provide any comments and suggestions to the environmental impact assessment report and the planned activities. Information on water resource sufficiency is provided in paragraph 1.4.4 of the EIA Report. Information on threats to public health is provided in paragraph 5.4 of the EIA Report. Paragraph 5.6 of the EIA Report provides information on climate change forecasts. Information on safety factors is provided in Sections 7 and 8 of the EIA Report.
3	Given the above, we urge you to take into account the above proposals and comments, ensure compliance with the legal guarantees of the population of the risk zone, and prevent neglect of their rights and interests, as for several years in a row there have been trends of non-compliance with the provisions of Articles 12-1, 12-2 of the Law of Ukraine “On the Use of Nuclear Energy and Radiation Safety”, suspension of its scope from 2019 to 2024 by the Laws of Ukraine, which contradicts the requirements of Article 22 of the Constitution of Ukraine; non-return of electricity benefits for consumers, etc. In addition, the location of an object of national importance in the region should provide guarantees for business and its insurance, and attract investors for the territorial community development. Besides, according to a preliminary public opinion poll, the public is extremely concerned and against the 5-6 power unit construction at the Khmelnytskyy NPP site due to the systematic failure to comply with the above legal requirements and disregard for their legitimate rights and interests.	
Letter of Shepetivka City Council dated 05.04.2024 No. 03-24/1319		
	During the clarification of the coordinates of the KhNPP’s 30-kilometer zone was determined that Shepetivka was not included in the list of 125 settlements in this zone, which is located	The size and boundaries of the observation zone (hereinafter referred to as the OZ) for

No.	Content of the comment or suggestion	Information on review and consideration
	27.5 km from the plant, and four other settlements of the former Shepetivka and Slavuta districts, including Plesnat village, which is currently part of the Shepetivka city territorial community. Based on the results of topographic surveys carried out with consideration of changes in the boundaries of Shepetivka, as defined by the Verkhovna Rada Resolution No. 64/98-VR of February 3, 1998, almost 30% of the town's territory is located in the KhNPP's 30-kilometer zone. In 2007, OJSC "Kyiv Research and Design Institute 'ENERGOPROEKT' together with the Ukrainian Research Institute of Environmental Problems (UkrRIEP) of the Ministry of Environmental Protection of Ukraine, Kharkiv, at the request of the Executive Committee of the Shepetivka City Council, developed a 'Scientific and Economic Justification for the Necessity of Including Shepetivka in the 30-kilometer observation zone of the Khmelnytskyy NPP'. The conclusions of this study state: - about 30% of the city's territory is located within the 30-kilometer zone of the KhNPP; - about one-third of the city's housing stock, the main recreation area, children's health camp, new drinking water intake "Lisova Haliavyna", water supply from Kamiankivske drinking water intake, as well as several enterprises, organizations, and institutions are located within the 30-km zone; - Section 4.1 of the justification proves that the radiation impact of the KhNPP on the entire territory of Shepetivka and all its residents is the same, and therefore it is meaningless to divide the city into two parts (by the boundary of the 30-kilometer zone) based on the radiation intensity of the KhNPP; - about a third of the city's population (almost 14 thousand residents) already lives in areas less than 30 km from the Khmelnytskyy NPP. There are also prospective residential areas in this zone with a population of more than 7 thousand people; - in the vicinity of Shepetivka, the natural factors analysis proves that the radiation impact on Shepetivka residents is no less than on residents of the nearest settlements within the 30-kilometer zone (for instance, Plishchyn village, which borders the city, is included in the Khmelnytskyy NPP's 30-km zone list of settlements around and is currently part of the	Khmelnytskyy NPP operating units were determined by the NPP technical design. The sufficiency of the size and boundaries of the observation zone for the operating Khmelnytskyy NPP units was substantiated and confirmed in the final safety analysis report for Unit 2, which passed the state nuclear and radiation safety assessment. The "Feasibility Study for the Construction of Khmelnytskyy NPP Units 3 and 4", which passed a comprehensive state review and was approved, also proved the sufficiency of the existing facilities for the operation of Khmelnytskyy NPP consisting of four VVER-1000 power units. For the design of new Khmelnytskyy NPP units 5 and 6 with the AP1000 reactor unit, the dimensions of the SS are set following the requirements of paragraphs 4.13-4.16 of NP 306.2.144-2008 "Safety Requirements for NPP Site Selection" and paragraphs 9.1 and 9.4 of the "Basic Sanitary Rules for Ensuring Radiation Safety of Ukraine" (OSPU-2005). The OZ is established based on calculations specified in NP 306.2.173-2011 "Requirements for Determining the Size and Boundaries of the Nuclear Power Plant Surveillance Zone", considering the cumulative impact from all power units. Article 45 of the Law of Ukraine "On the Use of Nuclear Energy and Radiation Safety" prescribes that the size and boundaries of the observation zone are determined in the design of a nuclear power plant following the rules and regulations in the field

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	settlements of the Shepetivka city territorial community); - there is a strong communication link between the city districts located inside and outside the 30-km zone, and between the city and non-urban areas within the 30-km zone. It proves that the factors related to KhNPP operation have a joint effect on the entire population of Shepetivka and, therefore, the same impact on the city population and other settlements within the 30-km zone. The State Sanitary and Epidemiological expertise of the above-mentioned scientific and economic justification was conducted in 2007 by the Marzeev Institute of Hygiene and Medical Ecology of the Academy of Medical Sciences of Ukraine. According to the conclusions of the State Sanitary and Epidemiological Expertise of the Ministry of Health of Ukraine (№05.03.02-07/47840 of 25.09.2007), it was found possible to include Shepetivka in the 30-kilometer zone of the Khmelnytskyy NPP. It should be noted that this conclusion is valid without any term limit. Paragraph 2.1 of the Requirements for Determining the Size and Boundaries of the Nuclear Power Plant Surveillance Zone, approved by the joint order of the State Nuclear Regulatory Inspectorate of Ukraine and the Ministry of Health of Ukraine No. 153/766 dated 07.11.2011 (as amended by the Order of the State Nuclear Regulatory Inspectorate of Ukraine No. 206/765 of 23.11.2015) provides that in case the outer boundary of the observation zone (hereinafter referred to as the OZ) passes through a settlement, the OZ boundary is adjusted so that the entire settlement within its administrative boundary is included in the NPP OZ. Considering the mentioned above, we urge you to consider and resolve the issue of including the city of Shepetivka and the village of Plesna, which is part of the Shepetivka urban territorial community (hromada), in the list of administrative-territorial units that are part of the 30-kilometer observation zone of the Khmelnytskyy NPP.	of nuclear energy use and are also agreed with the state nuclear and radiation safety regulatory authority. The legal standard is also contained in clause 6.8.3 of NP 306.2.141-2008 “General Safety Provisions for Nuclear Power Plants”, which defines that the size of the sanitary protection zone and observation zone is justified by the design of the nuclear power plant. Decision-making on the siting, design, and construction of nuclear facilities and radioactive waste handling facilities of national importance is within the exclusive competence of the Verkhovna Rada of Ukraine following Article 17 of the Law of Ukraine “On Nuclear Energy Use and Radiation Safety” and Article 2 of the Law of Ukraine “On the Procedure for Decision-Making on Siting, Design, and Construction of Nuclear Facilities and Radioactive Waste Handling Facilities of National Importance”. Therefore, revision and approval of the list of settlements to be included in the Exclusion Zone is possible during the design development of new power units of Khmelnytskyy NPP by the procedure established by law, after the Verkhovna Rada of Ukraine decides on siting, design, and construction of the nuclear facilities.
	Letter of Slavuta City Council dated 05.04.2024 No. 04-29/519	
1	In Section 4 of the notification, the last sentence should be revised to read as follows: “In the course of carrying out the activity, it is planned to spend at least 10 percent (up to 10 percent in	Partially considered

No.	Content of the comment or suggestion	Information on review and consideration
	the published version) of the construction project cost on the social development of the region”, since the development and economic growth of the caustic region, provision of business guarantees and its insurance should be ensured first and foremost.	The project will comply with all legal and organizational frameworks for environmental impact assessment following the requirements of the Law of Ukraine “On Environmental Impact Assessment” dated 23.05.2017 No. 2059-VIII. It should be noted that in connection with the entry into force on 29.12.2023 of the Law of Ukraine dated 13.07.2023 No. 3227-IX “On Amendments to Certain Laws of Ukraine on Improving and Digitalizing the Environmental Impact Assessment Procedure”, the environmental impact assessment procedure will now be implemented through a new Unified EIA Register on the Unified Environmental Platform of the Ministry of Environmental Protection and Natural Resources of Ukraine (the Ministry of Ecology) “EcoSystem”. The documentation to be posted there will be open, considering the peculiarities of martial law. The notification on the planned activities under the project “Construction of Power Units 5, 6 with the AP1000 Reactor Unit at the Khmelnytskyy NPP Site” was published on the EcoSystem platform in the Unified EIA Register and is not subject to change. Within 12 working days from the date of publication of the notice, the public had the right to provide the Ministry of Environment with comments and suggestions on the planned activities, the scope of studies, and the level of detail of information to be included in the EIA
2	It is worth noting that besides the positive consequences of the construction of such a facility, it is also necessary to specify its negative consequences for the population of the 30-kilometer risk zone, the threat to the health of this category of people, the threat to the environment and ecology, and the increased risks for investors, enterprises, and production. Section 4 of the notification should be supplemented with paragraph 2 as follows: The decision to build new power units will also have the following negative consequences: - a threat to the environment is a potential water resource shortage, as Ukrainian NPPs have repeatedly faced the problem of a lack of water for reactor cooling. Fresh water is used to cool them. Most of the regions of Ukraine have insufficient water resources: 0.14-0.72 thousand cubic meters per person per year. In Europe, the average per capita figure is 4.56 thousand mSv/year. In 2016 and 2017, Khmelnytskyy NPP additionally pumped water from the Goryn River to cool two power units. Despite this, KhNPP plans to build two additional units. This will affect the river's ecosystem; - a threat to the population health in the 30-kilometer risk zone of the Khmelnytskyy NPP. Increase in the number of people suffering from cancer, cardiovascular diseases, etc. - climate change. According to the 2021 Analysis of the Impact of Climate Change on Water Resources. Ukraine', most river basins will experience a decrease in average annual runoff this century. The average annual temperature in Ukraine is projected to increase by 0.8-1.10 C. The redistribution of precipitation throughout the year will also increase: there will be more precipitation in the cold season, and less in the warm season when the need for cooling of nuclear power plants increases; - safety factors - construction safety of the AP 1000 technology, Westinghouse Electric Company claims that due to simplified systems, AP 1000 reactors are cheaper to build, operate, and maintain (due to lower piping safety, fewer cables and pumps, and a smaller overall building footprint). However, according to the U.S. Nuclear Regulatory Commission's report on	

No.	Content of the comment or suggestion	Information on review and consideration
	the safety assessment of the AP 1000 reactor, the reactor shield would not resist a direct aircraft hit, which is the most important in martial law; - economic factors, including the risks of cost overspending and delayed construction under martial law. Please be aware that before the construction of new nuclear reactors, it is necessary to study the sufficiency of water resources and the impact of other facilities. It is also essential to consider climate change forecasts in each region where construction is planned (increased emissions and average annual temperature, atypical weather changes during seasons such as droughts or floods, changes in air and water quality, etc.).	Report. Subsequently, the Announcement on the start of public discussion and the EIA Report will be posted on the EcoSystem platform in the EIA Register. The public discussion duration is at least 25 working days dated the official publication of the Announcement and the EIA Report. At the stage of public discussion of the EIA report, the public is allowed to participate in public hearings and provide any comments and suggestions to the environmental impact assessment report and the planned activities. Information on water resource sufficiency is provided in paragraph 1.4.4 of the EIA Report. Information on threats to public health is provided in paragraph 5.4 of the EIA Report. Paragraph 5.6 of the EIA Report provides information on climate change forecasts. Information on safety factors is provided in Sections 7 and 8 of the EIA Report.
3	Given the above, we urge you to take into account the above proposals and comments, ensure compliance with the legal guarantees of the population of the risk zone, and prevent neglect of their rights and interests, as for several years in a row there have been trends of non-compliance with the provisions of Articles 12-1, 12-2 of the Law of Ukraine “On the Use of Nuclear Energy and Radiation Safety”, suspension of its scope from 2019 to 2024 by the Laws of Ukraine, which contradicts the requirements of Article 22 of the Constitution of Ukraine; non-return of electricity benefits for consumers, etc. In addition, the location of an object of national importance in the region should provide guarantees for business and its insurance, and attract investors for the territorial community development. Besides, according to a preliminary public opinion poll, the public is extremely concerned and against the 5-6 power unit construction at the Khmelnytskyy NPP site due to the systematic failure to comply with the above legal requirements and disregard for their legitimate rights and interests.	

Table 10.2 – Requirements of the Ministry of Environment for the scope of studies and level of detail of information to be included in the EIA Report

No.	Requirements of the Ministry of Environment	Information about the consideration
1	Include the technical characteristics information of the planned activity in the EIA Report, in particular: -type of equipment and its technical characteristics to be used in the implementation of the planned activity;	Information is provided in paragraph 1.4.2 of the EIA Report
	-technical documentation, information, and data confirming the compliance assessment of the proposed equipment with the regulatory documentation for its manufacture (passports, etc.);	Information is provided in paragraph 1.4.2 of the EIA Report
	-data on hazardous factors (substances, materials) to be used at the facility of the planned activity;	Information is provided in paragraph 1.5 of the EIA Report
	-information on the available material and technical base and its technical characteristics necessary for the planned activity.	Information is provided in paragraphs 1.3.3 and 1.3.4 of the EIA Report
2	Provide the calculations for assessing the seismic condition of the territory (location) of the planned activity in the EIA Report. If necessary, identify restrictions in the seismic zone.	Information is considered and provided in paragraph 1.3.7 of the EIA Report
3	Provide detailed information on the assessment of the projected impact on the geological environment and tectonics, as well as materials on the studies of karst phenomena at the planned activity in the EIA Report. Describe the engineering and geological zonation of the territory according to the risk of landslide and collapse processes, as well as the features of their development. Provide a description of slope stability and expected changes, indicating the type of possible landslide and collapse processes, their location, size, and the magnitude and speed of movement of soil masses (considering indirect consequences caused by landslide and collapse processes (deformation of existing buildings and structures, flooding of valleys during the formation of landslide dams, high waves during rapid displacement of earth masses into the water area, etc.)	Information considered and provided in paragraph 1.4.1 of the EIA Report
4	Detail the geological structure characteristics, composition and properties of soils within the area of possible impact during construction and operation of the proposed activity, as well as	The information is considered and provided in paragraphs 5.2.1 and 5.3.7.2 of the EIA Report

No.	Requirements of the Ministry of Environment	Information about the consideration
	information on the composition and properties of soils within the compressible stratum at the base of the structure in the EIA Report. Provide information on the categories and soil quality, analysis of the planned activity impacts on soils, considering the occurrence of hazardous geological processes and phenomena and other factors that negatively affect the soil condition. Reflect the measures to prevent or reduce the development of hazardous geological processes and phenomena, in particular, soil erosion in the EIA Report.	
5	Detail the description of the technological process of the planned activity, indicating all factors of impact on the water environment and technical solutions aimed at eliminating or reducing harmful impacts (emissions, releases, leaks into water bodies) in the EIA Report, including measures to prevent or reduce pollutants from entering the water environment, disruption of the hydrodynamic regime, depletion of surface and groundwater resources, water conditions deterioration, degradation of aquatic organisms and possible changes in the water balance of the territory.	Information is provided in paragraphs 1.5.2.2, 5.2.2, 5.3.7.5, and 7.4 of the EIA Report.
	The EIA Report should detail the treatment technology of all types of wastewater, provide information on the results of laboratory monitoring of water sources and water bodies in the affected area, and provide measures for the future control of their condition.	Information is provided in paragraph 5.3.3 of the EIA Report.
	Describe the peculiarities of the hydrological regime of the territory of the planned activity with a description of the water balance (site, catchment, and water body) and forecasting and modeling of extreme floods, development of channel processes, bank erosion, etc.	Information is provided in paragraphs 1.4.4, 3.3, 3.8.1.7 of the EIA Report.
	Include a detailed description of nuclear reactor cooling systems in the EIA Report.	Information is provided in paragraph 1.4.2.2 of the EIA Report.
	Investigate possible thermal contamination of water bodies within the observation zone (30 km).	Information is provided in paragraph 5.3.2 of the EIA Report.
	Provide data and analysis on the impact of the planned activity on the hydrological regime of the Goryn River and groundwater level.	Information is provided in paragraph 1.4.4 of the EIA Report.

No.	Requirements of the Ministry of Environment	Information about the consideration
6	In the EIA Report, in assessing the impact on atmospheric air, calculate the predicted air pollution by modeling the dispersion of pollutant emissions into the atmosphere, including consideration of the preliminary analysis of the existing anthropogenic background and the prospects for its change, and indicate measures to prevent or minimize such pollution.	Information is provided in paragraphs 1.5, 7.4, Appendix C of the EIA Report.
	Provide information on official characteristics certificates on the climatic conditions of the planned activity area (average annual wind speeds in the eight wind rose, etc.) and on the background content of pollutants in the air of the area where the facility is located for the current year.	Information is provided in Appendix D and Appendix E of the EIA Report.
7	Provide information on the current state of the treatment facilities at the enterprise, as well as assess their operation, considering the prospective additional load from the planned activities implementation. Also, include in the EIA Report data with supporting materials on limestone sludge accumulation sites, volumes of limestone sludge release, available sludge SFs with their parametric characteristics, and provide for ways to manage limestone sludge in the long term (if such sludge is available and operations with it are performed).	Information is provided in. Paragraphs 1.4.3.1, 5.3.3 of the EIA Report.
	To detail the relevant section of the EIA Report with information on waste handling (qualitative and quantitative characteristics of waste generated during the implementation of the planned activity, in particular, radwaste at all stages of the nuclear facility life cycle, including site selection, design, construction, and decommissioning).	Information is provided in paragraphs 1.3.7, 1.5.2.3, 5.3.10 of the EIA Report.
	Classify waste under the requirements of the Law of Ukraine “On Waste Management”.	Information is provided in paragraph 1.5.2.3 of the EIA Report.
8	The EIA Report includes information on the relation of the planned activity area to the areas and objects of the nature reserve fund (including the forest reserve of local importance “Pralis”), areas reserved for further conservation, areas and objects of the ecological network, cultural heritage sites, sanitary protection and security zones, water intakes, water bodies with indication of their status (including the width of the coastal protection zone, water protection zone, etc.) with the appropriate display of this information on a topographic basis (with the definition of scale).	Information is provided in paragraphs 3.7, and 5.2.3 of the EIA Report.

No.	Requirements of the Ministry of Environment	Information about the consideration
	Include calculations and analysis of the likely impact on these areas and objects, including compensation and environmental protection measures in the EIA Report.	Information is provided in paragraph 7.6 and Appendix C of the EIA Report.
9	Particular attention should be paid to the assessment of the likely impact on flora and fauna (habitats, migration routes, breeding conditions, impacts) in the implementation of the planned activity, including the proposed transport links for the implementation of the planned activity, indicating compensatory and environmental protection measures.	Information is considered and reflected in paragraph 5.2.3 of the EIA Report.
10	Update the EIA Report with information on the company's mandatory policy aimed at continuous monitoring and analysis of NPP safety, including the planned units 5 and 6 at the existing Khmelnytskyy NPP site.	Information is considered and provided in Section 8 of the EIA Report
11	Reflect the envisaged principles of NPP safety (ensuring safety culture; responsibility of the operating organization, state safety regulation; implementation of the defense-in-depth strategy; application of proven engineering and technical practices, quality management; NPP safety self-assessment; safety analysis; departmental supervision; independent inspections; consideration of the human factor; ensuring radiation safety; consideration of operational experience; scientific and technical support, etc.) to specify the mentioned principles and requirements arising from them following the norms, rules and standards on nuclear and radiation safety in the EIA Report.	Information is considered and provided in paragraph 8.6 of the EIA Report.
12	Include in the EIA Report the CCSUP Schedule (Comprehensive (Consolidated) Safety Upgrade Program for NPP Units) based on schedules of preventive maintenance and operations with fresh and spent nuclear fuel (in case of confidentiality, apply part eight of Article 4 of the Law of Ukraine "On Environmental Impact Assessment"). Provide data with forecasts of changes in the state of the environment under normal conditions and in case of design basis accidents at NPPs, considering the implementation of the CCSUP.	On 24.04.2024, Energoatom sent a letter No. 01-9098/46 to the Ministry of Environment with a justification for the exclusion of this item from the conditions list. The purpose of the Comprehensive (Consolidated) Safety Upgrade Program for NPPs is to increase the operational safety level and reliability of Russian-designed WWER power units due to increased requirements for nuclear and radiation safety in connection with the issuance of new or updating of existing regulatory documents on nuclear and radiation safety of Ukraine and considering the

No.	Requirements of the Ministry of Environment	Information about the consideration
		consequences of global events at NPPs, such as the accident at Fukushima Daiichi NPP, which revealed a significant safety deficit of NPPs. The design of power units 5 and 6 at Khmelnytskyy NPP will be based on the AP1000 Generation III+ design certified by the US regulatory authority, which is based on fundamental improvements in safety and the ability to respond to extreme events that led to the Fukushima Daiichi accident.
13	Model emergencies with defined zones of possible contamination (including the affected countries), and provide a list of measures to localize and eliminate emergencies.	Information is considered and provided in paragraphs 5.3.8, 5.3.9 and Section 8 of the EIA Report.
14	Include in the EIA Report an activities analysis considering the socio-economic burden of the region, existing ancillary facilities of the NPP and new planned auxiliary facilities.	Information is considered and provided in paragraph 4.10 of the EIA Report.
15	Investigate and include information on socio-economic risks from the planned activities in the EIA Report: -analysis of possible social conflicts related to the implementation of the planned activity; -display the dynamics of the population level around the facility; -in terms of calculating the economics of environmental management, justify further facility operation	Information is considered and provided in paragraph 5.4 of the EIA Report
16	Detail the assessment of likely impacts on human health, in particular, indicating the levels of electromagnetic and radiation pollution.	Information is considered and provided in paragraph 5.4 of the EIA Report.
17	Provide a references list indicating the sources used for descriptions and assessments in the development of the environmental impact assessment report (including the available list of certificates, letters received from competent organizations and services, etc.)	The references list is provided in the EIA Report in the section “References”.

Table 10.3 – All comments and suggestions received from the Polish authorities on the scope of environmental impact assessment documentation and information on consideration and incorporation

№	Comments	Information on consideration
Regional Director for Environmental Protection in Lublin		
1	Presentation of planned technical, technological, and organizational solutions to counteract the possibility of a design and beyond design accident, aimed at preventing exceeding the permissible level of pollution and environmental impact	Information is provided in paragraph 7.1 of the EIA Report
2	Presentation of information on the severe off-design accident or terrorist situation impact on the health and life of the Polish population	KhNPP is a nuclear and categorized facility Measures for a specific period are envisaged following SBC B.1.1-5:2007 "Composition, content, development procedure, coordination and approval of the section ENGINEERING AND TECHNICAL MEASURES OF CIVIL PROTECTION (CIVIL DEFENSE) in urban planning documentation for a specific period (for official use (FOU)". Nuclear material, radioactive waste and other ionizing radiation sources that are a potential source of environmental hazard at KhNPP is a subject to physical protection under the Law of Ukraine “On Physical Protection of Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Sources of Ionizing Radiation”. Sections on physical protection are developed based on the design risk and are restricted materials. Also, see paras. 5.3.8, 8.5 of the EIA Report.
3	Summary and conclusions of the submitted analyzes in a form accessible to the public regarding its participation in the transboundary procedure	The project will comply with all legal and organizational frameworks for environmental impact assessment according to the requirements of the Law of Ukraine “On Environmental Impact Assessment” dated 23.05.2017 No. 2059-VIII.

№	Comments	Information on consideration
		The transboundary environmental impact assessment of the construction of power units 5 and 6 at the Khmelnytskyy NPP site will be carried out following the requirements of the Law of Ukraine “On Environmental Impact Assessment” and the Convention on Environmental Impact Assessment in a Transboundary Context.
4	Presentation of procedures for informing the Polish party on the current radiological situation and in case of emergencies.	Information is provided in c 8.7 of the EIA Report.
5	Presentation of information on radwaste and spent nuclear fuel handling.	Information is provided in paras. 1.5.1, 5.3.10, 5.4.1 and 5.7.2.4 of the EIA Report.
6	Presentation of cumulative impacts considering the possibility of combining impacts	The information is provided in paras. 5.3.8, 5.5 of the EIA Report.
The Regional Director of Environmental Protection in Rzeszów identified the following issues to be considered during the documentation preparation		
1	• Presentation of the transboundary radioactive contamination assessment with assumptions: • with consideration of the cumulative impact of the planned power units 5 and 6 and other ones operated at a certain time at a certain site; • based on current meteorological conditions for the affected countries; • under normal operating conditions and in the event of an accident at a nuclear power plant.	Information is provided in paras 5.3.6, 5.3.8 of the EIA Report
2	Presentation of possible emergency and accident scenarios.	Information is provided in Section 7 of the EIA Report
3	Presentation of the planned preventive measures to be applied at nuclear facilities to avoid accidents and releases of hazardous substances and pollutants into the environment.	The information is provided in Section 8 and paragraph 7.1 of the EIA Report
4	Presentation of the planned radiological monitoring system	Information is provided in Section 11 of the EIA Report

№	Comments	Information on consideration
5	Presentation of the planned technology for storage and handling of spent nuclear fuel	Information is provided in paragraph 5.7.2.4 of the EIA Report
The Polish Geological Institute - National Research Institute has identified the following issues to be presented in the documentation		
1	Expected impact of the planned project on the hydrodynamic system of the active groundwater exchange zone	Information is provided in paragraph 5.2.2.2 of the EIA Report
2	Expected impact of the planned project on the temperature and chemical composition of the active groundwater exchange zone	Information is provided in paragraph 5.2.2.2 of the EIA Report
3	Expected impact of the planned activity on chemical denudation on soil stability under all power plant facilities	Information is provided in paragraph 5.2.1 of the EIA Report
4	Proposed method and location for reprocessing and handling spent nuclear fuel and radwaste	The information is provided in paras. 5.3.10, 5.4.1, 5.7.2.4 of the EIA Report
The National Nuclear Energy Agency has identified the following issues to be addressed in the prepared documentation		
1	Impact of construction of Units 5 and 6 on the safe operation of Units 1 and 2 and unfinished ones (Units 3,4) including impact on emergency plan measures	Information is provided in paras 5.1.1 and 5.6 of the EIA Report
2	Interaction with other Khmelnytskyy NPP units after commissioning of Units 5 and 6, including common systems for Units 5 and 6 and Units 1, 2, 3, 4.	Information is provided in paragraph 5.6 of the EIA Report
3	Organization of radiation monitoring of the environment in the area around Khmelnytskyy Nuclear Power Plant during the construction of power units 5 and 6 and their commissioning.	Information is provided in Section 11 of the EIA Report
4	Describe how KhNPP Units 5 and 6 will be similar to the AP1000 reference unit and the differences between them. Describe how KhNPP Units 5 and 6 will be similar to the AP1000 reference unit and the differences between them. What will be the impact of Ukrainian nuclear safety and radiological protection requirements on the design changes.	Information is provided in paragraph 8.1 of the EIA Report
5	Changes in the national power grid and power plant system in connection with the operation of Units 5 and 6. The method of thermal energy utilization	Regarding changes in the national power system: free connections at switchgear are envisaged to enable the connection of prospective consumers. Additional grid construction and construction of

№	Comments	Information on consideration
	of power units No. 5 and 6, as well as the impact on the existing heat supply system of the power plant.	additional powerlines 330 ÷ 750 kV (ПЛ 330 ÷ 750 кВ) will be implemented according to specific design decisions. Changes to the main power output scheme of the power units are envisaged - construction and installation of a new 330 kV switchgear; - installation of a 750/330 kV autotransformer at the existing open switchgear 750 kV; - construction of 330 kV transmission lines. If a decision is made to build a new 750 kV line to avoid crossing with existing lines, it is possible to postpone the connection of the 750 kV Rzeszów–Khmelnytskyy powerline. The final decisions will be made at the Design (Project) stage. The decisions regarding the use of thermal power units' energy, and the impact on the existing heat supply system of the power plant will be made at the Design (Project) stage.
6	The impact of the current situation in Ukraine on the construction and commissioning of power Units 5 and 6, as well as on the AP1000 reactor design itself with the reference design.	The design of the new power units is based on all decisions on Vogtle Unit 4. To provide additional protection against terrorist actions of the aggressor country, the option of placing the switchgear underground will be considered at the design stage.
7	Spent Nuclear Fuel and Radioactive Waste Management from Units 5 and 6 and Impact of Increased Spent Nuclear Fuel and Radioactive Waste on the National Spent Nuclear Fuel and Radioactive Waste Management Plan	Information is provided in paras. 5.7.2.4, 5.3.10 and 1.5.1 of the EIA Report.
8	Types and activity of radionuclides released to the environment, their physical and chemical form, methods, ways, and rates of release to the environment, as well as mechanisms of transfer of radionuclides in the environment, including mechanisms of dispersion and accumulation and their seasonal variability under normal conditions.	Information is provided in paras. 5.3.7, 5.3.8 and 1.5.1 of the EIA Report.

№	Comments	Information on consideration
9	Existing levels of radionuclide concentrations in the environment and their variability, as well as the presence of physical or chemical contaminants that may affect radionuclide transfer.	Information is provided in paragraph 5.3.7 of the EIA Report.
10	Natural and anthropogenic environmental features that will affect the transfer of radionuclides (e.g. geological, hydrological, and meteorological conditions, vegetation, or presence of water bodies, with special attention to features, that may affect the territory of the Polish Republic).	Considering the peculiarities of the natural and anthropogenic area character, the impact on the territory of the Polish Republic is practically absent. Information is provided in paragraph 5.3.8 of the EIA Report.
11	Detailed assumptions, including meteorological data and data on releases of radioactive substances into the environment in the event of a severe accident, as well as the results of forecasts of the radiological situation, including a detailed assessment of the potential impact on public health and the environment in the territory of the Polish Republic	To assess the radiological situation forecasts under the worst-case scenario - the beyond design-basis accident, the transboundary impact on the states, including the Polish Republic, was calculated. Such information is provided in Section 5.3.8 of the EIA. More details of such calculations will be provided in the safety analysis report.
12	Structure of agriculture, exports of agricultural products from the territories affected by the nuclear facility, and export trends of agricultural products.	Information is provided in paragraph .5.4.1 of the EIA Report.
13	Identified critical groups	Information is provided in paragraph 1.5.1 of the EIA Report.
14	The procedure for informing the Polish authorities in the event of an accident at the Khmelnytskyy NPP with the expected forecast of the radiological situation in the Republic of Poland, strategies for communication with residents of transboundary areas, including in the border areas of the Polish Republic, to ensure transparency and access to information.	Information is provided in paragraph 8.7 of the EIA Report.
15	Conclusions on the increase in cumulative environmental impact of the entire NPP after commissioning of the planned units	Information is provided in paragraph 5.5 of the EIA Report.
16	Complex assessment of the impact of a severe accident on all nuclear facilities located at the selected site	The accident consequence assessment, which was performed for the reference AP1000 project and passed the relevant approval procedures with the US regulatory authorities, showed the safety of the implemented project. The EIA Report uses the initial data from this analysis and will be implemented in the KhNPP AP1000 design. In addition, Section 5.3.8

№	Comments	Information on consideration
		of the EIA provides the radiological situation estimates under the worst-case scenario - a design-basis accident at AP1000; and Section 8 provides all the necessary information on the accidents analysis and their consequences. In turn, detailed assessments of the severe accident impact will be performed according to regulatory requirements and will be presented in the safety analysis report (SAR).
	In addition, in the next stages of transboundary consultations, the Polish party is interested in obtaining accurate external emergency plans, as well as access to the results of measurements within the framework of radiation monitoring of the environment in the area around Khmelnytskyy NPP during the construction of Units 5, 6 and their commissioning.	Online data on gamma background values, both during the operation and construction of NPP power units, are displayed on the website www.xaec.org.ua. However, to prevent the site from being disabled due to intensified hacker attacks during the Russian invasion of Ukraine, the site was restricted. Also, the current radiation background at all sites of operating Ukrainian NPPs can be found at the following link: https://energoatom.com.ua/ua/ The population of the 30-kilometer observation zone of the KhNPP branch is informed through social networks, media platforms, regional media, and information portals. Ukraine continues to implement the Strategy for the Integrated Automated Radiation Monitoring System (RM) according to the Resolution of the Cabinet of Ministers of Ukraine No. 323-r dated 29.04.2022. To improve the radiation safety level of the population of Ukraine and neighboring countries, increase the reliability and functionality of the radiation monitoring system throughout Ukraine, and integrate the Ukrainian RM system into the European and international RM network, the project "Support for the establishment of an integrated automated radiation monitoring system covering the entire territory of Ukraine" (IARMS) is currently being implemented.

11 A SUMMARY OF THE MONITORING AND CONTROL PROGRAMS FOR ENVIRONMENTAL IMPACTS DURING THE IMPLEMENTATION OF THE PLANNED ACTIVITY, AS WELL AS (IF NECESSARY) POST-PROJECT MONITORING PLANS

Ukraine has established a system of state environmental monitoring to ensure the collecting, processing, storage, and analysis of information on the environmental condition, forecasting its changes, and developing scientifically based recommendations for making effective management decisions.

The executive body that implements the state policy in the field of environmental protection, other specially authorized state bodies, as well as enterprises, institutions, and organizations whose activities lead to or may lead to environmental deterioration, shall monitor the state of the environment and the pollution level.

The monitoring system is based on the following principles:

– comprehensiveness / integrated (all components of the environment that may be affected by NPPs are covered and all types of pollution are taken into account)
– closed loop (there is a feedback between the NPP and the environment);
– systemic unity of NPP and environment;
– ensuring the radiation safety of people and the environment.

The monitoring system includes:

– a system for monitoring the radiation situation at the NPP site and the adjacent territory, including elements of the man-made environment;
– Atmospheric air control system;
– Surface and groundwater monitoring system;
– system for monitoring biological objects of surface waters (monitoring biocenoses and populations);
– system for monitoring the condition of silt and bottom sediments;
– system for monitoring geological processes and soil conditions;
– a system for monitoring the condition of the foundations of buildings and structures;
– warning system.

The radiation impact of NPPs on the environment, including the man-made environment, is assessed using radiation monitoring equipment that controls both the sources of radionuclides entering the environment (liquid discharges, gas and aerosol emissions, etc.) and the radiation situation at the NPP industrial site and the adjacent territory.

The radiation monitoring system is a set of technical means and organizational measures that perform the following main tasks:

– radiation monitoring of the state protective barriers conditions on the way of radioactive substances and ionizing radiation spreading;

– technological systems radiation monitoring;
– the environment radiation monitoring;
– control of organized emissions and discharges;
– leak detection in technological equipment;
– radiation dosimetric monitoring of internal and external personnel exposure;
– regulation and control of public exposure based on annual effective calculations and equivalent doses to critical groups;
– preparation of accounting and reporting documents on the radiation situation at NPPs, in the SPZ and AF, and personnel exposure.

The radiation monitoring system is installed permanently and operates in conjunction with regular and ad hoc radiation monitoring programs to help meet relevant regulatory requirements.

The AP1000 radiation monitoring system is functionally divided into two subsystems:

– radiological monitoring and sampling of process media, emissions, and discharges;
– radiation monitoring of the adjacent area.

The radiation monitoring system consists of distributed measuring instruments that include one or more detectors and a special radiation processor. Each one receives averages, stores the measured data, and transmits alarms and data to the plant control system (safety and security monitoring system for safety-related monitors) for monitoring (if necessary), display, and recording. These alarms are categorized into the following alarm levels: low (failure), warning, and high. Selected channels have alarms based on the rate of increase. It is also possible to store measurements.

To solve the above tasks, it is envisaged:

– remote (permanent or periodic) monitoring;
– control via permanently installed local means and portable devices;
– control via sampling methods of controlled environments with subsequent processing and measurement.

Organizationally, the radiation monitoring system includes the following subsystems:

– radiation technological monitoring;
– radiation dosimetric monitoring;
– individual dosimetric monitoring;
– radiation monitoring of the environment.

A special subdivision of Khmelnytskyy NPP performs permanent laboratory monitoring of air quality on the boundary of the SPZ. Air monitoring at Khmelnytskyy NPP includes five observation points located both in the area of the main industrial site (HVAC and greenhouse area) and settlements located at a distance of 4-8 km (Netishyn - sports complex and mill area, Komarivka village). All the obtained data are processed and, based on their results, a consolidated “Report on the Assessment of the Impact of

Non-Radiation Factors on the Environment" is prepared annually, which provides conclusions on the environmental impact of the NPP and formulates directions for improving environmental protection activities.

The impact of industrial and other economic facilities in Netishyn, as well as Khmelnytskyy NPP itself, on the Goryn River, as a source of water supply for the number of man-made objects was minimized by implementing the following measures:

– observations at the NPP industrial site, the territory of Netishyn, and floodplains of the Viliya and Horyn rivers;

– the sewage Disposal System (SDS) collects sanitary waste from the turbine building, annex building, and one of Units 5 and 6. It transports it to the existing household wastewater treatment plant, where it undergoes full biological treatment and post-treatment at the biological facilities and is then drained to the NPP cooling pond. The capacity of the existing treatment facilities is sufficient to accept and treat household wastewater from the designed power units. Thus, the treated wastewater from the industrial site of power units 5 and 6 is not discharged into the Goryn River and does not affect the pollution level in the river;

– the Waste Water System (WWS) collects non-radioactive wastewater from power unit equipment, building floor drains, process fluids, and system flushing residues before treatment. The wastewater is collected in turbine building sumps and sent to an oil separator, where the oil is coagulated and separated from the water and then transported off-site. If the wastewater does not contain oil, it is sent to a special wastewater retention tank (WWRB) for settling and treatment. Wastewater from the tank is pumped to a purge sump. In case of detection of radioactivity in the drainages from the settling tanks, the wastewater is sent from the settling tanks to the WLS for treatment and disposal. The Waste Water System (WWS) and the Passive Containment Cooling System (PCS) discharge to the Storm Drain System (DRS);

– the Storm Drain System (DRS) receives flows from the Gravity and Roof Drainage Collection system (RDS), treated drains from the Waste Water System (WWS) and liquid from the passive cooling system of the Passive Containment Cooling System (PCS) and discharges them from the power units. Wastewater from the Storm Drainage System (DRS) is supposed to be discharged into the inlet channel for use in the NPP cycle, which will reduce the need for fresh additional service water. A radiation detector is located on the common drainage pipeline of the turbine building pit pumps to enable timely shutdown of the wastewater flow and prevent its drainage into the environment.

– the purge flow of the cooling tower basins of the Circulating Water Supply (CWS) and Service Water (SWS) Systems is taken from the pump drainage manifold and directed to the purge sump of the wastewater collection and disposal system with subsequent drainage into the KhNPP cooling pond.

Liquid and solid radioactive waste is treated and stored under the requirements of the laws and regulations in force in Ukraine. The equipment layout, technological operations, and placement of liquid radioactive waste and solid radioactive waste in closed rooms prevent the leakage and emission of radioactive waste into the environment.

Soil monitoring is carried out at Khmelnytskyy NPP under the Regulations for Physical and Chemical Control of Soils, Sludge and Bottom Sediments at KhNPP, in the

Sanitary Protection Zone and Observation Zone No. 0.LO.6210.RG-17 and the Schedule for Sampling and Chemical Analysis of Soils, Sludge and Bottom Sediments №0.ЛО.6210.РГ-17 and «Schedule of sampling and chemical analysis of soils, silts and bottom sediments».

[redacted]

By regulatory requirements, the SPZ accommodates NPP auxiliary and maintenance facilities and carries out radiation monitoring.

During the startup of power units, the only potential source of chemical impact on the environment may be the cooling pond that receives treated industrial and household wastewater from the NPP site that does not contain radioactive contaminants, treated industrial and household wastewater (which is directed to the general household sewerage network), and stormwater drains from the NPP site.

The sanitary supervision authorities monitor water quality at the blowdown water drainage point, water quality in the Goryn River before the blowdown water is released, and water quality in the Goryn River at a distance of 500 meters downstream from the drainage point. In case of exceeding the threshold limit value (TLK) for pollutants, the bottom water outlet in the last hydraulic gate valve is closed and the blowdown is stopped.

Radioactive contamination of the territory during the maximum design basis accident and the beyond design basis accident will not change the surface soil layer's physical, chemical, or water-physical properties.

Under normal operating conditions of Khmelnytskyy NPP consisting of six power units and implementation of the project environmental protection measures, no negative impact on the environment will be ensured.

12 SUMMARY OF NON-TECHNICAL INFORMATION INTENDED FOR A WIDE AUDIENCE

The mission of the Energy Strategy of Ukraine until 2050 [1] is to create conditions for the sustainable development of the national economy by ensuring access to reliable, sustainable and modern energy sources.

Some of the main measures to achieve strategic goals in the electricity generation are as follows:

- make decisions on the construction of new generating capacities to replace those that will be decommissioned after 2025;
- make decisions and program to replace the NPP capacities that will be decommissioned after 2030;
- select the reactor technologies for the construction of new nuclear power units to replace the NPP capacities that will be decommissioned after 2030.

On August 31, 2021, in Washington, D.C., Petro Kotin, Energoatom President, and Patrick Fragman, President & CEO of Westinghouse Electric Company (WEC), in the presence of President of Ukraine Volodymyr Zelenskyy, signed a Memorandum of Understanding that provides for the construction of new nuclear power units using the AP1000 technology in Ukraine. The pilot project is the construction of two new AP1000 power units at the KhNPP site.

On June 02, 2022, at the KhNPP site, the Declaration on the Start of Energoatom and WEC Joint Project Implementation for the construction of AP1000 power units at the KhNPP site was signed.

The project envisages the construction of two power units with a relevant group of auxiliary buildings and structures within the KhNPP site. The land alienation for KhNPP construction was performed in accordance with engineering design including the future construction of power units. By the time Unit 1 was commissioned, the activities related to land alienation, reclamation and compensation for land occupation were fully completed.

The construction of power units 5&6 ensures:

- energy supply development and electricity availability;
- general improvement of living conditions and welfare of the population;
- employment generation in Netishyn and KhNPP region;
- qualified labor influx;
- social infrastructure development.

The AP1000 has been designed with environmental requirements as a priority. The public and NPP employees safety, as well as the environmental impact, are addressed as follows:

- Design features minimize operational releases.

- Strict targets for staff exposure.
- Reduction in total amount of radioactive wastes.
- Minimized amount of other hazardous waste (non-radioactive).
- AP1000 technology approach to plant safety was specifically designed to maximize the plant's resistance to catastrophic events that result in major infrastructure damage and total loss of power from a common cause, both on and off site.

Radiation protection of the operating personnel and exclusion of environmental contamination in the SRW system is ensured by:

- special equipment for SRW handling (containers, vehicles, etc.);
- mechanical means for handling operations;
- radiation monitoring and decontamination equipment.

All SRW transport and processing operations are performed with radiation monitoring to ensure radiation safety of the plant personnel.

All shields against the radionuclide release into the environment are controlled by the NPP radiation monitoring system.

The main source of air pollution with harmful chemical impurities is the startup boiler house, which, after the startup of power units 5 & 6, can be used only in some emergencies related to the simultaneous shutdown of all power units. Other sources of chemical emissions into the atmosphere are periodic and do not lead to a violation of the regulatory state of the surface layers.

The following measures will be taken to prevent or reduce the flow of pollutants into the aquatic environment, as well as to protect surface waters from depletion during the construction and operation of the facility:

- the NPP has a reverse process water supply system designed to minimize the environmental impact on surface water bodies of general use;
- all NPP wastewater after treatment is directed to the cooling pond and is not discharged directly into public water bodies;
- the NPP cooling pond is a regulating reservoir that allows water intake from the Goryn River only during high-water periods and, accordingly, does not affect the water management situation in the Goryn River basin;
- all NPP effluents entering the cooling pond are subject to hydrochemical control;
- in case of exceeding the level of mineralization and concentration of biogenic elements in the cooling pond, the cooling pond should be purged within the limits of reaching their MPC established by sanitary standards;
- compliance with the temperature conditions in the control points stipulated by the sanitary standards by diluting the blowdown water, controlled by appropriate water temperature measurements;
- compliance with the current legislation requirements for protection and rational use of surface water.

A noise impact from sources located on the industrial site on objects outside the NPP sanitary protection area is within normal limits.

There are no sources of electromagnetic radiation at KhNPP that exceed the limit values established by regulatory documents.

The legislation of Ukraine provides for economic measures to stimulate activities aimed at reducing the environmental impact, namely:

- limits on the use of natural resources and pollutant emissions;
- charge for the use of natural resources and pollutant emissions;
- compensation in accordance with the established procedure for damages caused by violation of applicable law.

The above payments, which are regularly made by KhNPP during the operation, are used to implement measures at the regional level to compensate for environmental damage caused by business activities.

No significant adverse environmental impact is expected from construction activities and implementation of the planned activities. The impact on the environment and population is assessed as acceptable.

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