MINISTRY OF ENERGY AND COAL INDUSTRY OF UKRAINE

National Nuclear Energy Generation
Company "Energoatom"
Detached Subdivision
"South-Ukraine NPP"

Agreed by
M.O. Feofentov
Chief Engineer, DS SUNPP
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SAFETY JUSTIFICATION FOR DS "SOUTH-UKRAINE NPP" POWER UNITS OPERATIONAL LIFETIME EXTENSION OVER THE DESIGNED PERIOD

NON-TECHNICAL SUMMARY

Yuzhnoukrainsk – 2015

CONTENTS

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ABBREVIATIONS

AGPS	-	Active Gas Purification System
BDBA	-	Beyond Design Basis Accident
BOD 5	-	Biochemical oxygen demand after 5 days
C(I)SUP	-	Comprehensive (Integrated) Safety Upgrade Program for Power Units of Ukraine Nuclear Power Plants
COD	-	Chemical oxygen demand
CMU	-	Cabinet of Ministers of Ukraine
DBA	-	Design Basis Accident
EA	-	Environmental Assessment
EDG	-	Emergency Diesel Generator
EGP	-	Exogenous geological processes
EIA	-	Environmental Impact Assessment
FA	-	Fuel assembly
HPP	-	Hydropower Plant
I&C	-	Instrumentation and Control
IEG	-	Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine
IRG	-	Inert radioactive gases
KhNPP	-	Khmelnytsky Nuclear Power Plant
LRAW	-	Liquid radioactive waste
MPC	-	Maximum permissible concentration
NF	-	Nuclear Facility
NPP	-	Nuclear Power Plant
PSP	-	Pumped-Storage Plant
PSR	-	Periodic Safety Review
PSRR	-	Periodic Safety Review Report
RAW	-	Radioactive waste
RNPP	-	Rivne Nuclear Power Plant
SE NNEGC	-	State-owned Enterprise National Nuclear Energy Generating Company
SF	-	Spent fuel
SG	-	Steam Generator
SNRIU	-	State Nuclear Regulatory Inspectorate of Ukraine
SRAW	-	Solid radioactive waste
SSC	-	Structures, systems and components
SU NPP	-	South-Ukraine Nuclear Power Plant
SVO	-	Reactor Water Cleanup System
Tashlyk PSP	-	Tashlyk Pumped-Storage Plant
ZNPP	-	Zaporizhzhya Nuclear Power Plant

INTRODUCTION

This non-technical summary is a review document produced on the basis of early reports, technical assessments, programs and scientific researches.

Ukraine currently has 15 power units at four nuclear power plants with a total installed capacity of 13.835 GW. All these nuclear power plants are operated by the State-owned Enterprise National Nuclear Energy Generating Company "Energoatom" (SE NNEGC "Energoatom").

Today, a 30-year design life of 12 out of 15 Ukrainian operating units has expired or will expire soon.

Power Units were designed based on conservative terms of their operation considering nuclear power industry level at that time. This problem is common for the World Nuclear industry: by 2020 the design life of approximately 80% of nuclear power units, operated in the world, will have expired. But a nuclear power plant operating experience, including the one in Ukraine, showed that an actual lifetime of the basic components of structures and equipment was much higher than it had been assumed in the past, and the replacement of components that require the replacement could be performed with reasonable costs. Therefore, the lifetime extension of power units is an accepted strategy and it is in place in the majority of countries that operate Nuclear Power Plants. "Energoatom" has every reason to consider Ukrainian power units lifetime extension to be a reasonable decision.

Within the above said strategy implementation, the Regulatory Authority of Ukraine (SNRIU) made a decision to extend the lifetime of Rivne Power Units 1&2 (V-213) of 420 and 416 MW correspondently until December 22, 2030 and October 22, 2031 correspondently. In addition, on November 28, 2013 the lifetime of South Ukraine Power Unit 1 was extended for 10 years by the Decision of the SNRIU Board.

The legal framework for SU NPP lifetime extension over the period beyond its design life are "Energy strategy of Ukraine for the period through to 2030" No. 1071 approved by the CMU dated 24.07.2013 and Ukraine Law No. 2861-IV "Concerning the system of making decisions on siting, designing, construction of nuclear facilities and national radwaste management facilities" dated 08.09.2005.

The extension of nuclear power unit lifetime after the expiration of their design life is regulated by the following laws and regulations:

- Ukraine Law "On Nuclear Energy Use and Radiation Safety" No. 39/95−VR, including alterations and amendments;
- Ukraine Law "On Authorizing Activity in Nuclear Energy Use";
- "General provisions of nuclear plant safety", NP 306.2.141-2008;
- "Requirements to NF modifications and to their safety assessment process", NP 306.2.106-2005;
- "General requirements to power units lifetime extension over the period beyond their design life based on the results of the Periodic Safety Review ", NP 306.2.099-2004;
- "Requirements to the structure and contents of a Periodic Safety Review report for operating power units". Agreed by the SNRCU ref. No.15-32/7040 dated 28.12.06, SOU−N YaEK 1.004:2007.

Thereby, the legal framework for operating power units lifetime extension over the period beyond their design life is in place in Ukraine. In addition, this activity is considered to be required as the lifetime extension beyond design life will allow providing both the electricity generation in Ukraine on a strategically required national level and accumulating funds required to decommission power units keeping down consumer load.

1 GROUNDS FOR ELABORATION OF A NON-TECHNICAL SUMMARY

1.1 System of decision-making in power unit lifetime extension

According to the Ukraine Law "Concerning the system of making decisions on siting, designing, construction of nuclear facilities and national radwaste management facilities", the Decision of power unit lifetime extension shall be made by the Regulatory Authority for Nuclear and Radiation Safety based on Periodic Safety Review documents through alterations made to the license. The main document based on which the SNRIU shall make a decision to renew SU NPP license to operate Power Unit No. 2 over the period beyond its design life is a Periodic Safety Review Report (hereinafter referred to as the PSRR).

To make a final decision, the SNRIU will also consider the results of public debates in ecological and social aspects of South Ukraine Power Unit No. 2 lifetime extension.

As per Resolution No. 1122 "Concerning the approval of procedure for public hearings in Nuclear Energy use and Radiation Safety" by the CMU dated 18.07.1998, the subject of public hearings is, in particular, studying of documents related to justification of safety during extended operational life of a NPP Unit and issues related to the abovesaid facilities impact on environment and public health.

In 2012 SU NPP held the public hearings on Power Unit 1 lifetime extension. Based on their results the state-owned enterprise "State Scientific and Engineering Center of Control Systems and Emergency Response" (Kyiv) produced a "Report on public hearings of documents related to justification of safety during extended operational life of South-Ukraine Power Unit 1" describing the procedure and results of public hearings.

In order to involve civic society in discussions of non-technical aspects of South-Ukraine Power Unit No. 2 lifetime extension, it is planning to continue public awareness campaign and to organize new public hearings.

Main theses that shall be communicated to the public are that extended operational life of Power Units over the period beyond their design life does not change current designs; does not provide for new construction of power units or their restructure or some components restructure for a different function, or site expansion. Thereby, any environmental factor does not change, all the parameters of environmental impacts remain on the same level, and maybe, they will go down owing to upgraded processing components and implemented supplementary environmental protection actions.

1.2. Data sources of the non-technical summary

This report is produced on the basis of an SU NPP Environmental Impact Assessment (EIA) performed by the Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine" (IEG) upon the request of "Energoatom" through South-Ukraine NPP (SU NPP).

To produce the EIA, they used data mainly from:

- Client provided data;
- Data of IEG in-house researches;
- Data provided by Ukraine National Academy institutions, scientific organizations reported to other institutions (foremost, the state-owned enterprise "State Scientific and Engineering Center of Control Systems and Emergency Response", S.I. Subbotin Institute of Geophysics of the National Academy of Sciences of Ukraine, Ukrainian Scientific and Research Institute of Ecological Problems (Kharkiv);
- Published sources.

SU NPP provided an EIA author with more than 100 information sources. The major actual data were obtained from:

- "Plant Radiation Safety Reports" (data of radiation safety and radiation protection situation

at SU NPP);
- “Non-radiation Factor Impact Reports” (results of monitoring of SU NPP non-radiation impact upon the environment);
- Periodic Safety Review Reports. Comprehensive safety analysis;
- Periodic Safety Review Reports. Factor No.14. “Radiological impact on the environment”;
- Comprehensive (integrated) Safety Upgrade Program for Power Units of Ukraine Nuclear Power Plants: environmental assessment;
- Environmental Audit of South-Ukraine Power Units;
- Environmental Assessment Report. Main Energoatom’s Report, etc.

1.3. Core results of the environment related documents in terms of plant safety during extended operational life of South-Ukraine Power Units

Reports of the Periodic Safety Review of Operating Power Units

Pursuant to the requirements of NP 306.2.141-2008 “General provisions of nuclear plant safety” and SOU-N YaEK 1.004: 2007 “Requirements to the structure and contents of a Periodic Safety Review report for operating power units”, SU NPP shall perform a periodic safety review of every power unit at regular intervals but at least every 10 years after the start of plant operation or upon demand of the Regulatory Authority. A similar approach is recommended in IAEA Safety Standards Series No. NS-G-2.10 “IAEA Periodic Safety Review of Nuclear Power Plants. SAFETY GUIDE”.

The objective of a PSR is to determine:
- matching of the power unit safety level with the current codes and regulations for Nuclear and Radiation Safety, norms and codes of design and engineering documentation, a safety analysis report and other documentation listed in an operating license;
- the adequacy of the arrangements that are in place to maintain plant safety until the next PSR or the end of plant lifetime;
- a list and terms of safety improvements to be implemented to resolve the safety issues that have been identified during safety assessment.

Periodic safety review reports for every power unit should be prepared based on the results of the Periodic Safety Review. These reports shall be submitted to the State Nuclear Regulatory Inspectorate of Ukraine. The PSR report is the main document based on which the Regulatory Authority makes a decision on SU NPP license renewal for the right to operate power units beyond their design life. The PSR report is produced for every power unit and covers all the aspects important to its safety including the environmental safety as well.

The PSR report includes 15 documents: a comprehensive safety analysis and 14 individual reports for every safety factor:
- SF-1 Plant design;
- SF-2 Actual condition of systems, structures and components;
- SF-3 Equipment qualification;
- SF-4 Ageing of structures, systems and components;
- SF-5 Deterministic safety analysis;
- SF-6 Probabilistic safety analysis;
- SF-7 Internal and external hazard analysis;
- SF-8 Safety performance;
- SF-9 Use of experience from other plants and research findings;
- SF-10 Organization and administration;
- SF-11 Procedures (Operational documentation);
- SF-12 The human factor;
- SF-13 Emergency planning.

- SF-14 Radiological impact on the environment

The PSR report is based on design and operational data, IAEA and WANO reports on Safety Assessment, power unit safety cases, etc.

The last PSR report for Power Unit No. 1 was prepared in 2013 and the PSR report for Power Unit No. 2 – in 2015.

Both PSR reports shows that:

- Power units are operated according to their designs adhering to Safe Operational Limits and Conditions, licensing documents and against current codes and regulations for Nuclear and Radiation Safety;
- Over the reporting period modernizations and modifications were made to power unit components and systems in order to enhance their safety including updating of design documentation and operating procedure;
- SSCs ageing management program has been elaborated and is in place, and that a justification has been provided to confirm that their actual technical condition can ensure their continued safe operation beyond design life;
- Corrective actions have been implemented or planned to correct or mitigate the revealed non-compliances with current codes and regulations for Nuclear and Radiation Safety;
- Operating procedures, administration charts, internal supervision charts, quality system introduced at all Power units and at the plant in general meet the safety principles and ensure the effective fulfillment of roles by an operating organization and plant management in accordance with Ukraine Law No. 39/95-VR and appropriate regulations;
- Actual impact of power unit operation on personnel, public and environment does not exceed radiation and environmental safety criteria and limits specified in regulatory documents;
- The existing conditions and outlined safety enhancement plans ensure the required level of safety during power unit continued operation.

Comprehensive analyses allow making and justifying generalized conclusions on technical capability to continue power units operation for 10 years after the end of their design life.

The task of PSR report volume “Radiological impact on the environment”, SF-14, is to:

- Describe the current radiation monitoring system of a SU NPP impact on the environment, modernizations of this system, and to provide monitoring results regarding an actual plant impact on the environment;
- Perform an analysis of actual plant impact on the environment and compare its results with specified limits;
- Provide information on activities designated to reduce the radiological plant impact on the environment and information that confirms that there are no pre-conditions for exceeding specified limits over the period beyond its design life.

“Comprehensive (integrated) Safety Upgrade Program for Power Units of Ukraine Nuclear Power Plants” (C(I)SUP) is elaborated in accordance with Ukraine’s President Executive Order No.585/2011 dated 12.05.2011 on putting into effect the Decision made by the Ukraine’s National Security and Defense Council of April 8, 2011 “Concerning safety enhancement of Ukrainian Nuclear Power Plants”.

The objective of this Program is to:

- Enhance safety and reliability of nuclear power plants;
- Reduce plant accident risks in the event of natural disasters or any other extreme hazard;
- Improve the effectiveness of DBA and BDBA management and to minimize these accidents consequences.

The authors of the C(I)SUP are Public company “Kyiv Scientific & Research and Design Institute “EnergoProekt” and Public Limited Company “Kharkiv Scientific & Research and Design Institute “EnergoProekt”.

To ensure compliance of the C(I)SUP with the environmental protection and environmental safety requirements, an Environmental Assessment (EA) has been performed.

Following the accident at the Fukushima Daiichi Unit 1 in Japan, the European Council of 24 March 2011 requested that a comprehensive safety and risk assessment be performed on all EU nuclear plants. The European Nuclear Safety Regulators Group (ENSREG) and the European Commission achieved consensus on the stress test specifications. The objective of the stress tests was to assess in detail extreme natural hazards and their combinations to prevent severe accidents resulting from their impact upon plant safety functions.

The Regulatory Authority of Ukraine in collaboration with the State Inspectorate for Safety under man-induced accidents and NNEGC "Energoatom" has elaborated a action plan for a special-purpose out-of-time safety assessment and further safety enhancement of Ukraine Power Units considering lessons learned from the Fukushima-1 disaster. Pursuant to this Plan a special-purpose out-of-time safety assessment was performed at all Ukrainian operating power units.

The stress-test results are depicted in a National Report of Ukraine prepared by the Regulatory Authority. SU NPP – related chapters are covered by Part 1 "Operating NPPs of Ukraine" of this Report.

Environmental Audit of Power Units

An Environmental Audit Report for South-Ukraine Power Units and Environmental Audit Conclusions for South-Ukraine Power Units were prepared in 2012.

The companies that performed the Environmental Audit were the state-owned enterprise "State Scientific and Engineering Center of Control Systems and Emergency Response" (Kyiv) and Ukrainian Scientific and Research Institute of Ecological Problems (Kharkiv).

The Environmental Audit Client was NNEGC "Energoatom" through SU NPP.

The purpose of the audit was to determine ecological justification and effectiveness of SU NPP activity during units continued operation, and to confirm the compliance of this activity with the Environmental Protection Act.

The Environmental Audit for SU NPP showed that:

- SU NPP over its operation period had not had any significant negative impact on the environment of the region;
- Plant activity met the current Environmental Protection Act;
- Environment protection actions being implemented at the facility under environmental audit might be recognized effective, comprehensive and justified, and an environment protection activity – effective and, to a large extent, sufficient;
- Environment management system at the facility under environmental audit is rather effective.

The general conclusion of an environmental audit confirms a capability to continue normal operations of SU NPP without a significant negative impact on the environment.

2 GENERAL CHARACTERISTICS OF SU NPP

2.1 General data

South-Ukraine NPP is a separate division of the State-owned Enterprise "National Nuclear Energy Generating Company "Energoatom" (NNEGC "Energoatom"). NNEGC "Energoatom" conducts its activity in accordance with its Charter and reports to the Ministry of Energy and Coal Industry of Ukraine that sets a national policy in the Industry. As per Ukraine Law "On Nuclear Energy Use and Radiation Safety" through Resolution No. 1268 by the CMU of 17.10.1996 "Concerning the set up of the National Nuclear Energy Generating Company "Energoatom", the role of an operating organization that will bear responsibility for the safety of all Ukrainian NPPs was assigned to "Energoatom".

SU NPP is designed to generate electricity in the southern region of Ukraine with a population over 5 mln. persons to provide it to consumers in Mykolaiv Region, Odesa Region, Kherson region, and the Autonomous Republic of Crimea. SU NPP ensures more than 10% of the total energy produced in Ukraine.

A feasibility study of SU NPP construction was conducted by Kharkiv division of "AtomEnergoProekt" Institute (today, Public Limited Company "Kharkiv Institute "EnergoProekt") and approved by Order No.10 of the Ministry of Energy of the USSR dated February 18, 1971 and agreed upon with the Council of Ministers of the Ukrainian RSR through Resolution No.525 dated December 2, 1971.

The nuclear power plant was constructed on the basis of an engineering design for the 1st construction stage (2000 MW) and 2nd construction stage (2000 MW) approved by Resolutions No.163-RS and No.8787/41 by the Council of Ministers of the USSR dated 23.01.1975 and June 25, 1980 correspondently.

The main technical characteristic of SU NPP:

- Number of reactors is 3 (see table 2.1.);
- Reactor type: WWER -1000;
- plant electrical output in total is 3000 MW.

Table 2.1. – SU NPP power units

Power Unit No.	Reactor type	Construction start	Commissioning date
1	WWER-1000/302	01.03.1977	22.12.1982
2	WWER-1000/338	01.10.1979	06.01.1985
3	WWER-1000/320	01.02.1985	20.09.1989

The design life of power units is 30 years.

The construction of SU NPP – 4 was started in 1983. By 1989 a large scope of work had been done in terms of the main building and support facilities, however, on the basis of Resolution No.647 by the Council of Ministers of the USSR dated August 16, 1989 , the construction was stopped and Power Unit No. 4 was restructured into a full-scope simulator for the plant Training Center.

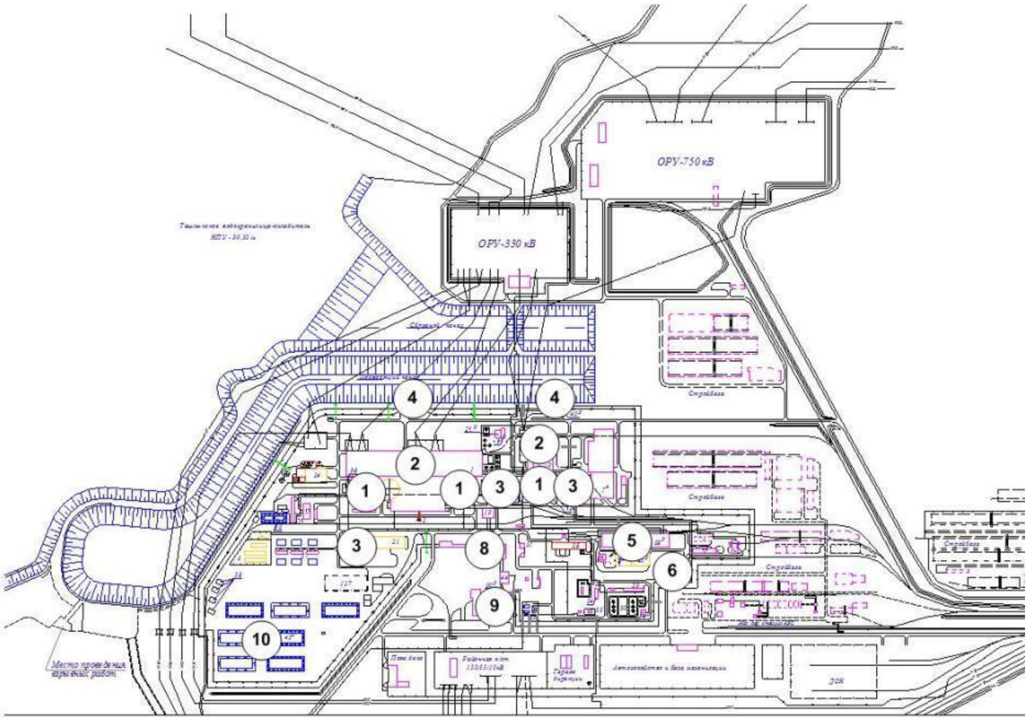
SU NPP is a core of the South-Ukraine Power and Hydro Complex that also comprises Olexandrivka Hydro and Tashlyk PSP. It is the only facility in Ukraine with multipurpose use of basic nuclear and maneuvering pumped-storage capacities and water resources of the Southern Buh river.

Processes

One power unit is composed of:

- WWER-1000 reactor;
- K-1000-60/1500 steam condensing turbine;
- TVV-1000-4 generator.

Below you can find a SU NPP site plan.



1 – RPV
2 – Turbine hall
3 - DG
4 – unit pump station
5 – radwaste treatment building
6 – solid radwaste storage facility
7 – annexe buildings
8 – lab and services buildings
9 – office buildings and check point
10 – spray cooling pond

Fig. 2.1 – SU NPP site plan

Water-moderated water-cooled power reactor WWER-1000 on thermal neutrons is designated to produce heat energy (3000MW rated thermal power) as a part of the Reactor Facility. Nuclear reactor operation is based on controlled fission chain reaction in 235U contained in nuclear fuel. The reactor core consists of fuel assemblies positioned at the nodes of a hexagonal grid. Fuel used in WWER NPPs is in the form of low enriched uranium dioxide pellets that are stacked into a metallic zirconium alloy tubes.

Each WWER-1000 Power Unit consists of two circuits (fig. 2.2.): primary circuit (radioactive) is a water circuit that is used for removing the heat, generated in the reactor core; secondary circuit (non-radioactive) is a steam circuit that takes the thermal power from the primary circuit and uses it in the turbine generator.

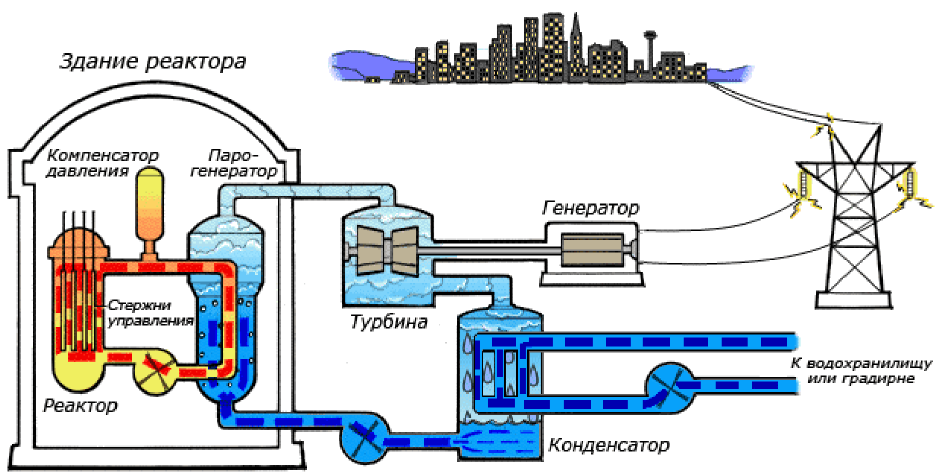


Fig. 2.2. – WWER-1000 Power Unit diagram

The main circulation circuit includes a reactor and four circulation cooling loops. Each circulation cooling loop consists of:

- Steam Generator;
- Reactor Coolant Pump;
- Main circulation piping that combines loop equipment with the reactor.

The energy released by nuclear fission is removed by the coolant circulation of which is forced by the Reactor Coolant Pumps through the reactor core. Through the main circulation pipes the "hot" coolant, from the reactor, is pumped to the SG where the heat is transferred to secondary water and then returns back to the reactor with the help of the RCP. The dry, saturated steam generated in the steam generators secondary circuit is directed to the turbine set equipped with an electric generator of 1000 MW electric output.

In the WWER-1000 Reactor borated water of 160 kgf/cm2 serves both as a moderator and a coolant. The total coolant flow rate is 84.800 m^3/g. The water temperature at the reactor inlet when operated at rated power is 290 ^oC, at the reactor outlet – 320 ^oC.

Like in any steam power plant, only 1/3 of heat energy in the form of steam can be converted into electricity due to thermodynamic limits. The low potential energy of the turbine waste steam is released into the open cooling pond through water cooling system. Cooling evaporation is approximately 40 mln. m^3 per year.

2.2 "Energoatom"'s strategy regarding Power Units lifetime extension

Currently, Ukraine operates 15 power units of 13.835 GW installed capacity in total at 4 NPPs: 6 power units at Zaporizhzhya NPP, 4 power units at Rivne NPP, 3 power units at South-Ukraine NPP and 2 power units at Khmelnytsky NPP. Today, a 30-year design life of 12 out of 15 Ukrainian operating units has expired or will expire soon. If power unit decommissioning scenario is implemented, it will result into 75-80% reduction in total capacity of nuclear industry that is equal to a 40% loss of the electricity generated in total in Ukraine.

The design life of South-Ukraine Power Unit No.1 expired in 2012 and South-Ukraine Power Unit No. 2 will expire in 2015, and South-Ukraine Power Unit No. 3 will expire in 2019.

"Energoatom" neither considers decommissioning to be reasonable nor has resources required for any Power Unit decommissioning. The Company's Strategy lies in step-by-step Power Units lifetime extension. (table 2.2.).

Within the above said strategy implementation, the Regulatory Authority of Ukraine (SNRIU) made a decision to extend the lifetime of Rivne Power Units 1&2 (V-213) of 420 and 416 MW correspondently until December 22, 2030 and October 22, 2031 correspondently granting special licenses. In addition, on November 28, 2013 the lifetime of South Ukraine Power Unit No. 1 was extended for 10 years by the Decision of the SNRIU Board

Table 2.2. – "Energoatom" activity regarding power units lifetime extension

NPP	Power Unit No.	Electrical output, MW	Type	Commissioning date	The end of design life	NNEGC activity related to lifetime extension
Zaporizhzhya	1	1000	V-320	10.12.1984	23.12.2015	In progress
	2	1000	V-320	22.07.1985	19.02.2016	In progress
	3	1000	V-320	10.12.1986	05.03.2017	Started
	4	1000	V-320	18.12.1987	04.04.2018	Started
	5	1000	V-320	14.08.1989	27.05.2020	Planned
	6	1000	V-320	19.10.1995	21.10.2026	Planned
South-Ukraine	1	1000	V-302	31.12.1982	02.12.2013	Lifetime is extended until 02.12.2023
	2	1000	V-338	09.01.1985	12.05.2015	In progress
	3	1000	V-320	20.09.1989	10.02.2020	Planned

NPP	Power Unit No.	Electrical output, MW	Type	Commissioning date	The end of design life	NNEGC activity related to lifetime extension
Rivne	1	420	V-213	22.12.1980	22.12.2010	Lifetime is extended until 22.12.2030
	2	415	V-213	22.12.1981	22.12.2011	Lifetime is extended until 22.12.2031
	3	1000	V-320	21.12.1986	11.12.2017	Started
	4	1000	V-320	10.10.2004	07.06.2035	Not defined
Khmelnytsky	1	1000	V-320	22.12.1987	13.12.2018	Started
	2	1000	V-320	07.08.2004	07.09.2035	Not defined

Options of decisions regarding power units the design life of which has expired

All potential options presuppose decommissioning of power units with expired design life.

The International Atomic Energy Agency (IAEA) has defined three options for decommissioning:

- *Immediate Dismantling (or Early Site Release).*
- *Safe Enclosure* or deferred dismantling.
- *Entombment*.

The Ukraine national regulatory framework defines "NPP decommissioning is a NF lifecycle phase that started after the end of energy generation and arisen from an expired design life or decision of early termination of power unit operation" (par. 2.39, SNRIU Order "General provisions of Nuclear Plants safety" (NP.306.2.141-2008).

"General provisions of safety during decommissioning of NPPs and research reactors" (approved by Order No. 2 by the Ministry for Environmental Protection and Nuclear Safety dated 09.01.1998) defines the following terms:

Decommissioning is a set of measures performed after nuclear fuel removal and facility operation termination in the result of which this facility can no longer be used for the purposes it was built for, and that ensures that there is no unacceptable risk from the facility to personnel and public health and safety or the environment.

Operation termination is a final phase of NF operation that is implemented after making a decision on decommissioning and during which the NF is brought to the condition when the nuclear fuel is removed from the site or being within the site it is stored exclusively in spent fuel storage facilities designated for long-term safe storing.

NF decommissioning process is divided into the following phases:

Final shutdown is a phase in NF decommissioning when it is brought to the condition that excludes the possibility to use this facility for the purposes it was built for;

Mothballing is a phase in NF decommissioning when it is brought to the condition that corresponds to the safe storage of ionizing radiation sources during a particular period of time;

Hold-up – is a phase in NF decommissioning when it is left in dormancy that corresponds to the safe storage of ionizing radiation sources that are in it;

Dismantling is a phase in NF decommissioning when ionizing radiation sources are removed from it or placed in radwaste storage facilities located in its territory.

Decommissioning of a NF is undertaken according to a Decommissioning Project approved by the Regulatory Authority. This project includes a radiation protection program, radwaste management program, Quality Assurance program, action plan in the event of a radiation accident and facility physical protection action plan.

A license for NF decommissioning presupposes granting of specific permits to implement each phase of NF decommissioning.

Decommissioning costs, in addition to such costs as power unit capacity, its lifetime and period to the final shutdown, are depend on many other factors (mainly, NF type and condition, problems related to residual material processing and storage, boundary standards for radiation protection, procedure for granting license, personnel costs, work schedule).

According to the most common assessments, the decommissioning cost of one power unit will be 1 billion € but an international experience shows that the actual costs can be higher. For instance, in Germany an estimated cost for reactor decommissioning over 10 years starting from the date of appropriate decision making has increased from 55 to 250 bln. €.

Comparison of expected outcomes resulted from denying power unit lifetime extension

Considering that denying power unit lifetime extension will surely result into plant decommissioning or closure, there are the following options:

1. Decommissioning (closure) of power units with expired design life, creating, in parallel, generating capacities adequate by their output. This option may be implemented in two ways:
    a. Construction of new NPPs.
    b. Creation of replacement generating capacities: thermal, hydropower, non-conventional (wind, solar, etc.).
2. Decommissioning (closure) of power units with expired design life without creating generating capacities adequate by their output ("zero" option). This option may be implemented also in two ways:
    a. Replacement of energy shortage with energy imports.
    b. Drastic reduction in electricity use that can be alleviated by energy saving, an accelerated introduction of state-of-the-art energy efficient technologies, revolutionary and rapid structural industrial changes, municipal infrastructure reforms made in parallel on a national scale, etc.

There is also a possibility of multiple options or all options in one combination or another.

An analysis of economic impacts, social consequences and ecological effects in the event of each option implementation performed in the EIA shows that today, there is no efficient alternative to continued operation of NPP, in particular, SU NPP.

2.3 Data on the resources used

SU NPP is located in the southern part of the Dnieper Upland on the left bank of the Southern Buh river midstream, it is administratively situated in Arbuzynka District of Mykolaiv Region. The district center, Arbuzynka village, is in 12 km distance from the NPP industrial site, the Regional Center, Mykolaiv town, is in 112 km distance.

Land resources

More than 10 km^2 is under SU NPP in total, 3,3 km^2 out of them is under the industrial site and 7 km^2 is under Tashlyk cooling water pond.

379.29 ha land parcels for construction and operation of the industrial area, warehouses and access road to subsidiary farming has been granted for SU NPP use on a permanent basis as per State Land Transfer Act No. II-MK No. 002166.

To ensure operation of Tashlyk PSP underground structures, "Energoatom" received authorization of the State Committee of Natural Resources of the Ministry of Environment protection of Ukraine to use subsurface resources under registration number No. 3507 dated November 11, 2004.

Fig. 2.3. shows land parcels under the South-Ukraine Power and Hydro Complex including SU NPP.

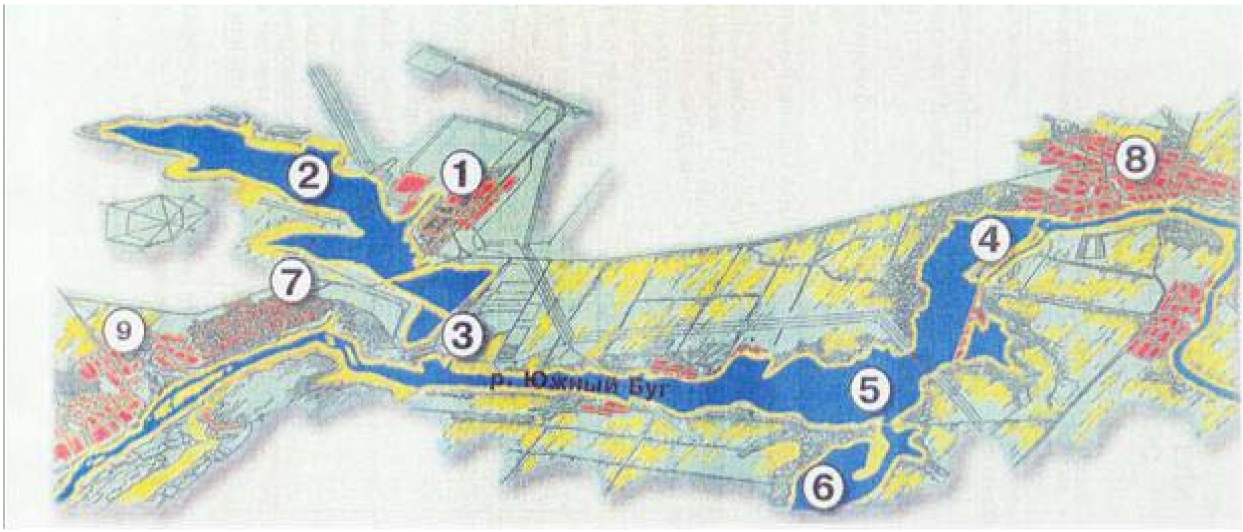


Fig. 2.3. – the South-Ukraine Power and Hydro Complex.
1 – South-Ukraine NPP; 2 – Tashlyk cooling pond; 3 - Tashlyk PSP;
4 – Olexandrivka hydrosystem; 5 – Olexandrivka water storage reservoir; 6 – Prybuzhzhia water storage reservoir;
7 – Yuzhnoukrainsk town, 8 – Olexandrivka village; 9 – Kostyantynivka village

Water resources

Water withdrawals for SU NPP recycling water supply are done from the Southern Buh river through Tashlyk cooling pond. In 2014 the volume of recycling water supply was 3.499,7 mln.m^3, in previous years this figure didn't differ significantly, i.e., in 2010 – 3.383,6 mln.m^3.

Water consumption for business and drinking needs by years has varied more perceptibly, i.e. in 2014 the water consumption was 604.9 thousand m^3, in 2010 – 1429,4 thousand m^3.

Water consumption limits for SU NPP for 2014 were 90.700,0 thousand m^3 of service water and 2.961,3 thousand m^3 of portable water for the plant itself and 134.8 thousand m^3 for divisions within the town.

Average annual water withdrawals are about 50.000…70.000 thousand m^3 of service water and 600…1.400 thousand m^3 of portable water; unavoidable losses are 35.000…40.000 thousand m^3. For example, in 2014 water withdrawals were 71.478,1+573,8+31,1 thousand m^3, losses – 38.462,4+120,6 thousand m^3, and in 2010, correspondently, - 67.087,9+1.396,2+33,2 thousand m^3 and 35.588,6+246,7 thousand m^3.

Fig. 2.3 shows the dynamics in actual volume of water consumed by SU NPP from the Southern Buh river in recent years.

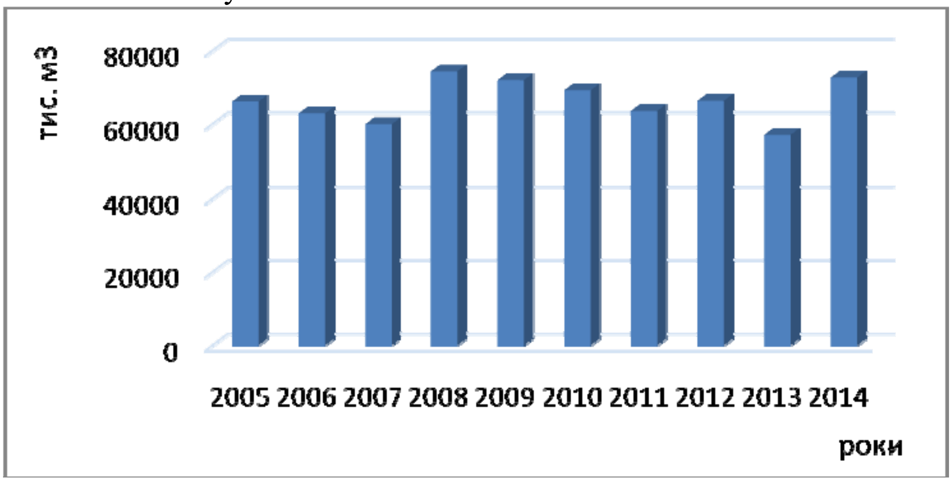


Fig. 2.3. – Dynamics in actual volume of water consumed by SU NPP from the Southern Buh river

Waste water after waste water treatment plants are discharged in Tashlyk cooling pond. The capacity of waste water treatment plants of Yuzhmoukrainsk domestic sewage is 34.5 thousand m^3/day, the capacity of waste water treatment plants of the industrial site is 4,2 thousand m^3/day.

Energy resources

Energy consumption for in-house plant's needs is 6 - 7% of the total electricity generated by the plant. In future it is planning to cut down these volumes by introducing power efficient equipment and organizational arrangements aimed at energy saving.

For emergency power supply and other needs annually the plant uses 2 000 m^3 of diesel fuel. Nearly 7 000 m^3 of oil is used to ensure turbogenerator turbine operation and other needs.

Permissive documents that regulate an environmental protection activity of SU NPP are drawn up on timely basis in accordance with national regulatory documents. SU NPP work activity is undertaken without any environmental protection limitations and penal sanctions.

2.4. Characteristic of sources and forms of influence on environment

The main forms of possible impact on environment during SU NPP operation are radiation, chemical and physical (thermal) impacts.

Radiation impact

According to the document "Periodic safety review" at SU NPP there are the following sources of radiation influence:

- reactor, including vessel internals, primary coolant;
- spent fuel pool;
- spent fuel;
- pipelines and primary circuit equipment (circulating pumps, steam generators, pressurizers, valves etc.);
- reactor water cleanup system (SVO) and its equipment;
- contaminated pipelines and equipment of ventilation systems and active gas purification systems;
- parts and mechanisms of control and protection system, sensors of control and measuring instruments and radiation monitoring that are directly related with measuring of primary circuit parameters;
- radioactive waste;
- sources of ionizing radiation - radioactive sources that are supplied for technical needs (defectoscopy, verification and equipment calibration etc.).

Under NPP normal operation the radioactive products are localized in the special water purification system and active gas purification system of reactor facility. In these conditions the radioactive substance spreading into environment is conditioned mainly by radioactive gas release from feedwater deaerators and controlled leakage tanks as well as possible leakiness in power unit technological systems. To reduce the release activity we decontaminate the radioactive air using special filters installed in the ventilation systems. After this a gaseous mixture is ejected through vent stack.

If steam generators are leaking the fission products get into the secondary coolant. When secondary circuit is leaking there is a possibility that radioactive substances can be in the workrooms of normally occupied area. From there in a transit way through the drain system of equipment and turbine hall floor they can reach Tashlyk storage pond.

The discharges through storm sewage from monitoring tanks of system to treat floor drains and active laundry radioactive sewage are possible source of radioactive contamination of Tashlyk storage pond.

Besides the radioisotope fission products the radioactive substances get into the environment as products of neutron activation in the course of constructional materials' corrosion. Tritium is a very important activation product. Tritium release from primary circuit is possible in case of leakages and water pouring into the tanks intended for primary circuit water pouring.

Repair and maintenance during reactor shutdown are also sources of different radioactive waste that is originated after equipment opening and repair. Certain primary circuit components contaminated during neutron exposure as well as contaminated elements of reactor department equipment and auxiliary building equipment can be replaced that causes additional generation of solid radioactive waste.

Handling with liquid and solid radioactive waste, their storage is realized according to the "Sanitary regulations of NPP design and operation". Under normal operation, design basis accidents and the most likely beyond design basis accidents it is practically excluded that these types of radioactive waste spread to the environment.

Thermal impact

Approximately two thirds of thermal energy generating in the reactors is discharged through the cooling systems to the environment. So, thermal factor has a dominating influence on the environment on conditions that we work under normal mode.

In the SU NPP cooling systems the thermal waste in heat exchangers is transmitted to the cooling circulating water that by means of cooling water pond (Tashlyk cooling water pond), spray ponds and mechanical-draft towers takes away heat to the atmosphere.

Water evaporation in the circular cooling systems results in salts' build-up. The salts arrive with feed water. According to the technological constraints on salt content it is necessary to blow down the cooling systems that salt condition will be on allowable level.

The constant blow down of SU NPP cooling water pond is not provided in the design. The periodical blow down was made with discharge of blowdown water from Tashlyk cooling water pond to Southern Buh river and since 2007 - to Alexandrivka storage pond.

The indicators of heat removal from SU NPP reactor department:

- under normal operation:
  minimum 2,9x10^6 W;
  maximum 23,4x10^6 W;
  at the average 17,4x10^6 W;
- under emergency reactor cooling:
  64,0x10^6 W the first 3 hours;
  31,4x10^6 W, the next 6-10 hours.

The cooling capacity of Tashlyk storage pond can manage the following thermal load:

- 3 operating power units in the cold part of the year
- 2 operating power units in the warm part of the year.

The heat flow to the atmosphere:

- 1 operating power unit 1,7...2,6x10^9 W
- 3 operating power units 3,4...5,3x10^9 W.

Chemical impact

The sources of chemical impact on environment are periodical nonradioactive releases and discharges originating in the buildings and constructions at SU NPP site and having chemical elements and substances which boundary presence is established in the applicable sanitary codes and rules.

Gas-aerosol nonradioactive releases from auxiliary buildings and workrooms are spreading into the atmospheric air.

On the whole the pollutants releases into the air consist of: 30% of sulfur dioxide, 20% of solids (carbon black, dust), 20% of non methane volatile organic compound. The rest of compound is nitrogen dioxide, carbon oxide and carbon dioxide, carbonic compounds, metal compounds, hydrogen sulfide, ammonia, chlorine etc.

SU NPP industrial sewage and Yuzhnoukrainsk sewage water are discharged to the

Tashlyk cooling water pond and later on they are discharged to Alexandrivka storage pond jointly with blowdown water. This is made according to the “Regulations on Tashlyk cooling water pond blowdown into Alexandrivka storage pond”.

SU NPP operates the treatment facilities of household sewage from Yuzhnoukrainsk (productivity 34 500 m3/day) and site treatment facilities (4 200 m3/day). The sewage water after the third maturation pond is discharged to Tashlyk cooling water pond.

Industrial conventionally clean surface runoff and rain water (from site and construction base) are discharged to the network of industrial storm sewage.

2.5. Environmental, radiation, sanitary-and-epidemiologic restrictions of activities

Ukrainian law “On environment protection” (dated 25.06.1991, № 1264-XII) establishes legal, economic and social bases of environment protection. It is manifested in environmental policy aimed at preservation of safe environment, protection of population lives and health against negative influence conditioned by environmental pollution etc.

According to the existing legislative and legal acts and normative documents the SU NPP activities have some restrictions: sanitary and hygienic, fire protection, town planning, territorial. Namely:

Impact restriction on atmospheric air:

- observance of requirements as to the maximum permissible concentration of pollutants and greenhouse gases in the atmospheric air of settlements;
- setting of buffer area;
- elimination of any impact exceeding normative allowable level beyond the buffer area.

Impact restriction on aquatic environment is established in the the Water Code of Ukraine and requirements of other normative and legal acts concerning the sewage water discharge, prevention of aquatic environment pollution and preservation of rivers’ water content.

The legislative requirements about impact restrictions on animal and plant life:

- preservation of biodiversity in animal and plant life;
- preservation of location of plants’ growth;
- it is inadmissible to make worse the natural habitat, migration routes and conditions of wild animals' breeding;
- prevention of degradation of plants’ habitat conditions and prevention of negative consequences in the result of economical activity.

The legislative requirements about impact restrictions on soil:

- protection of agricultural lands, forests' areas and bushes from unfounded change of target use;
- soil protection from erosion, underflooding, waterlogging, devastation, packing, pollution by production residue.

The environmental restrictions related with radiation safety are established by *state system of legal regulation to ensure radiation safety and environmental protection during use of atomic energy*. This system includes:

– legislative acts of national level establishing the ensuring of radiation safety and environmental protection:
    - Ukrainian Law “On nuclear energy use and radiation safety” (№ 39/95-VR dated 08.02.1995) establishes the citizens’ rights and obligations in the area of nuclear energy use. It also regulates the activity related with use of nuclear installations, establishes the priority of radiation protection in atomic industry;
    - Ukrainian Law “On human protection from ionizing radiation” (№ 15/98VR, dated 14.01.1998) establishes the state role in ensuring protection of life, health and citizens' property from negative impact of ionizing radiation in the result of human activity as well as state role in cases of radiation accidents (preventive and rescue measures and

compensation for losses).

– interdepartment normative documents on radiation protection and radiation safety:
- “General provisions on NPP safety” (NP.306.2.141-2008) establish goals and criteria of NPPs’ safety, main technical and organizational measures aimed at their implementation, protection of NPPs’ personnel, population and environment from possible radiation impact;
- “Radiation safety standards of Ukraine” (NRBU-97, NRBU-97 / D-2000) establish main principles of radiation safety, regulate observation of prescribed main dose threshold, elimination of unnecessary exposure, reduce radiation dose to the lowest possible level and prescribe the limits of radiation exposure for staff and population;
- “Basic sanitary rules on radiation safety of Ukraine” (DSP 6.177.2005-09-02) establish sanitary, hygienic, organizatational and technical requirements for radiation safety ensuring during practical activity as to current and potential radiation exposure of staff and population as well as in the situations of interventions;
- “Sanitary rules for NPP design and operation” (SP AS-88) establish requirements for radiation safety ensuring for staff and population, as well as requirements on environmental protection in the course of NPP design and operation;
- Radiation safety rules during NPP operation (PRB AS-89) establish the radiation safety requirements for all the types of activities at operating NPPs.

The environmental restrictions in the area of radioactive waste handling are established by appropriate *legal regulation state system.* This system regulates all the aspects of radioactive waste handling in Ukraine. The main elements of this system:

– Ukrainian Law and CMU directives:
  - “On radioactive waste handling” № 255/95-VR, dated 30.06.1995;
- “On ratification of joint convention on spent nuclear fuel handling and safety of radioactive waste handling” № 1688-III (1688-14), dated 20.04.2000;
  - “On licencing activity in the area of nuclear power usage” № 1370-XIV, dated 11.01.2000;
- “On introduction of changes to certain Ukrainian Laws on radioactive waste handling” dated 17.09.2008, № 515-VI;
- “On state environmental special-purpose programme on radioactive waste handling” dated 17.09.2008, № 516-VI;
- “Strategy of radioactive waste handling in Ukraine” approved by CMU directive dated 19.08.2009, № 990-r.
- norms, rules, standards and other regulatory documents:
- ND 306.607-95 Radioactive waste handling. Requirements for radioactive waste handling before waste disposal. General provisions.
- NP 306.5.04/2.059-2002, Order of state stock-taking of radioactive waste.
- NP 306.5.04/2.060-2002, Safety conditions and requirements (licence conditions) for activity related with radioactive waste processing, storage and disposal.
- NP 306.6.095-2004, Safety conditions and requirements (licence conditions) for activity related with radioactive materials transportation.
- NP 306.4.159-2010, Order of radioactive materials exemption from the regulatory control within the framework of practical activities.
- Sanitary standards “Level of radioactive materials exemption from the regulatory control” approuved in the resolution of Chief Sanitary Inspector of Ukraine, dated 30.06.2010, № 22.
- RD 306.4.098-2004 Recommendations to establish criteria for reception of conditioned radioactive waste for disposal in near surface repositories.
– documents and standards of industry level (NNEGC “Energoatom”):
- “Comprehensive program on radioactive waste handling for 2015-2016. NNEGC “Energoatom”. PM-D.0.18.174-12 (starting 01.10.2012);
- STP 0.03.051-2004, Solid radioactive waste. Determination of radioactivity and isotopic composition. General provisions;

- STP 0.03.059-2005 Reference levels for radioactive waste generating at NPPs. Methodological guidances on their determination;
- SOU YaEK 1.037:2013 NPP short-lived low- and middle-level radioactive waste. Requirements for the end product of reprocessing;
- SOU NAEK 031:2013 Characterization of NPP radioactive materials to justify the exemption from the regulatory control. Methodological guidances.

Normative legal requirements of indicated legislative acts establish main environmental and sanitary restrictions for NPPs operation as to radiation protection. To implement these requirements at NPP they develop regulations, instructions, statutes, programs, keep and fill in documentations on radiation monitoring, etc.

2.6. Waste handling at SU NPP

In the result of SU NPP production activity there are two groups of waste: radioactive and normal waste (production waste and domestic waste). Based on the aggregate state these two groups include liquid and solid waste.

Radioactive waste handling

NNEGC "Energoatom" policy in the area of radioactive waste management

At NPP the generation of electricity goes with generating of radioactive waste having different activity and aggregate states. The waste generating takes place both during main technological process and during scheduled and repair actions.

Ukrainian Law "On radioactive waste handling" defines the radioactive waste as tangible objects and substances which radionuclides' activity or radioactive contamination exceed the limits established by acting norms on conditions that use of these objects and substances isn't provided.

The radioactive waste categorization is established in State Sanitary Rules: "Main Sanitary Rules for radiation protection ensuring in Ukraine" DSP 6.177-2005-09-02.

Safe radioactive waste handling is one of the most important factors of stable development of state nuclear-power industry.

Radioactive waste handing at all the NPPs includes waste collecting, radioactive waste pretreatment to the condition permitting waste transportation, temporary storage, processing and temporary storage in NPP design storage facilities for liquid and solid waste. The design of NPPs didn't stipulate the equipment for treatment and transfer of conditioned radioactive waste before disposal. So, improvement of radioactive waste handling system at NPP is a necessity. This improvement shall ensure radioactive waste processing to the condition permitting radioactive waste transfer to specialized enterprise for long-term storage in centralized storages and final waste disposal.

The radioactive waste handling is performed according to the following documents:

- Ukrainian Law "On radioactive waste handling";
- Updated energy strategy of Ukraine for the period to 2030;
- Strategy of radioactive waste handling in Ukraine, approved by CMU directive dated 19.08.2009, № 990-r;
- State environmental special-purpose programme on radioactive waste handling (Ukrainian Law "On state environmental special-purpose programme on radioactive waste handling" dated 17.09.2008 № 516-VI);
- "Comprehensive program on order handling for 2015-2016. SE "NNEGC 'Energoatom'" PM-D.0.18.174-12 (hereinafter referred to as Comprehensive program). This document has been put into force by the order dated 01.10.2012 № 838-r.

During operation the SU NPP generates two principal types of radioactive waste: liquid and solid waste.

Liquid radioactive waste

During NPP operation some contaminated mediums (sewage) are generated and gathered. The contaminated mediums (sewage) are floor drains that after appropriate processing form a residuum. Residuum is a liquid salts' concentrate belonging to the liquid radioactive waste. In turn the residuum is reprocessed at the deep evaporation installations, forming more concentrated product that during cooling reaches its solid phase (Table 3.4.)

Sources of floor drains generation:

- uncontrolled leakage of the primary circuit;
- leakage of spent fuel pools;
- decontamination water;
- drain from laundries and shower rooms;
- laboratory drain;
- regenerative waters from condensate demineralizing plant filters and reactor water cleanup system filters;
- operational equipment washing.

System of liquid radioactive waste handling at SU NPP.

The temporary storage of liquid radioactive waste is performed in 14 tanks made of stainless steel and located in the auxiliary buildings 1 and 2.

The total volume of liqiud radwaste repositpry buildings is 5159 m^3 , namely:

- 710 m^3 for filtering materials' storage;
- 3709 m^3 for residuum storage;
- 740 m^3 for reserve volume.

The average annual filling of tanks is kepd at 60-80% from total volume of liqiud radwaste repositpry tanks and is 3000-3500 m^3.

Solid radioactive waste

Solid radioactive waste are divided into 3 categories according to their radioactivity levels:

- 1st category: treating and insulation materials, overalls, footwear, personal radiation protection equipment, flexible polymers, building refuse, devices and tools.
- 2nd category: pipes, armature, parts of pumps and drives of protection and monitoring system, ventilation system filters, scrap metal, heat-insulating materials, changeable indicators.
- 3rd category: protective sleeves, units for control/compensation of emergency switching, ion chambers with cable flats, sensors of thermal yield and energy output with cable flats.

The radioactive waste of the 1st and 2nd categories are kept in concrete tanks at storage which capacity is calculated based on the following criteria:

- period of storage: 10 years;
- possibility of future movement and disposal;
- storage of fire-hazardous and fire-safe waste in plastic bags;
- storage of specialized ventilation filters without pretreatment.

The radioactive waste of the 3rd category are kept in appropriate units' repositories.

The main sources of solid radioactive waste generating are units' maintenances and servicing, including:

- operation of NPP equipment, buildings and constructions;
- equipment reconstruction and modernization;
- equipment decommissioning including steam generators replacement;
- decontamination of equipment, premises, NPP buildings and constructions;
- equipment servicing and maintenance;
- works on assembly, disassembling and heat insulation replacement;
- construction and construction&reconstruction works;
- replacement of obsolete and worked-out elements of equipment, consumables;
- replacement of threadbear overalls, personal protection equipment;
- implementation of sanitary and hygienic measures in controlled access area.

As solid radioactive waste we treat:

- metal junk that has been formed during maintenance;
- general mechanical rubber goods, elastron and cable production that is unusable;
- used filters of ventilation systems from reactor department and auxiliary building;
- heat insulation that is unusable for reuse;
- wipe material, unusable working clothes, worn-out personal protection equipment, paper;
- building refuse generated in the results of maintenance;
- first circuit equipment and failed equipment that is technologically related with first circuit;
- all the objects and details extracted from the reactor core.

For solid radioactive waste storage at SU NPP there are 4 storage buildings with total volume of tanks 27114 m^3 with separate storage of radioactive waste on the basis of the types and activity.

Detailed data on the volume of liquid and solid radioactive waste, information on waste handling is given yearly in "Reports on analysis of sources and amount of radioactive media, liquid radwaste, solid radwaste generated during operation/scheduled maintenance of SU NPP power units".

Spent fuel handling

The spent fuel is generated in the course of electricity generation in nuclear reactors. Average annual volume of spent fuel shipped from a WWER-1000 power unit for storage is 42 fuel assemblies. Annually SU NPP uses about 126 assemblies.

After use in reactor core (reaching of designed fuel burnup) the spent fuel is shipped to the spent fuel pools where it is storaged during 4-5 years for reduction of radioactivity and decay heat. After cooling the spent fuel is shipped to the special containers ensuring its safety during transportation.

The actual status of nuclear power engineering in the world is conditioning by the current level of science and technology and don't permit to take the final decision on the following spent fuel handling. At the world level there are several approaches to this question:

A deferred decision stipulates a long-term storage of spent fuel. It permits to take the final decision in the future, taking into account future technologies and economic factors. The spent fuel reprocessing gives a chance of receiving components and substances that use is economically sound and their reprocessing will considerably reduce the number of waste for disposal. The reprocessing may be local or it can be done in the other countries with return of spent highly active fuel to the country of origin.

After spent fuel decay and conditioning the spent fuel is transported to the final storage at a geologic storage site. It is designed to hold radioactive-decay product and actinides during the time necessary to prevent some negative environmental effects.

At present spent fuel from SU NPP is sent for storage to Russia.

Ukrainian specialists at ZNPP have experience in spent fuel storage at "dry" containers. This fact permitted the operating organization SE NNEGC "Energoatom" to announce an international bid. Based on its results they signed a contract with American Company «Holtec International» on building of spent fuel centralized storage of "dry" type for RNPP, KhNPP and SU NPP.

Technical and economic assessment of investment for building of spent fuel centralized storage of "dry" type is developed by general designer - public corporation Kyiv Research & Development Institute "Energoproekt". Verkhovna Rada of Ukraine issued the law №4384-VI (dated 09.02.2012). Under this law the spent fuel centralized storage of "dry" type is a part of single spent fuel management complex of State specialized enterprise Chornobyl NPP and is located in the Kyiv region in the exclusion zone contaminated after Chornobyl disaster. The total capacity of centralized storage is 16529 of spent fuel assemblies from WWER-440 and WWER-1000.

Non-radioactive waste handling

As a result of SU NPP operation there are 59 types of non-radioactive hazardous toxic waste having the following safety classes:

1st safety class: used luminescent lamps containing mercury, used chemicals (partially) – 2 types of waste.

2nd safety class: used oil products, used lead-acid batteries and alkaline accumulators, etc. – 5 types of waste.

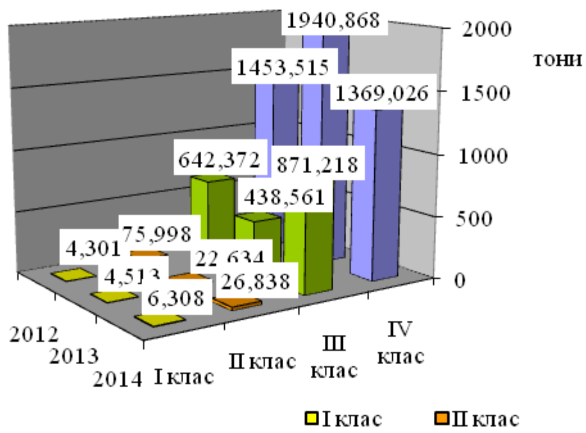
3rd safety class: greasy rags, sand with black oil traces, used sleepers, used oil filters, etc.– 11 types of waste.

4th safety class: heat insulation waste, woodworking waste, underburning lime, domestic waste, building refuse, used rubber, cullet, waste paper, used tyres, etc – 41 types of waste.

SU NPP is operating according to limits approuved by Governing Bodies on Ecology and Natural Resources of Mukolaiv Region State Administration. These limits for 2014-2016 concern generation and location of waste at SU NPP and recreation center "Druzhba". Based on these limits the Ministry of ecology and natural resources of Ukraine issued permits for location of hazardous waste.

Last reporting period dynamics of hazardous toxic waste generation based on the safety classes is at Figure 2.4.

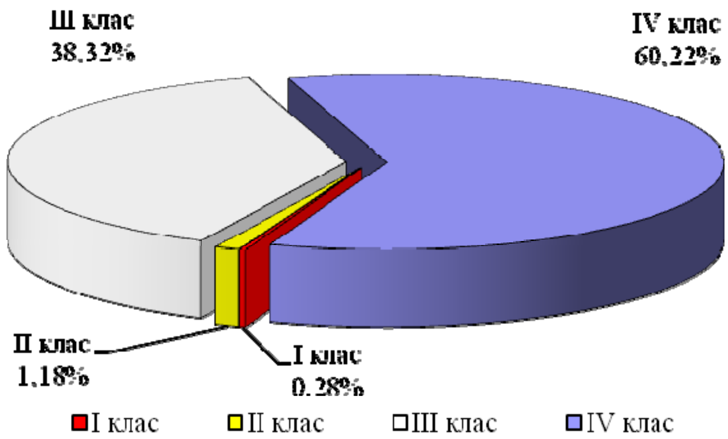
Detailed data about places and conditions of temporary storage and their further transfer to recycling or waste burial are in "Annual reports about non-radiation factors impact on environment".



x-axis: safety class (клас - safety class)
y-axis: tonne (тони - tonnes)

Figure 2.4. – Volume of non-radioactive waste generation at SU NPP

At Figure 2.5. we can see the correlation of waste volume and safety classes.



(клас - safety class)

Figure 2.5. – The correlation of non-radioactive waste volume and safety classes at SU NPP, 2014.

2.7. Assessment of possible emergencies

System of emergency preparedness and response

"SU NPP emergency plan" is putting into force by Director general order as component part of NNEGC "Energoatom" System of emergency preparedness and response. Emergency plan establishes the SU NPP emergency organizational structure, division of responsibility and duties concerning emergency response, list of emergency response means, list of external organizations involved in emergency response, list and order of emergency actions at the site and buffer area.

SU NPP System of emergency preparedness and response - an interdependent complex of technical facilities and resources, organizational, technical and radiobiological& sanitary measures performing by operating organization to prevent or reduce the radiation influence on personnel, population and environment in case of nuclear of radiation accident at NPP.

Main targets of Emergency Preparedness and Response System at SU NPP:

- maintaining of necessary level of emergency preparedness at SU NPP;
- response in case of accidents and emergency situations including protection of personnel, population and environment.

Potential accidents during operation of SU NPP power units

The acceptance criterion for ecological consequences of accidents is established in NRBU-97.

To analyse radiation consequences of design basis accidents and beyond design-basis accidents at SU NPP they take into account:

- maximum design basis accident – accident caused by double-ended rupture of cooling system (loss-of-coolant accident) at the nominal energy level;
- depressurization of cover at steam generator collector;
- accident during fuel handling and spent fuel handling;
- accident caused by cooling line damage outside the reactor.

At SU NPP they conduct the analysis of severe beyond design accidents as a part of safety analysis in C(I)SUP.

Mitigation of accident consequences

SU NPP emergency safety is based on the following safety principles and criteria:

- NPP safety is ensured by the use of
  - physical barriers in the direction of spreading of ionizing radiation and radioactive substances into environment,
  - system of technical and organizational measures as to protection of barriers and keeping their efficiency for protection of personnel, population and environment.
- During NPP operation they monitor the barriers' integrity in all the direction of spreading of radioactive substances. Under normal operation all the barriers and means of their protection are in working condition. The NPP operation at power is prohibited if there is a failed barrier that is specified in the plant design or there is a failed equipment protecting this barrier.

Physical barriers in the direction of radioactive releases spreading (fuel matrix, fuel cladding, coolant circuit boundary, containment, biological shielding):

- availability of special safety systems based on the parallel trains performing the same function;
- safety system ensures principles of independence, redundancy, physical separation and accounting of every incident;
- high technical features of accident localization system to prevent the radioactive substance spreading into the environment;
- technological processes have a high level of control and automation including an emergency management in the course of the most important phase (first phase) without personnel envolvment;
- safety ensuring provided external influence specific for plant under review including nature and technogeneous impact;
- safety ensuring in broad spectrum of initial events with a glance of postulated failures, possible personnel errors and additional impacts;
- use of conservative approach to choose engineering solutions impacting the safety;
- usage of measures and engineering solutions aimed at:
  - protection of accident localization system in case of design basis accident,
  - prevention of initial event transfer into design-basis accident,
  - consequences' mitigation of the accidents if prevention had failed;
- ensuring of possibility to check and test the equipment and systems that are important to safety to maintain them in working condition;
- arrangement of buffer area and radiation control area;
- quality assurance with a glance of requirements of relevant normative documents.

System of technical and organizational measures has 5 levels:

Level 1: Creation of conditions preventing violation of normal operation;
Level 2: Prevention of design-basis accidents using normal operation system;
Level 3: Prevention of accidents at safety systems;
Level 4: Beyond design-basis accidents' management;
Level 5: Planning of measures on protection of personnel and population.

Questions concerning the *fire safety at SU NPP* are examined in detail in the Annex F.

2.8. List of the main influence sources and affected area boundaries

The nature of SUNPP industrial activity means that the main form of potential influence is determined by the radiation factor.

Radiation influence sources at SUNPP site

According to peculiarities of the process cycle the sources of radioactivity are as follows:

- reactor, reactor vessel internals, primary coolant;
- spent fuel and refueling pond;
- spent nuclear fuel;

- primary pipelines and equipment (circulating pumps, steam generators (SG), pressurizers, valves, etc.);
- reactor water cleanup systems (SVO) and their equipment;
- contaminated pipelines and equipment of ventilation systems, active gas purification system (AGPS);
- components and mechanisms of Reactor Control and Protection System, I&C sensors and radiation monitoring sensors directly related to primary parameter measurements;
- radioactive waste (RAW);
- radioactive sources supplied for engineering purposes (for flaw detection, for calibration and graduation of instrumentation equipment, etc.).

During SUNPP normal operation the main quantity of radioactive products of the reactor facility are confined in the systems of reactor water cleanup and active gas purification.

The volumes of radioactive substance releases into the environment are mostly caused by releases of radioactive gases from the makeup deaerators, controlled leakage water tanks and through possible leakiness in different process systems of the power unit that contain radioactive materials.

To reduce the release intensity radioactive air is treated using the special-purpose filters installed in the ventilation systems. Gaseous mixture is released through the vent stack after its treatment in the active gas purification system.

In case of loss of SG integrity the fission products enter the secondary circuit coolant and in case of its tightness loss radioactive substances can be transferred into the industrial premises of normally occupied area and through the drain system and floor drains in the turbine hall into the environment (Tashlyk reservoir).

The potential source of radioactive discharges can be water run-off which comes from the tanks of floor drain treatment system TD and TR (SVO-3) and active laundry cleanup system TX (SVO-7) into stormwater sewer system and with its discharges into the Tashlyk reservoir.

Actions on emission intensity limit that have been taken at the design stage, control over emission rate and operation of treatment facilities (SVO and AGPS) in the design mode ensure compliance with the requirements of sanitary rules during the plant operation. No cases of excess of airborne emission intensity over permissible levels have been detected during SUNPP normal operation.

Potential objects of impact and affected area boundaries

All components of natural environment namely geological, air and water environment, soils, flora and fauna refer to the potential objects of SUNPP impact. Social and anthropogenic environment are also affected by its impact.

SUNPP buffer area is defined by the radius of 2.5 km according to the design (Fig. 2.6).

Fig. 2.6. – SUNPP buffer area

SUNPP surveillance area with radius of 30 km is presented in Fig. 2.7.

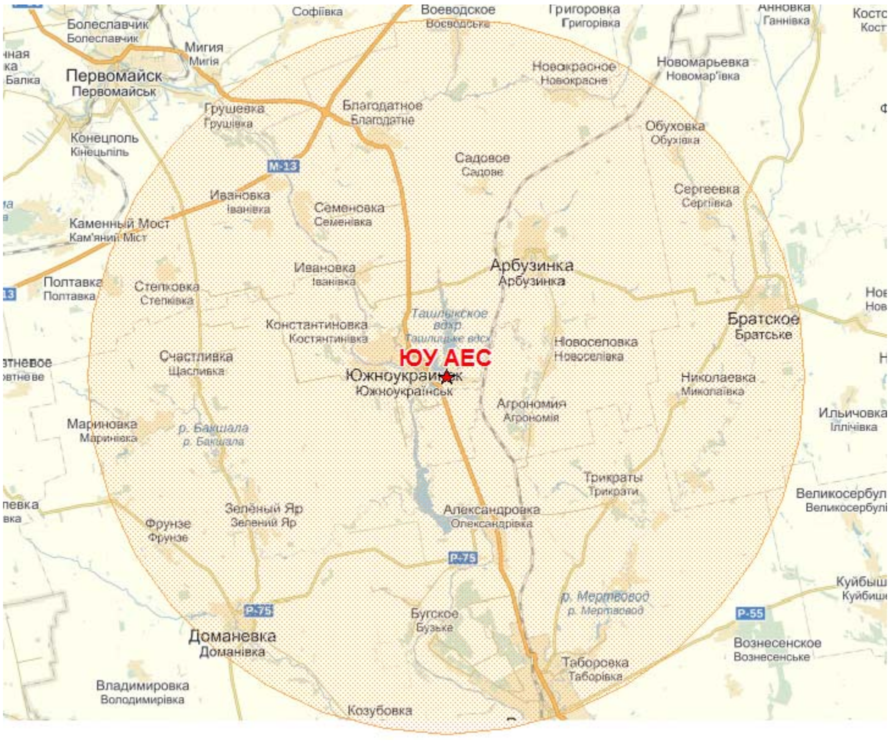


Fig.2.7 – SUNPP surveillance area

3 CHARACTERISTIC OF THE ENVIRONMENT AND ASSESSMENT OF INFLUENCES OF SUNPP AND SOUTH-UKRAINE POWER COMPLEX OPERATION ON IT

SUNPP site is situated in the southwestern part of the Dniepro Highland and is characterized by the typical valley and gully relief with the plain undulating interstream area and deeply incised river valleys. Present-day relief is caused by geological structure, neotectonic movements, river erosivity and climatic features. There are three main types of relief there:

accumulative and denudation, denudation, erosive and accumulative ones. In general, the area is accumulative and denudation valley which is slightly inclined to the southeast and intensively incised by the river valleys, ravines and gullies.

3.1. Microclimate

South-Ukraine Power Complex including SUNPP is situated in the northern part of steppe zone. It is characterized by not very cold and dry winter, hot summer with low and unstable watering and oft-recurring dry periods and hot dry winds.

The territory microclimate can be potentially affected by water evaporation in SUNPP cooling systems. It is 40 million m^3 per year. Evaporation can result in strengthening of fogs and precipitations, in change of temperature conditions. Changes in microclimate conditions are analyzed by comparing the data received at the weather stations in Pervomaisk, Voznesensk and Yuzhnoukrainsk. The main temperature trends over the period of climate surveillance are presented in Fig. 3.1 – 3.3.

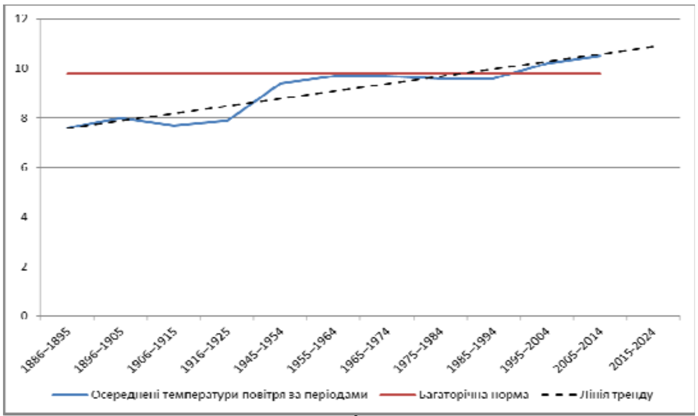


Fig. 3.1. – Dynamics of averaged air temperatures, ^{0}C, over the period of surveillance in the area of SUNPP influence

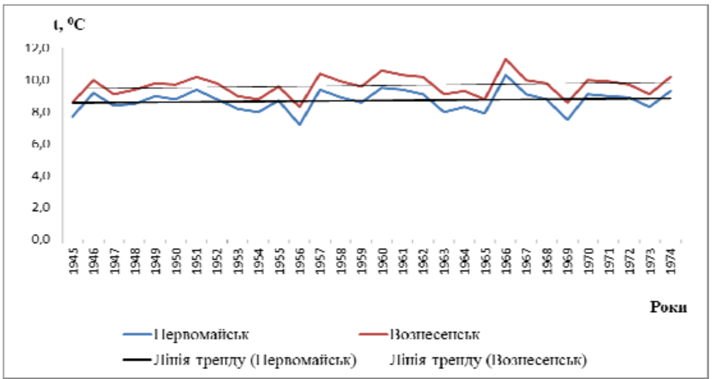


Fig. 3.2. – Dynamics of average annual air temperatures, ^{0}C, over the period of surveillance from 1945 to 1975 at the weather stations in Pervomaisk and Voznesensk

Fig. 3.3. – Dynamics of average annual air temperatures, ^{0}C, over the period of surveillance from 1975 to 2014 at the weather stations in Pervomaisk and Voznesensk

In general the results of meteorological surveillance data analysis indicate that against the background of average annual temperature increase linked to global warming, the temperature fluctuations within SUNPP surveillance area are practically invisible. Similar situation has been observed when analyzing precipitation and wind regime.

So, at this stage we can state no impact of SUNPP operation on microclimate that gives reason to predict the absence of such impact in the future after SUNPP power unit life extension.

3.2. Geological environment

SUNPP impact on geological environment took place at the stage of construction of the power units and other facilities and has been defined by SUNPP site.

SUNPP territory is located within the Ukrainian crystalline core-area which is formed by the fractured rock mass of the Lower Proterozoic. The following four layers are seperated in the geological section. They are:

- crystalline rocks of the Ukrainian Shield;
- old crust of weathering;
- sedimentary bed rock mass;
- blanket cover of quaternary deposits.

Seismicity

According to the results of investigations of the Institute of Geophysics named after S.I. Subbotin, National Academy of Science of Ukraine it has been recognized that:

- the area has a complex tectonic structure, all big tectonic faults are surrounded by lots of associated faults of lower ranks with different levels of neotectonic activity;
- none of the fractures is tectonically active;
- there are no local seismically active zones near the site –no signs of local seismicity associated with the mentioned fractures have been recorded using instrumental seismological observations;
- no seismically active fracture associated with the Vrancea zone has been detected ;
- tectonic faults of lower ranks that stand out on the plant site do not go under the main buildings and facilities of SUNPP and Tashlyk Pumped-Storage Plant (Tashlyk PSP) and as to its seismic and tectonic potential can not generate dangerous earthquakes;
- induced seismicity research results demonstrated that probability of its occurrence is low.

To monitor seismicity and its possible changes related to SUNPP operation the stationary seismic station with the network of portable seismic points functions in its territory (Fig. 3.4).

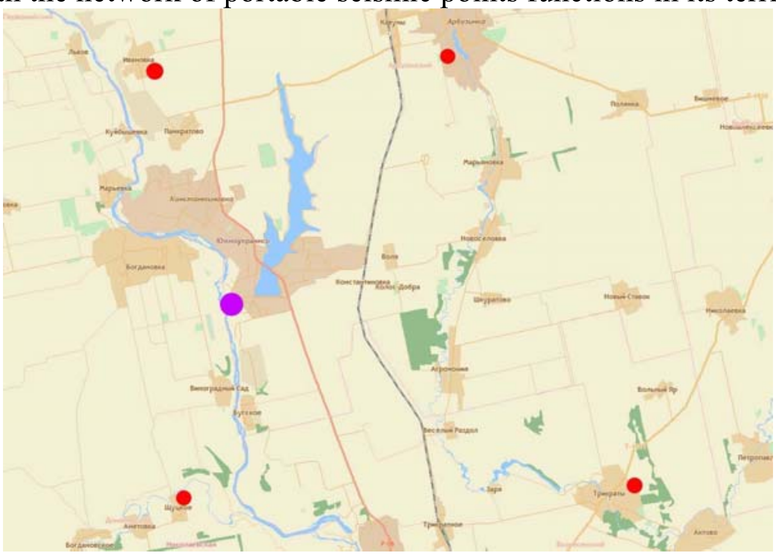


Fig. 3.4. – Network of seismic surveillances

●seismic points; ● seismic station

In tectonic respect the territory is located in the Kirovograd Megablock of the Ukrainian Shield and South-Ukrainian Monocline. The biggest several tectonic faults are marked out, none of them can be referred to a tectonically active fracture along its full length due to lack of movements in the quaternary period (i.e. the last 20 thousand years).

In the area of SUNPP location a number of big tectonic faults of mantle and crustmantle deposits has been marked out such as: Pervomaisk, Odesa, Talne, Petrivsk, Vradiivka, Central and Kirovograd ones. In addition, it has been established that none of these fractures can be referred to tectonically active ones along the full length (due to lack of movements over the last 10000-20000 years).

Neotectoncs of the area is characterized by the following features. At different distances from the boundary of the South-Ukraine Power Complex (from 1 to 4,5 km) the following lineament zones are extended: one submeridional, two sublatitudinal, one north-eastern and one north-western zones. In addition, submeridional and north-eastern zones cross the plant site that can potentially affect the plant structures stability, increase the present-day geological processes (first of all seismic ones). It concens particularly the place of zone crossing which covers the significant territory of the facility location.

The site is located in the center of the circular geological structure of intermediate type.

In general the plant site is characterized by the calm field of +30 m isobases with their local northerly lowering up to +10 m. 2,5-3 km to the west the total amplitude increase up to +60-70 m is observed.

So the degree of safety in accordance with neotectonic criteria is generally assessed as a satisfactory one.

Rather dangerous engineering and geological processes and phenomena

Spreading of exogenous geological processes (EGP) is determined by the geological structure of the territory and geomorphological conditions that cause their probability, spatial distribution and their development rate. EGP are natural processes, their activation as a result of the man-induced impact is an objective consequence of any interference related to changes in runoff conditions and levels of surface and ground water. Engineering solutions as to mitigation of EGP concequences are ineffective as a rule.

The zone of an intensive present-day EGP development is the cost line and and costal territory of Oleksandrivka reservoir. EGP in the area of Oleksandrivka Hydropower Plant (Oleksandrivka HPP) are adverse ones both from environmental, technological and operational aspects.

With regard to environmental aspects the adverse processes are as follows:

1) abrasion of Oleksandrivka reservoir slopes with taking of land masses composed of the rocks of deluvial, proluvial and aluvial complexes;

2) progressive increase of the groundwater level which activates suffosion and soil slips on the slopes composed of carbonate and loamy rocks;

3) increase of fragmentary material transfer to the water area by overland runoff rill-washing erosion and sheet washing) due to re-formation of equilibrium profile along the full length of Oleksandrivka reservoir swash line.

With regard to technological and operational aspects EGP lead to:

1) displacement of water mass in Oleksandrivka reservoir by microfragmental material (as the normal water level is to be stable) and loss of actual reservoir volume and consequent siltation of large areas of water, biota growth and lastly, to negative impact on HPP power generating capacity and on Tashlyk PSP pump units operation;

2) activation of Tashlyk PSP headwater filtration (Fig. 2.5) which will stimulate extension of Tashlyk PSP operation in the reverse mode and correspondent increase of power consumption.

So, we can ascertain the presence of negative consequences of EGP intensification caused by the man-induced impact as a result of operation of Tashlyk PSP and Oleksandrivka hydroengineering complex. Even significant capital investments can not prevent EGP intensification or mitigate their effects. In the course of time natural processes will be balanced and EGP intensification will be gradually attenuated.

3.3. Non-radiation releases into the atmosphere

SUNPP releases the pollutants into the atmosphere in accordance with pollution permits issued by Ecology and Natural Resources Office of the State Administration in Mykolaiv region.

According to "Report on Pollutant Release Inventory" SUNPP releases into the atmosphere from 405 pollutant emission sources (401 stationary pollutant emission sources and 4 mobile pollutant emission sources). Emission sources are located in 23 industrial areas of the plant.

Non-radiation impacts of SUNPP on the air are limited by releases of emergency diesel generators (EDG), vehicle fleet, machinery, diesel locomotives and SUNPP auxiliary facilities and services.

Emissions are assessed by quarterly calculations and annual monitoring of industrial stationary air pollutant sources. Pollutant concentration in settlements as a result of emissions does not exceed the permissible norms.

Based on the Report on inventory of sources of pollutant emissions into the atmosphere and taking into account the actual time of equipment operation the annul reports are drawn up according to 2TP form (air).

Changes in volume of pollutants released into the atmosphere from stationary emission sources are presented in Fig. 3.5.

Sharp increase in gross emissions of pollutants into the atmosphere results from complete inventory of releases in 2013 to comply with the requirements of environmental legislation of Ukraine on the necessity to calculate greenhouse gas emissions when burning all types of fossil fuel and to count in all emission sources that are located in industrial areas of the plant.

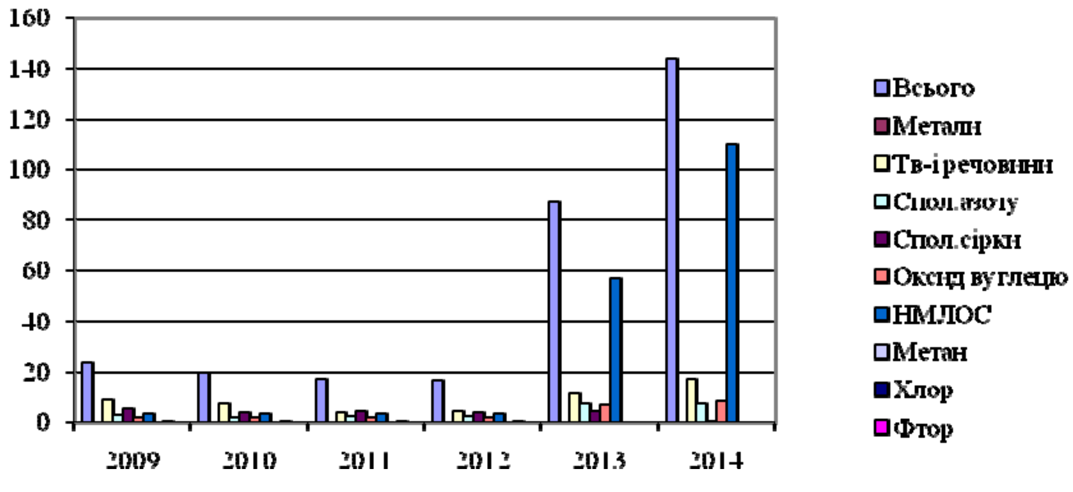


Fig. 3.5. – Changes in volume of pollutants released into the atmosphere at SUNPP over the last years

3.4. Impacts of radiation factors

SUNPP services resposible for nuclear and radiation safety prepare annual reports on radiation safety at the plant that provide information on radiation doses of the plant staff (including information on the doses received during Scheduled Outages), control over observance of radiation and hygienic parameters in the work rooms, radiation monitoring of protective barriers, radiation effect on the population and the environment, actions to improve radiation safety, etc. All cases of exceeding the specified levels of radiation pollution are separately recorded.

Collective and individual doses of the staff

The dynamics of individual and collective doses of accumulated exposure (external and internal one) at SUNPP is presented in Fig. 3.6 (Information is provided according to the data of the plant radiation safety service).

Fig. 3.6. – Dynamics of individual and collective annual doses of accumulated exposure (external and internal one) at SUNPP

Reference levels of external and internal exposure doses for SUNPP personnel of category A in compliance with “Reference levels of releases and discharges of radioactive substances into the environment and exposure doses for category A personnel at SUNPP (Radiation and hygiene regulations of Group I)” are as follows: 15 mSv/year, permissible levels – 20 mSv/year, for women under 45 years of age 1,4 and 2,0 mSv respectively for any 2 months. As can be seen from the above the personnel radiation safety regualations are not violated at SUNPP.

Radiation effect on the environment

Radiation factor in retrospective

According to the data of radiation observations that have been made before NPP design and construction in the area where the NPP and the town of Yuzhnoukrainsk are located the average levels of natural gamma radiation were 15 mcR/year and no more than 20 mcR/year which is caused by the cropped out granitic rocks. Thus individual and population doses are 135 mRem/year and 10^5 person-rem per year.

The content of long-lived radionuclides of global origin in all samples investigated in the environment varies in picocurie per kg(l). It may rarely reach 10-20 picocurie per kg and only in the Pivdennyi (Southern) Buh bottom deposits and in algae it is higher than 50 picocurie per kg which is associated with cumulative properties of the river silts.

Analysis of the environment radioactivity levels after the Chornobyl accident shows continuous decrease of ^{90}Sr i ^{137}Cs isotopes content in the biosphere due to decay and dispersal. In this case, the content of radionuclides listed above is two-three times less than the natural content of potassium-40 (^{40}K).

In general, radiation situation in the area of SUNPP location is formed due to natural radiation sources and can be considered as a safe one from radiation and hygienic point of view.

Gas and aerosol radioactive releases

The reference and permissible levels of releases at SUNPP specified by RG.0.0026.0159 “Permissible gas and aerosol release and allowable discharge of radioactive substances into the environment and water body. (Radiation and hygiene regulations of Group I)” are given below:

Table 3.1. - Reference levels of releases

Type and parameter of monitoring	Unit	Reference level
Daily monitoring		
Inert radioactive gases (IRG)	GBq/day	1200,0
Radioiodine	MBq/day	140,0
Long-lived radionuclides	MBq/day	4,3
Monthly monitoring		
^{60}Co	MBq/month	12,0
^{134}Cs	MBq/month	5,8
^{137}Cs	MBq/month	11,0

Table 3.2. - Permissible levels of releases

Type and parameter of monitoring	Unit	Release limit
Long-lived radionuclides	GBq/day	0,75
IRG	GBq/day	45000,00
Radionuclides of iodine	GBq/day	3,90
^{51}Cr	GBq/day	850,00
^{54}Mn	GBq/day	5,90
^{59}Fe	GBq/day	12,00
^{58}Co	GBq/day	15,00
^{60}Co	GBq/day	0,32
^{89}Sr	GBq/day	20,00
^{90}Sr	GBq/day	0,38
^{95}Zr	GBq/day	19,00
^{95}Nb	GBq/day	41,00
^{110m}Ag	GBq/day	0,53
^{134}Cs	GBq/day	0,45
^{137}Cs	GBq/day	0,45
^{3}H	GBq/day	2100,00

Measurement results for gas and aerosol radionuclides releases through the vent stacks of SUNPP in 2014 are given in the Table 3.3.

Table 3.3. – Averaged values of gas and aerosol radioactive releases through SUNPP vent stacks in 2014

IRG,	Long-lived	Iodine-131,	^{137}Cs	^{134}Cs	^{60}Co	^{58}Co	^{54}Mn	^{51}Cr	^{90}Sr

GBq/day	radionuclides, kBq/day	kBq/day	kBq/month						
60,48	68,54	118,28	201,24	67,05	613,89	85,30	106,49	732,39	45,8
average daily			average monthly						

Intensity of gas and aerosol releases both in 2014 and in previous years is significantly below the prescribed permissible levels. It is demonstrated in the following table.

Table 3.4. – Values of radionuclides releases at SUNPP, unity check value, % of release limit

Release	2010	2011	2012	2013	2014
IRG	0,29	0,17	0,16	0,10	0,135
Radioiodine	0,04	0,04	0,01	0,01	0,003
^{137}Cs	0,00	0,00	0,00	0,00	0,002
^{134}Cs	0,00	0,00	0,00	0,00	0,00
^{90}Sr	0,00	0,01	0,00	0,00	0,00
^{60}Co	0,01	0,00	0,01	0,01	0,006
^{58}Co	0,00	0,00	0,00	0,00	0,00
^{54}Mn	0,00	0,00	0,00	0,00	0,00
^{51}Cr	0,00	0,00	0,00	0,00	0,00
In total over a year	0,34	0,22	0,18	0,12	0,146

Thus radionuclides releases at SUNPP do not reach the prescribed limits.

The following table demonstrates that the intensity of releases at SUNPP trends to decrease.

Table 3.5. - Annual rate of radioactive substances releases per 1000 MW of installed capacity at SUNPP by years

Releases	2007	2008	2009	2010	2011	2012	2013	2014
IRG, GBq/year	1,90 E+04	1,57 E+04	1,01 E+04	1,55 E+04	9,35 E+03	8,55 E+03	5,59 E+03	7,36 E+03
Long-lived radionuclides,	1,07 E+01	1,24 E+01	9,47 E+00	1,06 E+01	1,13 E+01	8,82 E+00	9,02 E+00	8,36 E+00
Radioiodine, MBq/year	1,07 E+02	1,54 E+02	1,03 E+02	1,65 E+02	1,64 E+02	5,70 E+01	2,53 E+01	1,44 E+01

Gamma dose rate

Environmental gamma exposure dose rate (gamma background) is constantly monitored at the stationary surveillance stations/points. The measurement results over the last years are given in Table 3.6.

Table 3.6. - Average environmental gamma dose rate in the monitoring points at SUNPP, mcR/year.

Surveillance stations	Distance from NPP, km	2014	2013	2012	2011	2010	2009
Point No.1	1,0	10,7	10,9	11,3	11,7	13,0	12,8
Point No.4	0,4	10,6	11,1	11,3	11,6	11,5	12,7
Point No.2	0,5	10,8	11,1	11,2	11,4	11,1	13,2
Point No.3	0,2	11,3	12,0	11,7	11,7	12,9	13,3
Point No.5	0,5	10,9	12,0	11,7	11,8	13,0	13,1
Hydrosection	2,0	11,0	12,0	10,5	11,0	12,7	12,3

Surveillance stations	Distance from NPP, km	2014	2013	2012	2011	2010	2009
Yuzhnoukrainsk (town)	3,0	10,3	10,2	10,6	10,7	12,5	12,7
Volia (village)	4,5	10,3	10,7	10,5	10,6	12,9	13,0
Agronomia (village)	5,0	12,8	10,4	12,9	13,6	13,0	12,6
Storehouse of Workers' Supply Department	3,0	10,8	13,1	10,4	10,8	12,3	12,8
Kostiantynivka (village)	6,0	10,9	10,3	11,1	11,5	12,5	13.2
Bohdanivka (village)	7,0	10,5	10,8	10,2	10,9	12,6	13,0
Domestic sewage treatment facilities	7,0	11,9	12,1	13,3	12,7	12,5	12,5
Buzke (village)	7,5	10,3	10,7	10,7	11,1	12,9	12,5
Velykyi Rozdol (village)	9,0	11,0	12,6	11,8	12,5	12,8	13,0
Marianivka (village)	10,0	11,6	11,6	12,3	11,3	12,5	13,0
Oleksiivka (village)	10,5	10,3	10,3	10,6	10,4	12,7	12,5
Arbuzynka (urban-type village) - (A)	11,0	11,0	11,2	11,1	11,5	13,0	12,9
Arbuzynka (urban-type village) - (B)	12,5	10,7	10,9	10,8	11,0	12,5	12,7
Anetivka (village)	13,0	10,5	10,5	9,9	10,6	12,7	11,6
Oleksandrivka (urban-type village)	14,0	11,1	10,3	11,2	11,3	12,6	13.0
Koshtove (village)	14,4	10,7	10,3	10,8	10,8	12,8	12,9
Novokrasne (village)	25,0	10,4	10,3	10,7	11,0	12,9	12,7
Taborivka (village)	25,0	10,2	9,8	9,9	9,5	12,8	12,3
Riabokoneve (village) - monitoring point	33,5	11,2	11,1	11,1	11,5	13,0	12,6

Gamma background levels that are recorded in the settlements in SUNPP surveillance area are typical for natural background that depends on impact of the following environmental factors: activity of crystalline rock (thorium content) and of soil (radiopotassium content), climatic and weather factors (solar activity), etc. During previous period of surveillance the levels of gamma background did not change too with the exception of the first years after the Chornobyl accident.

Concentration of radionuclides in the atmosphere

To control the content of radioactive substances in the atmospheric fallouts, the monitoring is conducted every month in 25 surveillance stations of SUNPP surveillance area according to RG.0.0026.0120 "Regulation of radiation monitoring at SUNPP".

Average annual values of radionuclide concentration in the surface air over the period of surveillance starting from 1983 reveal that the content of ^{137}Cs and ^{90}Sr isotopes in the air of area of interest remains at the level of previous years and is even in radiation motoring points.

Quantitative values of such radionuclides are significantly below the concentrations permissible in line with NRBU-97.

The averaged results of radionuclides content in the surface air for 2014 are presented in Table 3.7.

Table 3.7. – Average radionuclides content in the surface air for 2014 according to the surveillance areas, mcBq/m^3

Radionuclide	Surveillance area	Permissible concentrations in

	Buffer area	Buffer area – 10 km	10-20 km	> 20 km	the air for category B
^{137}Cs	1,68	1,47	1,55	1,48	8,0E+05
^{134}Cs	0,99	0,98	0,96	0,98	1,0E+06
^{60}Co	1,32	1,22	1,18	1,24	1,0E+06
^{54}Mn	1,14	1,09	1,09	1,10	2,0E+07
^{131}I	1,78	1,77	1,76	1,76	4,0E+06
^{90}Sr	0,39	0,29	0,34	0,12	2,0E+05

As can be seen from the above none of the monitored radionuclide values approaches the permissible levels. The similar situation has been observed over the previous years. Long-term observation results demonstrate that the radioactivity of fallouts and the content of such radionuclides as 137Cs and 90Sr correspond to the global level in all surveillance stations. Radionuclides concentration has been increased only in the second half of the 1980s under the influence of Chornobyl releases transfer.

Atmospheric fallout radioactivity

Monitoring results for radionuclides density in the atmospheric fallouts over 2014 are given in Table 3.8.

Table 3.8. – Radionuclides in atmospheric fallouts over 2014, 10^7 Bq/km^2

Radius (surveillance area)	Quarter	Radionuclides				
		^{90}Sr	^{137}Cs	^{134}Cs	^{60}Co	^{54}Mn
Zero (NPP territory)	I	0,0537	0,0163	0,0096	0,0179	0,0103
	II		0,018	0,0095	0,0146	0,0115
	III	0,1017	0,0134	0,0076	0,016	0,013
	IV		0,026	0,009	0,015	0,011
The 1st (0-3 km)	I	0,0177	0,0106	0,0043	0,006	0,0047
	II		0,0084	0,0038	0,0056	0,0052
	III	0,0322	0,005	0,0045	0,0065	0,006
	IV		0,0065	0,0051	0,0061	0,0061
The 2nd (3-8 km)	I	0,0094	0,0057	0,0034	0,0042	0,0345
	II		0,0112	0,0028	0,0049	0,0035
	III	0,0339	0,011	0,0026	0,0031	0,0039
	IV		0,0083	0,0025	0,0037	0,0037
The 3rd (8-16 km)	I	0,0178	0,0087	0,0047	0,0059	0,0051
	II		0,0124	0,005	0,0075	0,0055
	III	0,0205	0,0101	0,0051	0,0316	0,019
	IV		0,0066	0,0045	0,0061	0,0055
The 4th (16-24 km)	I	0,0039	0,0195	0,0096	0,0134	0,0126
	II		0,0164	0,0101	0,0129	0,012
	III	0,042	0,0106	0,0102	0,013	0,012
	IV		0,0132	0,0099	0,0116	0,0105
Riabokoneve (monitoring point)	I	0,0472	0,0087	0,0077	0,0119	0,0087
	II		0,0091	0,0069	0,0105	0,0082

Radius (surveillance area)	Quarter	Radionuclides				
		^{90}Sr	^{137}Cs	^{134}Cs	^{60}Co	^{54}Mn
	III	0,0255	0,025	0,0075	0,01	0,0205
	IV		0,0075	0,0066	0,014	0,0079

The same values have been observed during the previous years. The levels of radionuclides content do not differ from the global ones.

Radioactive discharges

SUNPP executes controlled discharges of contaminated water from the spray ponds and cooling towers to the external water body through the Tashlyk reservoir which performs a function of the plant cooling pond. Discharges are monitored and accounted with drawing up of sanitary certificate on discharge of residual water to the environment.

The list of radionuclides and limit values of their content in releases and discharges is specified by RG.0.0026.0159 "Permissible gas and aerosol release and allowable discharge of radioactive substances into the environment and water body. (Radiation and hygiene regulations of Group I)".

Reference and permissible levels of radionuclides releases at SUNPP are presented in Table 3.9.

Table 3.9. – Reference and permissible levels of releases

Levels	Unit	^{137}Cs	^{134}Cs	^{60}Co	^{58}Co	^{54}Mn	^{90}Sr	^{51}Cr	^{3}H
Reference	MBq/quater	297	168	63	-	-	60	-	7,80 E+06
	MBq/month	99	56	21	-	-	20	-	2,60 E+06
Permissible	MBq/year	1,60 E+04	1,80 E+04	3,10 E+04	6,20 E+05	2,20 E+05	4,00 E+03	4,40 E+07	1,20 E+08

Actual levels of contaminated water discharges from cooling towers and spray ponds did not reach the reference levels in the previous years as it is shown below, MBq/year:

Table 3.10. – Actual levels of contaminated water discharges from cooling towers and spray ponds

Year	^{137}Cs	^{134}Cs	^{60}Co	^{58}Co	^{54}Mn	^{90}Sr	^{51}Cr	^{3}H
2014	51,3	36,1	37,4	34,8	36,1	68,0	310,8	2,53E+06
2012	25,1	15,3	15,7	13,5	13,2	50,3	49,2	1,05E+06
2010	25,9	10,0	18,4	0,5	4,3	24,7	0,8	1,15E+06

Volume of water discharges from cooling towers and spray ponds is as follows:

Year	Volume of water discharges from cooling towers and spray ponds, m^3
2014	164 400
2012	65 700
2010	41 566

Table 3.11. - Values of radionuclides releases at SUNPP, unity check value, % of release limits

Release	2006	2007	2008	2009	2010	2011	2012	2013	2014
^{137}Cs	0,94	1,24	0,47	0,12	0,22	0,37	0,16	0,36	0,32
^{134}Cs	0,35	0,43	0,16	0,03	0,08	0,18	0,09	0,24	0,20
^{60}Co	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01
^{58}Co	0,04	0,11	0,08	0,10	0,07	0,05	0,05	0,13	0,12

^{54}Mn	0,01	0,01	0,00	0,01	0,00	0,01	0,01	0,02	0,02
^{90}Sr				0,04	0,61	1,09	1,26	2,06	1,70
^{51}Cr	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
^{3}H	6,27	1,42	0,64	0,57	0,96	0,73	0,87	1,18	2,11
In total for a year	7,61	3,20	1,35	0,87	1,95	2,42	2,43	4,00	4,48

As can be seen from the above the releases are insignificant in comparison with the set limits.

Radionuclides concentration in water bodies and fish

Results of radionuclides concentration measurement in water bodies in the monitored section lines during last years of surveillance (2013 and 2014) are presented bellow. The close results have been recorded over the last years.

Table 3.12. – Radionuclides concentration in water bodies, Bq/l

Section line	Radio nuclide	Per quarters				2014	2013	Quality target
		I	II	III	IV			
Tashlyk reservoir near the dam sluice	^{3}H	1,70E+02	1,69E+02	1,58E+02	1,47E+02	1,61E+02	1,66E+02	3,0E+04
	^{90}Sr	3,82E-02	4,12E-02	2,82E-02	3,38E-02	3,54E-02	4,30E-02	1,0E+01
	^{134}Cs	8,69E-03	9,58E-03	9,25E-03	8,67E-03	9,05E-03	9,05E-03	7,0E+01
	^{137}Cs	1,16E-02	1,09E-02	1,15E-02	1,23E-02	1,16E-02	1,14E-02	1,0E+02
The Pivdennyi Buh 500 m below water outlet from the Tashlyk reservoir	^{3}H	1,27E+01	1,68E+01	1,51E+01	1,65E+01	1,53E+01	1,40E+01	3,0E+04
	^{90}Sr	2,64E-02	2,62E-02	2,28E-02	2,83E-02	2,59E-02	2,42E-02	1,0E+01
	^{134}Cs	7,28E-03	7,83E-03	7,25E-03	7,67E-03	7,51E-03	6,90E-03	7,0E+01
	^{137}Cs	9,33E-03	1,02E-02	9,83E-03	9,83E-03	9,80E-03	9,30E-03	1,0E+02

46589670 m^3 of water have been discharged during blowdowns from the Tashlyk reservoir to the Pivdennyi Bug.

Table 3.13. - Radionuclides concentration in bottom deposits, Bq/kg

Section line	Radionuclide									
	^{90}Sr		^{137}Cs		^{134}Cs		^{60}Co		^{54}Mn	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
The Pivdennyi Buh:										
Oleksiivka	5,33	3,71	0,64	0,79	0,37	0,46	0,30	0,38	0,32	0,41
Buzke	3,68	3,89	0,87	0,75	0,35	0,42	0,41	0,44	0,27	0,64
The Tashlyk reservoir:										
- riverhead (Arbuzynka bridge)	4,33	3,52	9,15	5,38	0,29	0,39	0,46	0,41	0,21	0,33
- thermal discharge	3,38	3,65	10,37	6,59	0,29	0,36	0,50	0,41	0,33	0,42
- near the dam	2,30	3,51	3,29	4,7	0,30	0,29	0,48	0,45	0,37	0,39

Consequently, sanitary norms exceeding as to radioactive contamination of aquatic environment has not been recorded.

Table 3.14. - Radionuclides concentration in fish from the cooling pond, Bq/kg

Monitored organs	**Radionuclide**			
	^{90}Sr		**^{137}Cs**	
	2013	**2014**	**2013**	**2014**
Flesh	0,27	0,21	0,324	0,245
Heads, bones	1,94	0,85	0,243	0,51

In line with DR-97 as of June 25, 1997 permissible content of ^{137}Cs is 150 Bq/kg and of ^{90}Sr – 35 Bq/kg in the fish flesh. So, no negative impact of SUNPP discharges on radioactive fish contamination has been registered.

Radioactive contamination of soils

The levels of radionuclides contamination of soils over the last year of surveillance are given in Tables 3.15 and 3.16.

Table 3.15. – Average density of radionuclides activity in soils in the areas of surveillance, 2014, kBq/m^2

Radionuclide	**Density of contamination**			
	Buffer area	**Buffer area – 10 km**	**10-20 km**	**> 20 km**
^{137}Cs	2,16E-01	2,75E-01	3,86E-01	3,05E-01
^{134}Cs	1,71E-02	1,79E-02	2,01E-02	2,02E-02
^{60}Co	1,71E-02	2,04E-02	2,20E-02	2,27E-02
^{90}Sr	1,65E-02	1,96E-02	1,87E-02	2,10E-02

Table 3.16. – Average specific activity of radionuclides in soils and vegetation in the areas of surveillance, Bq/kg

Radius of surveillance	**Soils**				**Vegetation**			
	^{90}Sr		**^{137}Cs**		**^{90}Sr**		**^{137}Cs**	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
zero radius	8,75	8,75	4,45	5,04	0,30	0,75	0,47	0,42
1st radius	1,89	11,67	3,98	7,21	0,93	0,59	0,63	0,45
2nd radius	9,20	9,09	8,48	7,56	0,43	0,5	0,45	0,45
3rd radius	3,61	3,47	9,24	13,26	0,44	0,44	0,396	0,42
4th radius	6,32	11,79	11,75	9,77	0,61	0,37	0,48	0,45
Riabokoneve	4,83	5,42	7,42	8,88	0,61	0,32	0,45	0,48

It should be noted that the recorded levels of radioactivity in soils and vegetation are typical for the most of Ukrainian territory after the Chornobyl accident and do not pose any threat.

3.5. Groundwater

According to hydrogeological zoning the left-bank territory of Ukraine is located within the Ukrainian fracture water basin and the right-bank part is situated within the Black Sea artesian basin (Fig. 3.7). The combination of geological and structural as well as climatic conditions of the territory makes it possible to create fracture-type groundwater in the crystalline rock of the Lower Proterozoic and pore-and- stratum-type groundwater in the Mesozoic and Cainozoic deposits. The chemical composition of groundwater is characterized by the increased salinity level (5,5 - 6,7 g/dm^3) and high sulphate-ion.

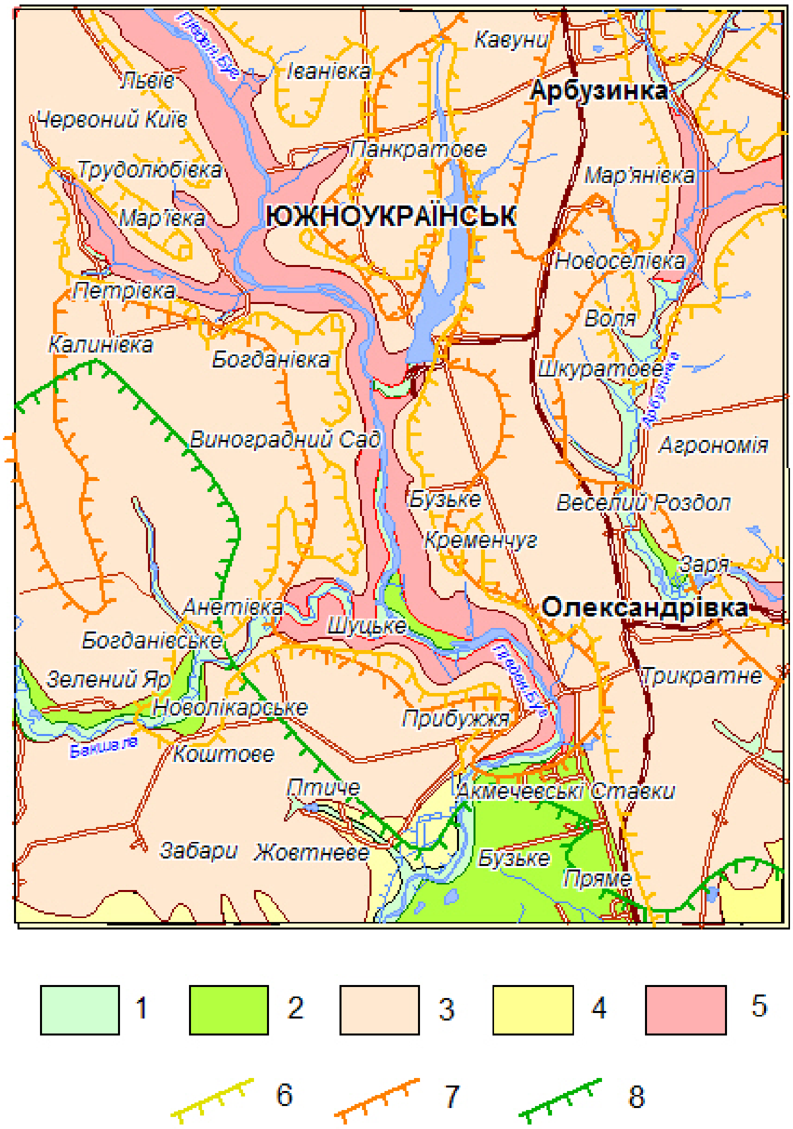


Fig. 3.7. – Hydrogeological map of SU NPP affected area:
1–5 – expansion area of complex water-bearing levels: *1* – water-bearing level at actual alluvial deposits of flood beds and gully bottoms. Loams, loamy sands, sands, some places with pebbles and gravel of crystalline rock; *2* – water-bearing level in middle-upper- glacial alluvial deposits of the third, second and first surface terraces. Sands, loams, loamy sands; *3* – water-bearing level in lower-middle-upper- glacial aeolian-deluvial deposits. Forest like loams; *4* – water-bearing level system in middle-and upper- Sarmatian, Meotian and Pontian deposits. Differently-grained sands, limestones, sandstones; *5* – waters of rock fracture zone of Precambrian crystalline rock and their landwastes. Gneisses, granites; *6 – 8* – spreading boundary of complex water-bearing levels: *6* – water-bearing level system in middle-and upper- Sarmatian, Meotian and Pontian deposits; *7* – water-bearing level system in Eocene deposits; *8* – water-bearing level in Lower Cretaceous and Cenomanian deposits. Sandstones, sands, chalk-stone.

All kinds of ground waters are drained by the valleys of the Pivdennyi Buh and its local inflows and have a hydraulic connection with the surface waters.

Within the territory under research there are:

- water-bearing level of alluvial deposits of a flood bed and surface terraces (stratification depth from 0,1–0,5 to 5 m; a water-table aquifer; specific discharge of well from is 0,02 to 2 l/s and more);
- water-bearing level of forest like deposits (is located at various depth, slightly watered; specific discharge of well from is 0,2 to 0,4 l/s; low-mineralized waters);
- water-bearing level of Sarmatian layer of Neogene (slightly watered; specific discharge of well is 2 l/s; mainly fresh waters);
- water-bearing level of rock fracture zone of Precambrian crystalline rock (low pressure water; specific discharge of well is from 0,1 to 2,8 m^3/h; low-mineralized waters).

All kinds of ground waters belong to rock fracture type, spread entirely in granitoid of lower Proterosoic and build a single water-bearing level system of low pressure water. The biggest fractured ground spreads up to the depth of 10–15 m, and then it gradually decreases up to the depth of 50–60 m. The stratification depth of ground water level in river valleys and gullies varies from 0,5–5,0 m to 10–15 m, at watershed divide it reaches 20–30m.

Ground waters have hydrocarbonate-sulphate or sulphate- hydrocarbonate chemical composition and only ground waters of the Pivdennyi Buh flood bed are fresh ones-hydrocarbonate-calcium waters.

Upon the completion of the construction of Tashlyk reservoir the hydrogeologic conditions have been definitely changed. According to the ground water monitoring data, these changes can be tracked in the coastal area of Tashlyk reservoir, at the interstream area of the Pivdennyi Buh – Tashlyk, at the territory of SU NPP site, in the coastal area of Olexandrivka and Bakshala reservoirs. Changes in hydrogeologic conditions include the processes as follows:

- significant part of dry rock within the impact of the reservoir back-water is saturated by water;
- pressure head and thickness of water-bearing levels have been increased;
- immature water-bearing level in forest like covering loams gets stiff character;
- in the lower part of Tashlyk reservoir in the interstream area of the Pivdennyi Buh, where the ground waters underlay below NWL (normal water level) 99,5 m, water is constantly filtered from the cooling pond to the Pivdennyi Buh;
- under ground water backing conditions (as a result of construction of Tashlyk reservoir) the ground water level has been increased at 1,5–3,0 m in the eastern part and at 6–8 m in the western part within the territory of SU NPP site).

As a result of construction of Tashlyk reservoir and ground waters backing at the NPP site there has been created a man-induced water-bearing level in the bulked loam of planning and deluvial forest like loams of glacial age. At the industrial site the ground water level rose at 3,8-4,9 m, up to the elevation 100,6-101,6 m abs.

Due to the flooding of the industrial site and water saturation of deluvial loams at the expense of desalination of salt complex of the rock mineralization(7,9 – 8,7 g/dm^3) and sulfate attack (sulfate content 4140 – 4830 mg/dm^3) of the ground waters have been increased.

Over the recent years hydrodynamic conditions of the territory of the industrial site became stable.

SU NPP site ground waters are controlled quarterly by well sampling and its laboratory analysis. Indicators of total beta activity and tritium activity in the well water are generally peculiar to ground and surface waters of the region and don't exceed the values specified by the document NRBU-97 for drinking water.

3.6. Surface waters

Hydrographic network

Hydrographic network of SU NPP location is represented by the Pivdennyi Buh with its left water flow- Tashlyk gully and its right water flow- the Bakshala.

The Pivdennyi Buh is a major waterway of the region. Its overall length is - 792 km, the intake area is 63,7 thousand km^2, the depth varies from 1,5 to 8 m with the riverbed width from 50 to 200 m. The river flow rate is 0,1-0,3 m/s. The long-term average annual flow of the Pivdennyi Buh is 2,9 km^3.

For SU NPP service water supply in 1980 in Tashlyk gully there was built a cooling pond with the capacity of 86 million m^3 and water service area of 8,6 km^2 at NWL 99,5 m. Annual average flow of Tashlyk gully stream is 0,15 m^3/s, and a maximum spring flood flow is 5 % of the supply which is about 52 m^3/s.

Physical-chemical characteristics of water

Upon the results of hydrochemical monitoring which is carried out at the observation network of Hydrometeo Service of Ukraine, data for the period since 1970 were analyzed at the sites which are located downstream of the town of Pervomaisk and Oleksandrivka. It allowed performing an analysis of the quality of surface waters over the periods: 1970–1980 (till the beginning of construction of Tashlyk reservoir), 1981–1990 (sequential putting into operation of three SU NPP power units), for the period of 1990–2000 (operation of power units including setting and calling off a moratorium for «blowdown» of Tashlyk reservoir) and for the recent years (after 2001, when Tashlyk PSP construction was resumed and put into operation).

At figures 3.8. – 3.11. average seasonal concentrations of specific water pollution indexes.

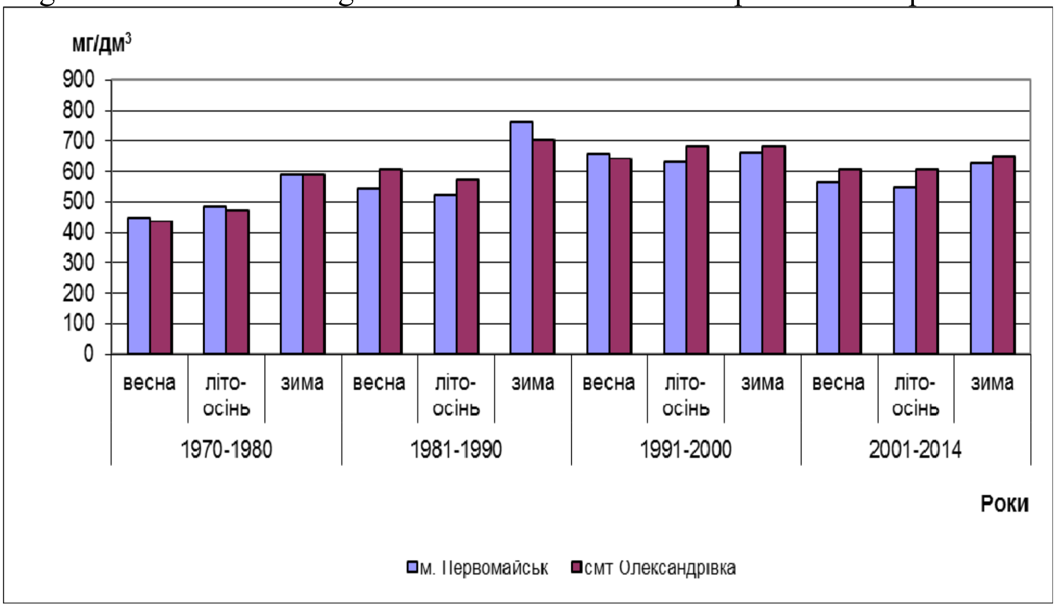


Fig. 3.8. – Dynamics of long-term average mineralization values of the Pivdennyi Buh at the surveillance stations of Pervomaisk and Oleksandrivka

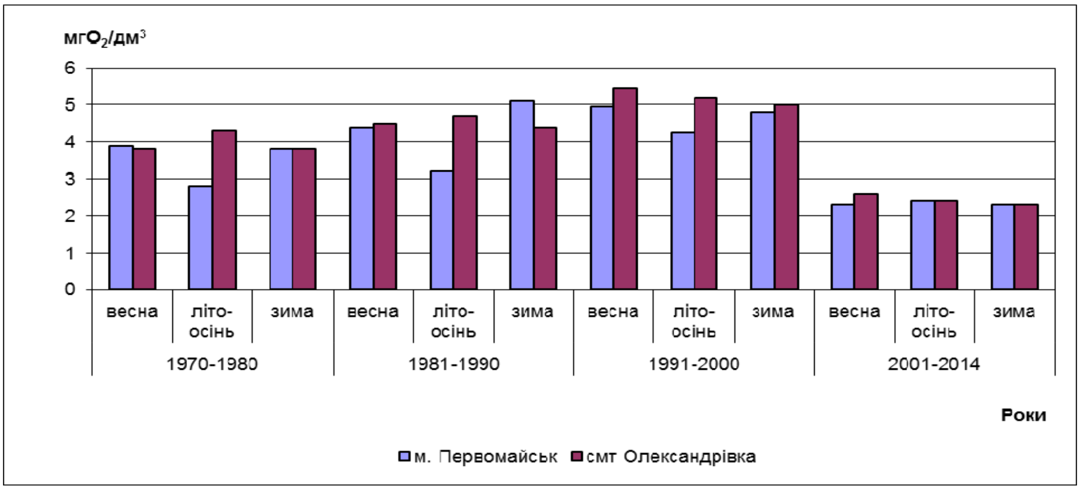


Fig. 3.9. – Dynamics of long-term average concentrations of BOD5 of the Pivdennyi Buh at the

surveillance stations of Pervomaisk and Oleksandrivka

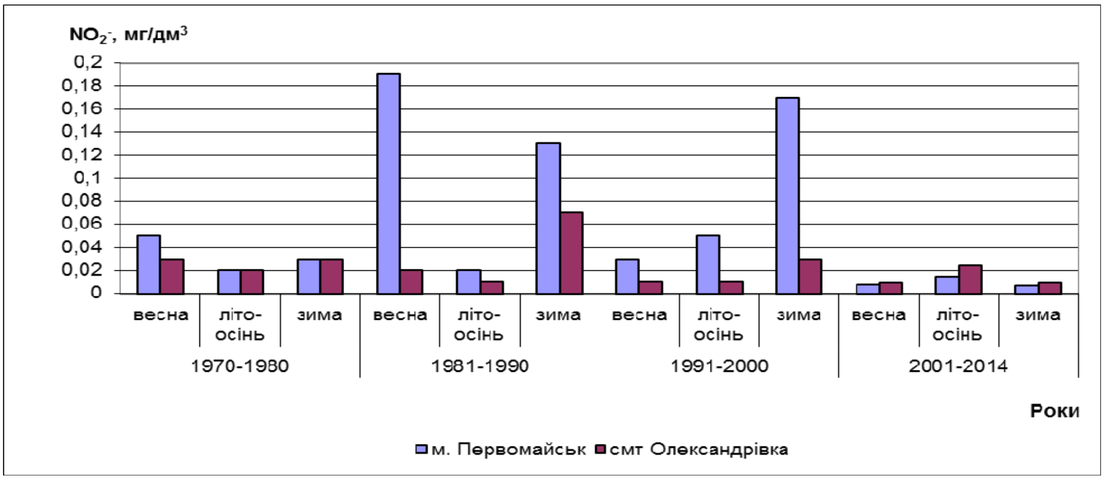


Fig. 3.10. – Dynamics of long-term average concentrations of nitrite ions of of the Pivdennyi Buh at the surveillance stations of Pervomaisk and Oleksandrivka

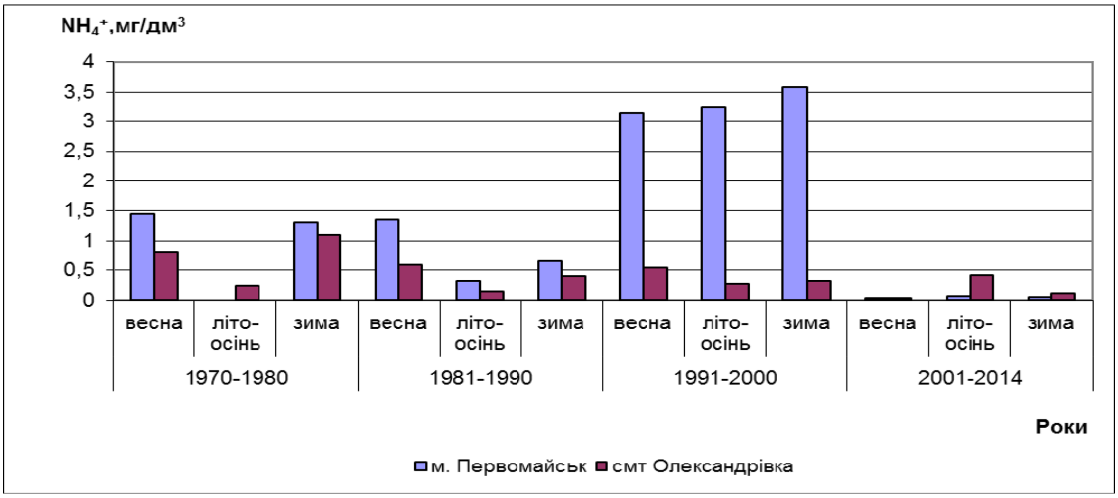


Рис. 3.11. – Dynamics of long-term average concentrations of ammonium ions of the Pivdennyi Buh at the surveillance stations of Pervomaisk and Oleksandrivka

Therefore within the period from 1991 to 2000 seasonal levelling of principal ions and mineralization took place with their further decrease. At Olexandrivka surveillance station (downstream of Tashlyk PSP affected area) ion concentration of organic compounds are less than at Pervomaisk surveillance station (upstream of Tashlyk PSP affected area), it is related with the processes of water self-purification in Olexandrivka reservoir.

Data about complete water chemistry of Olexandrivka reservoir for the recent years are represented in Table 3.17, of Tashlyk reservoir – in Table 3.18.

Table 3.17. – Dynamics of hydrochemical water indicators of the Pivdennyi Buh at Olexandrivka reservoir (Tashlyk reservoir site)

Indicator (index)	Unit	MPC	Average annual content					
			2014	**2013**	**2012**	**2011**	**2010**	**2009**
Smell	points	1	1	1	1	1	1	1
Transparency	cm	< 30	-	-	-	-	21	25
Colour	degree	Not/determined (n/d)	52	51	49	40	-	-
Temperature	C^0		12,1	12,3	13,1	11,7	12,4	12,3
O_2	mg O_2/ dm^3	> 6	9,83	11,11	11,01	11,26	10,88	10,65
pH	units	6,5-8,5	8,34	8,40	8,34	8,39	8,40	8,40

Indicator (index)		Unit	MPC	Average annual content					
				2014	2013	2012	2011	2010	2009
Total hardness		mg- eq/dm^3	n/d	5,7	5,6	5,7	5,7	5,6	5,6
Alkalinity		mg- eq/dm^3	n/d	5,68	5,20	5,23	5,43	5,45	5,24
Anions	HCO_3^-	mg/dm^3	n/d	323	289	301	310	310	297
	SO_4^{2-}	mg/dm^3	< 100	70	78	84	77	77	76
	Cl^-	mg/dm^3	< 300	41	41	45	43	42	45
Cations	Ca^{2+}	mg/dm^3	< 180	66	63	62	60	64	66
	Mg^{2+}	mg/dm^3	< 50	29	29	32	33	29	28
	Na^++ K^+	mg/dm^3	< 170	59	51	57	56	58	52
Dry residue		mg/dm^3	< 1000	572	546	572	579	551	515
Biogenic substances	NH_4^+	mg/dm^3	0,5-1,0	0,28	0,34	0,27	0,34	0,33	0,24
	NO_2^-	mg/dm^3	< 0,08	0,044	0,061	0,064	0,050	0,055	0,046
	NO_3^-	mg/dm^3	< 40	4,17	5,08	6,01	4,66	3,95	4,09
	PO_4^3	mg/dm^3	< 0,70	0,31	0,34	0,38	0,29	0,36	0,33
SiO_3^{2-}		mg/dm^3	n/d	12,57	11,92	11,42	11,80	9,36	9,60
Permanganate oxidation		mg O_2/ dm^3	n/d	6,69	6,61	7,02	7,04	7,38	6,76
Oil products		mg/dm^3	< 0,05	0,018	0,016	0,017	0,019	0,019	0,020
Suspended substances		mg/dm^3	< 25,00	16,00	16,00	17,00	17,00	16,48	12,98
BOD_5		mg O_2/ dm^3	< 3,0	2,34	2,96	2,91	2,53	2,20	2,95
COD		mg/dm^3	< 50	36,00	29,00	34,00	38,00	33,22	38,20
Anionic surfactants		mg/dm^3	< 0,028	0,013	0,014	0,018	0,017	0,014	0,012
Total iron		mg/dm^3	< 0,10	0,061	0,091	0,085	0,065	0,110	0,075
Nickel		mg/dm^3	< 0,010	0,0044	0,0035	0,0052	0,0047	0,0031	0,0033
Copper		mg/dm^3	< 0,001	0,012	0,012	0,011	0,016	0,016	0,010
Chrome		mg/dm^3	< 0,005	-	-	-	-	0,0011	0,0022
Fluorine		mg/dm^3	< 0,05	0,33	0,28	0,29	0,34	0,31	0,32

The analysis of hydrochemical monitoring results allows confirming that water level rise in Olexandrivka reservoir in general has not led to significant changes in hydrochemical conditions of the reservoir.

Table 3.18. – Dynamics of hydrochemical water indicators of Tashlyk reservoir

Indicator (index)		Unit	MPC	Average annual content					
				2014	2013	2012	2011	2010	2009
Smell		points	1	1	1	1	1	1	1
Transparency		cm	< 30	22	22	20	22	22	25
Colour		degree	n/d	28,4	25,1	28,1	28,0	27,3	26,6
Temperature		C^0		7,35	8,26	7,78	7,79	7,96	8,00
O_2		mg O_2/ dm^3	> 6	8,61	8,70	8,71	8,72	8,69	8,65
pH		units	6,5-8,5	8,9	9,2	9,1	8,6	8,4	8,4
Total hardness		mg- eq/dm^3	n/d	6,06	5,97	6,10	5,82	5,87	5,62
Alkalinity		mg- eq/dm^3	n/d	22	22	20	22	22	25
Anions	HCO_3^-	mg/dm^3	n/d	324	314	323	307	312	299
	SO_4^{2-}	mg/dm^3	< 100	335	377	363	334	319	334
	Cl^-	mg/dm^3	< 300	125	141	135	129	123	124
Cations	Ca^{2+}	mg/dm^3	< 180	51	50	48	46	49	51
	Mg^{2+}	mg/dm^3	< 50	77	81	81	77	72	71
	Na^++ K^+	mg/dm^3	< 170	169	189	184	172	167	169
Dry residue		mg/dm^3	< 1000	1050	1095	1123	1064	1032	1034
Biogenic substa	NH_4^+	mg/dm^3	0,5-1,0	0,22	0,23	0,23	0,29	0,27	0,26
	NO_2^-	mg/dm^3	< 0,08	0,044	0,058	0,051	0,045	0,036	0,038
	NO_3^-	mg/dm^3	< 40	3,90	2,86	2,83	2,65	2,37	3,30

Indicator (index)	Unit	MPC	Average annual content					
			2014	2013	2012	2011	2010	2009
PO_4^{3}	mg/dm^3	< 0,70	0,14	0,115	0,135	0,11	0,13	0,13
SiO_3^{2-}	mg/dm^3	n/d	14,72	11,48	10,06	7,59	6,76	7,30
Oil products	mg/dm^3	< 0,05	0,020	0,017	0,019	0,019	0,020	0,020
Suspended substances	mg/dm^3	< 25,00	19,00	19,00	18,00	19,00	17,27	15,65
BOD_5	mg O_2/ dm^3	< 3,0	1,83	2,29	2,03	1,62	1,33	1,52
COD	mg/dm^3	< 50	39,00	31,00	36,00	38,50	30,74	41,26
Anionic surfactants	mg/dm^3	< 0,028	0,014	0,015	0,018	0,014	0,013	0,013
Total iron	mg/dm^3	< 0,10	0,065	0,076	0,074	0,059	0,104	0,074
Nickel	mg/dm^3	< 0,010	0,0096	0,0124	0,0131	0,0106	0,0100	0,0107
Copper	mg/dm^3	< 0,001	0,024	0,032	0,035	0,036	0,034	0,031
Chrome	mg/dm^3	< 0,005	-	-	-	-	0,0017	0,0019
Fluorine	mg/dm^3	< 0,05	0,49	0,43	0,42	0,48	0,43	0,53

Therefore Tashlyk reservoir is an industrial reservoir which doesn't meet the requirements imposed to fishery waters for some water quality indicators.

Fig. 3.12. represents water volumes which were discharged from Tashlyk reservoir into Olexandrivka reservoir and Table 3.19. represents calculated quantity of polluting substances which were discharged with the return waters in 2014.

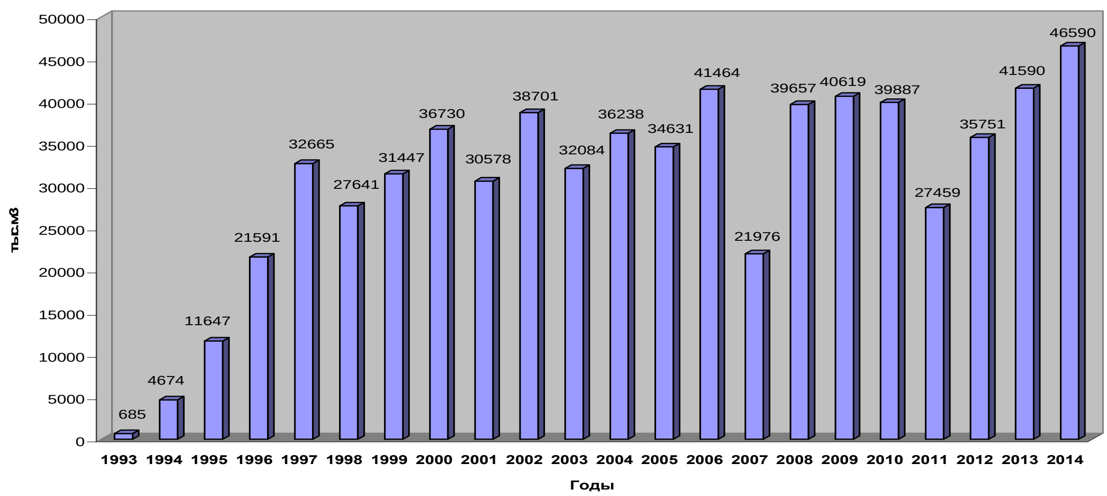


Fig. 3.12. – Water volumes which were discharged from Tashlyk reservoir into Olexandrivka reservoir (before 2007 –into the Pivdennyi Buh)

Table 3.19. – Calculated quantity of polluting substances which were discharged with return waters from Tashlyk reservoir into Olexandrivka reservoir in 2014.

Ingredients	Limit	Discharge
Suspended substances	1137,820	-
BOD_5	129,930	-
Ammonium nitrogen	21,440	-
Nitrites	3,660	-
Nitrates	342,480	6,298
Chlorides	8262,430	3906,451
Sulfates	22705,920	12395,773
Phosphates	18,290	0,955
Total iron	6,310	0,049
COD	2541,800	-

Oil products	3,150	-
Copper	1,450	0,015
Nickel	0,630	-
Fluorine	32,800	2,445
Anionic surfactants	1,140	-

Therefore limits for polluting substances discharge are not exceeded.

Water conditions of the Pivdennyi Buh are characterized by irregularity of flow distribution over the year and outside the territory of the basin. As the analysis of hydrologic data demonstrates average annual flow of the Pivdennyi Buh in the vicinity of the river mouth is 87,0 m^3/s over the period from 1918 to 1950. After the creation of most of reservoirs, ponds, in 1951–1980, average annual flow went up to 93 m^3/s, after the creation of SU NPP cooling pond in 1981–1999, — the flow value didn't change and is about 92 m^3/s (Fig. 3.13).

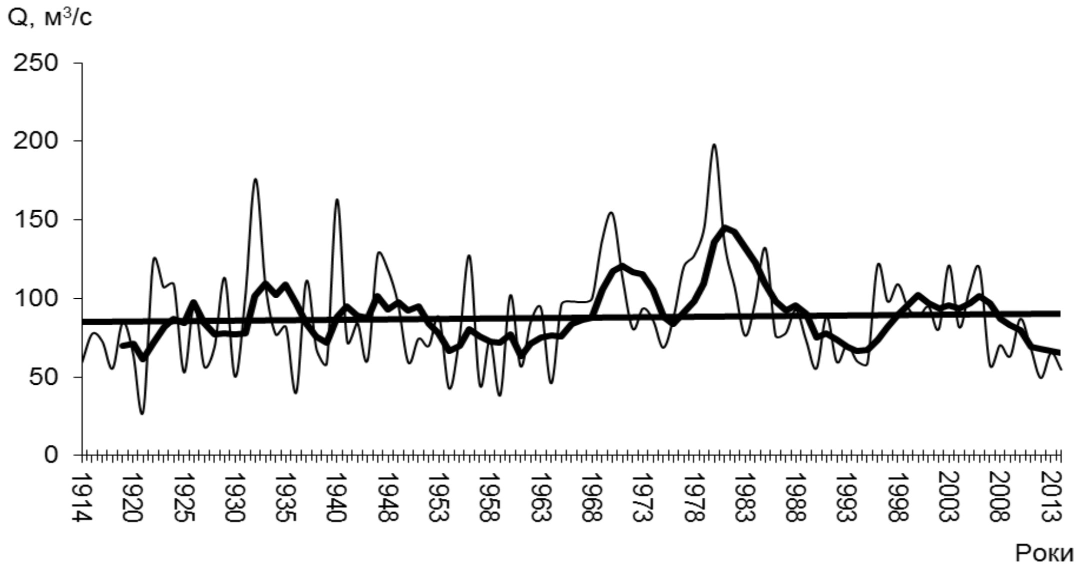


Рис. 3.13. – Chronological distribution of average annual water flow in the direction of the Pivdennyi Buh = Olexandrivka

When calculating *intra-annual flow distribution* season assembly method has been applied by means of which dryness of each month in percent in high-, average-, low-water year is specified (Table 3.20.)

Table 3.20. – Intra-annual flow distribution (absolute values, m^3/s, and their share per year, %) the Pivdennyi Buh – Olexandrivka

Dryness of the year	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II
High-water year P = 5 %	652,3 32,4	249,9 12,5	104 5,1	141,2 6,9	96,8 4,7	67 3,3	140,6 6,9	90,7 4,4	72,4 3,5	189 9,3	123,8 6,0	92,9 4,5
Average water year P = 50 %	241,3 22,3	146,9 13,5	76,7 7,1	76,8 7,1	51,8 4,8	40,1 3,7	83,1 7,6	64,7 5,9	51,1 4,8	110,2 10,2	75,6 7,0	62,9 5,8
Low - water year = 95 %	101,6 18,6	73,7 13,5	53,6 9,8	37,6 6,9	29,3 5,4	22,8 4,2	39,6 7,2	32,6 6,0	23,3 4,3	55,6 10,2	41,6 7,6	33,6 6,1

Assessment of the cooling pond impact on the Pivdennyi Buh flow

The flow distribution over the period after the construction of SU NPP cooling pond and Olexandrivka reservoir filling till the elevation of NWL which is 16,0 m (1985–2014), upstream of (the town of Pervomaisk) and downstream of South-Ukraine Power Complex (Olexandrivka), represented in Fig. 3.14., shows that water intake at water bodies of South-Ukraine Power Complex didn't lead to noticeable decrease of the Pivdennyi Buh water flow.

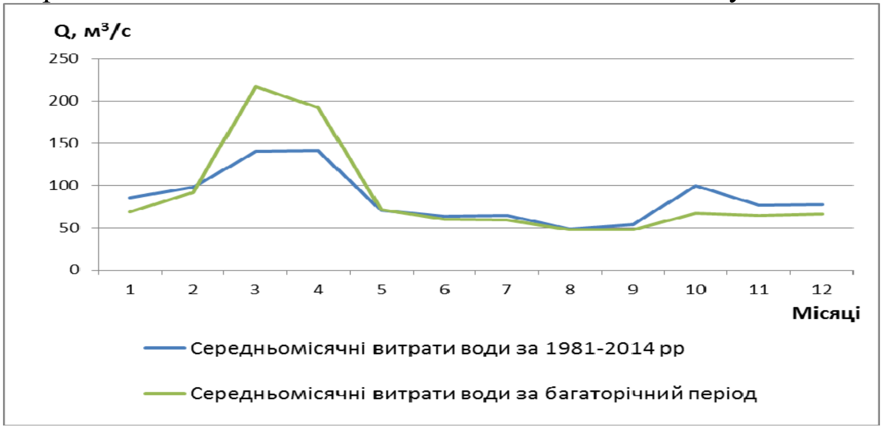


Fig. 3.14. – Graph of average monthly water flow of the Pivdennyi Buh at Olexandrivka surveillance stations

Irreplaceable water losses at SU NPP with all three operating power units consist of evaporation losses and water intake is about 1,2 m^3/s. Long-term average water flow of the Pivdennyi Buh in the vicinity of Olexandrivka is 89,0 m^3/s, and the historical low of 28,0 m^3/s was recorded in 1921. Therefore irreplaceable water losses of the Pivdennyi Buh at SU NPP is 1,4% of long-term average water flow and 4,3 % of the minimum one.

3.7. Soils

The main soil formation at SU NPP region is forests with underlying red and brown clays that have complex mechanical composition of high water penetration capacity leading to formation of solonetzic chernozem and saline chernozem.

At water-parting plains and their slopes exclusively fertile chernozem was formed in forests and forest like loams of the glacial period. Filled- up chernozem and meadow-chernozem soils were formed at hills and gullies of deluvial forests.

The river valleys are covered with alluvial deposits of yellow and brown or grayish-yellow carbon-bearing loams and sandy loams at which meadow, meadow-bog and bog soils were formed. Eluvium of magnetic material occurs at the slopes of the river valleys and gullies cropped up with granites and gneisses. At the river-bed semiterrestrial and hydromorphous soils of the meadow system were formed and in the places of high-salt waters occurrence alkaline soils were formed.

Non-radiation impact

SU NPP brought an impact on soils during the plant construction, namely in the destruction of fertile soil within the territory of NPP industrial site.

At present there is no impact on soils and it is not expected in future during the implementation of planned activities related to the extension of SU NPP power units operation.

The radiological impact

The content of radionuclides in soil is specified by radiopotassium (^{40}K), technogenic pollution is presented by radiocesium (^{137}Cs) of global origin. There is no noticeable contribution related to SU NPP operation into radioactive contamination of the soil. (Table 3.21.).

Table 3.21. – Average specific activity of radioactive nuclides in the soils of SU NPP surveillance area settlements for the surveillance period

Soil sampling places	Soil, kBq/m^2

	^{137}Cs	^{90}Sr	^{40}K
Pankratove (village)	0,3	-	27,1
Yuzhnoukrainsk (town)	0,48	0,12	28,6
Kostiantynivka (village)	0,36	-	30,8
Agronomia (village)	0,32	0,38	26,1
Buzke (village)	0,30	-	26,9
Bohdanivka (village)	0,46	0,28	30,7
Vynogradny Sad (village)	0,35	-	27,1

At Fig.3.15. and Fig. 3.16. there are maps of distribution of equivalent dose rate of gamma radiation and cesium -137 activity in SU NPP surveillance area compiled upon the results of field control radioecological survey as of 2015.

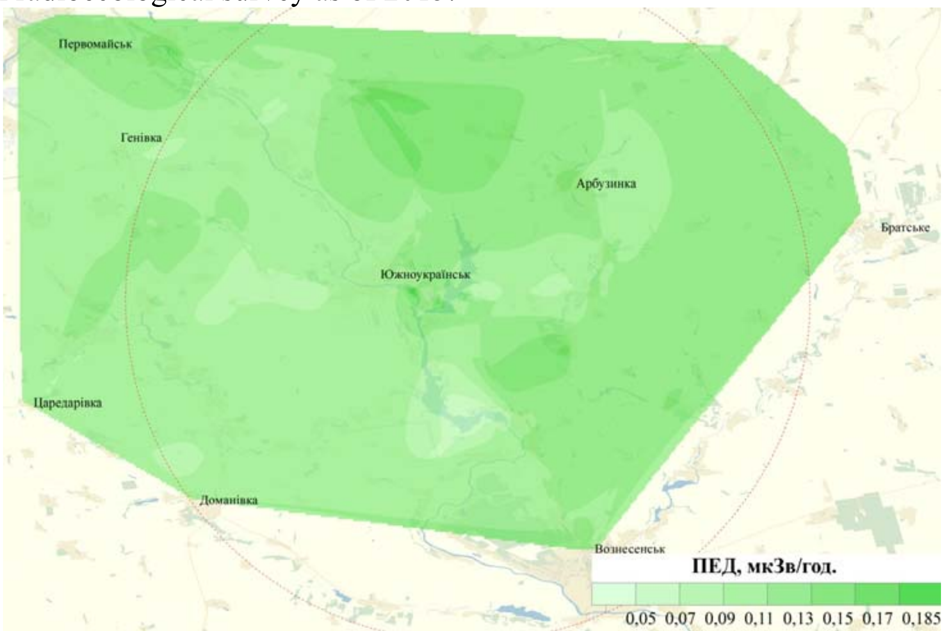


Fig. 3.15. – **Map of distribution of equivalent dose rate in SU NPP surveillance area**

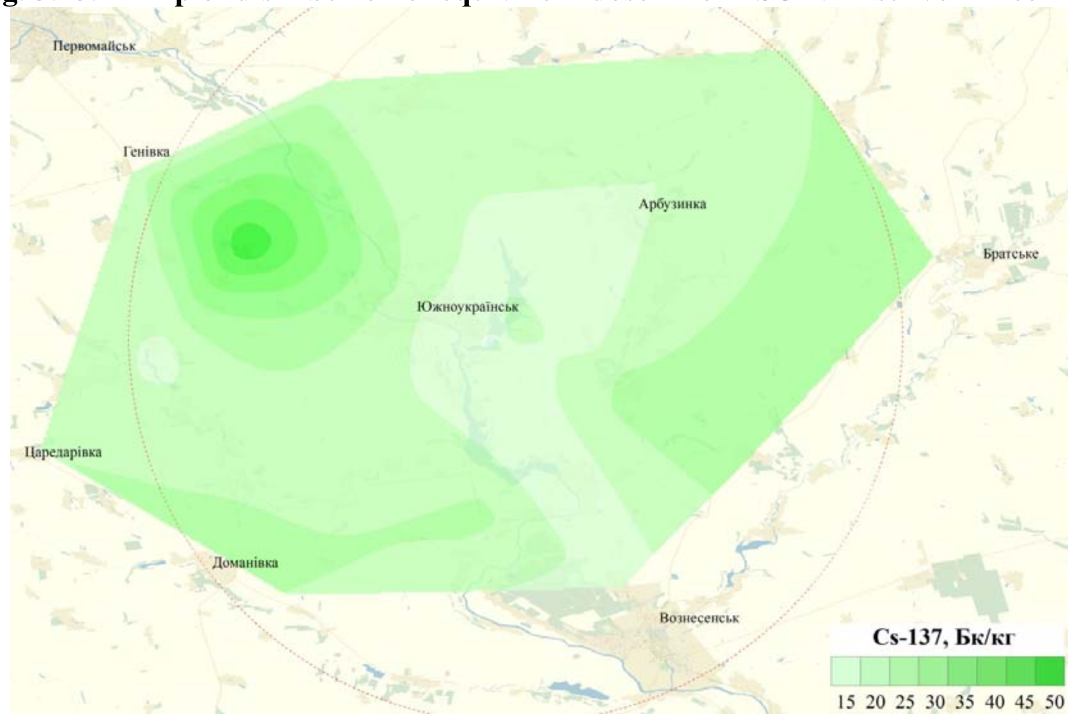


Fig. 3.16. – Map of distribution of radiocesium activity in soil in SU NPP surveillance area

The results of field control radioecological survey show that there is no radioactive contamination of environment within the surveillance area indicating the impacts of SU NPP site that exceed permissible limits or may be the ground for response. Radiation environment doesn't differ from the background indicators.

3.8. Flora and fauna

The territory of SU NPP surveillance area is located in granite and steppe Pobuzhzhe which is a unique floristic area locating within the Pivdennyi Buh canyon valley.

In accordance with geobotanical subdivision SU NPP surveillance area within 30 kilometers belong to subpontian herb fescue-mat-grass steppe. Local flora comprises of about 900 species of vascular plants, 27 out of them have been registered in the National Red List, 4 out of them – in the European Red List.

Major changes of the vegetation cover within SU NPP 30 km surveillance area took place at the beginning of the construction and are related with the agricultural development. Biological diversity damaged by the creation of Tashlyk PSP and Olexandrivka reservoir level rise was compensated by implementation of activities aimed at transfer of population of precious and endangered species.

In accordance with zoogeographic subdivision the territory belongs to western steppe zone of North Greater Black Sea Region. The fauna of backboned animals comprises of about of 300 species, 46 out of them are under the state protection. Within SU NPP surveillance area there have been registered 31 species of terrestrial insects, 3 species of fish, 3 species of reptiles, 19 species of birds and 7 species of mammals registered in the National Red List.

Surveillance study of fauna in Tashlyk PSP affected area in 2014 and comparison of its results with the previous visual observations showed that there are no significant changes in species composition and population of terrestrial backboned animals. One can observe an increase of semi-aquatic bird population that is related with the increase of shallow water zone area appeared after the water level rise and due to the improvement of bird's feeding conditions.

Within SU NPP 30 km zone endemic animal species have not been registered, some species are disappearing or their population is decreasing.

The flora and fauna of SU NPP surveillance area are characterized by the following trends which are not directly related with the plant operation:

- implementation of adventive material;
- development of ruderal species;
- decrease of steppe species;
- development of aquatic birds species;
- decrease of forest cover;
- increase of reserved areas.

To save rare phytogenofond and biological diversity of natural floristic complexes and due to the development of South-Ukraine Power Complex there have been developed and implemented a regional philosophy for population monitoring of rare species, florotopological complexes and phytoinvasion processes.

Taking into account a floristic (endemism, relic vegetation) and floroco-zoological (species that have international, state and regional co-zoological status) unique character of granite and steppe Pobuzhzhe, there have been developed and implemented a monitoring of populations of rare florofond of vascular and cryptogamic plants, natural floristic complexes, populations of expansive adventitious plant species and synanthropic floristic complexes.

The strategy for population research enables identifying the biological potential of a species under the specific conditions, clarifying natural and anthropogenic factors of its disappearance, non-compliance of morphological and physiological peculiarities with their growth conditions.

Filling of Olexandrivka reservoir first up to the elevation of 16,0 m, and further up to 16,9 m as well as keeping its stable level created favorable conditions for significant decrease of synantropization in natural floristic complexes and invasive processes in the region. The above mentioned aspect in general will be a favorable environment-oriented factor to save populations of rare plant species.

Cultivation introduction and reintroduction of rare species are of great importance.

Along with the protection of rare and disappearing plant species in the places of their natural growth (in situ), their growth and protection outside their natural growth location is of great importance (ex situ). Imitation of homeostatic population of rare plant species during the reintroduction process is a prospective trend in protection and reproduction of rare plant genofond. Under the conditions of natural growth location degradation it will allow increasing phytogenous potential and will contribute to its protection.

The logical completion of works related to reintroduction of rare and disappearing plant species is their reintroduction into natural ecosystem. The works of such kind are being implemented for rare floristic species of granite and steppe Pobuzhzhe region. Due to the reintroduction of the species from Tashlyk PSP affected area into natural ecophytons of the Pivdennyi Buh valley. Their lost and transformed local populations will be restored to their normal state.

The impact of radioactive pollution on flora and fauna

The content of radionuclides in vegetation is defined by ^{40}K, there is no noticeable contribution related to SU NPP facilities operation into radioactive pollution of flora until now. (Table 3.22.).

The results of investigation of radionuclides content in samples of milk, meat, cereal and vegetables, taken in the farms and settlements located in SU NPP surveillance area show that total activity of radionuclides in agricultural products is specified by ^{40}K, the content of ^{137}Cs and ^{90}Sr doesn't exceed 1% of the total activity.

Therefore under SU NPP normal operating conditions SU NPP does not have a negative radiation impact on flora and fauna.

Table 3.22. – Average specific activity of radioactive nuclides in vegetation of SU NPP surveillance area settlements for the surveillance period

Sampling places	Vegetation, Bq/kg		
	^{137}Cs	^{90}Sr	^{40}K
Pankratove (village)	24	-	530
Yuzhnoukrainsk (town)	19	3,2	680
Kostiantynivka (village)	32	-	380
Agronomia (village)	10	5,5	690
Buzke (village)	31	-	990
Bohdanivka (village)	13	3,7	420
Vynogradny Sad (village)	35	-	780

3.9. Nature Reserve Fund

Within SU NPP surveillance area there are 30 nature reserve entities of local significance – botanical natural reserves, forest reserves, hydrologic reserves, protected landscapes, ichthyologic and wildfowl reserves, natural landmarks and natural park-monuments of the garden art.

The biggest reserve for its territory and status is National Nature Park «Buzky Gard».

Before 2009 this conservation area belonged to the Regional Landscape Park « Granite and Steppe Pobuzhzhe». National Nature Park was established by the Decree of the President of Ukraine № 279/2009 as of 30.04.2009; by the Order of the Minister for the Environment as of 19.06.2009. The Regulation about National Nature Park «Buzky Gard» has been developed and approved». The Regional Landscape Park «Granite and Steppe Pobuzhzhe» has an area by 129 ha greater than the area of National Nature Park «Buzky Gard», but most of its areas are included into National Nature Park «Buzky Gard».

The park is located on the grounds of Arbuzynka, Bratske, Voznesensk, Domanivka and Pervomaisk districts of Mykolaiv Region in the valleys of the Pivdennyi Buh, the Velyka Korabelna, the Mertvovod and the Arbuzynka.

The total area of the park territory is 6138,13 ha, including 2650,85 ha of lands that are granted to the park for the constant use and 3487,28 ha of lands that are incorporated into its territory without its withdrawal from the land owners and land-users. .

The length of the park along with the Pivdennyi Buh is 58 km, the total length of boundaries is 280 km. There are 35 settlements located in the park territory and in the direct vicinity of its boundaries. The Pivdennyi Buh runs in the cliff, stony riverbanks creating a narrow canyon like valley with grand granite cliffs, waterfalls and islands.

The tasks that are assigned to the park are as follows: conservation of unique natural complexes and historical landscapes, implementation of ecological educational activities, creation of conditions for package holiday; implementation of scientific research activities, elaboration of scientific recommendations.

National Nature Park «Buzky Gard» comprises of three conservational research units in Mygiya, Bogdanivka and Trikraty.

Within the boundaries of the park there is a wetland «Buzki Broyaky», which meet all eighth criteria of Ramsar Convention as an international wetland.

At present the park territory comprises of nature reserve entities of local significance which are as follows:

- ichthyologic reserve «Pivdennobuzky» – 40,0 ha,
- botanical natural monument «Bakshala River Mouth» – 5,0 ha,
- geological natural monument «Protychanska Skelya» – 0,03 ha,
- geological natural monument «Turetsky Stil» – 0,01 ha,
- reserved natural landmark «Labirynt» – 247,0 ha,
- reserved natural landmark «Vasyleva Pasika» – 252,0 ha
- reserved natural landmark «Livoberezhzhia» – 226,0 ha,
- reserved natural landmark «Litniy Khutir Skarzhynskogo» – 105,7 ha.

Trikraty Forest is of great value within the park territory which consists of several reserved natural landmarks («Labirynt», «Vasyleva Pasika» and «Litniy Khutir Skarzhynskogo»).

The Pivdennyi Buh canyon has a unique recreational potential. There are considerable reserves of radon waters. One of the most beautiful natural water slalom route is located in natural landmark Protych. The canyon cliffs are the favorite places for the competition between climbers. Splendid scenically attractive landscapes of the region attract a lot of amateurs of walking and horse-riding tourism and give unforgettable experience of communion with nature. There is a hunting entity located in the park surroundings.

The park territory is the subject of scientific research, educational tour and serves as a basis for getting field experience for students of the leading universities of Ukraine.

4. The impact on the social environment

Administratively SU NPP territory which is along with Tashlyk PSP, Olexandrivka HPP and Olexandrivka reservoir included into South-Ukraine Power Complex and located in Mykolaiv Region. The territory which is affected by the above mentioned facilities having the total area of 3,9 thousand km^2, comprises of two towns Yuzhnoukrainsk and Voznesensk as well as settlements of Arbuzynka, Domanivka and Voznesensk districts having the population of about 180 thousand people.

The most populous settlements within the research area are Pervomaisk, Yuzhnoukrainsk, Olexandrivka, Kostiantynivka connected by asphalt roads.

In the eastern part of the territory there is a highway Odesa–Pervomaisk, in the southern part – Olexandrivka–Domanivka.

Economically this region is an energy generating (SU NPP, Kostiantynivka HPP, Olexandrivka HPP) and agricultural one, furthermore it has some mining enterprises of local significance (stone pit, sand pit).

South-Ukraine NPP is a basic industrial facility of the region. The number of people involved at SU NPP is about 6 000 people.

The basic economic activity for population is agriculture. The rate of unemployment – national average one. Natural decrease of population exceeds migration increase. There is a trend towards the ageing of the population.

For SU NPP there have been established a buffer area with 2,5 km-radius zone within which residence and permanent stay for population is prohibited as well as other activity not related to SU NPP operation.

SU NPP 30km surveillance area is a zone of permanent control. Within SU NPP surveillance area resident population is about 143 thousand people, 41 thousand out of them live in SU NPP satellite town –the town of Yuzhnoukrainsk that is closer to the NPP than any other settlement – nearly at the boundary of the surveillance area.

Within the surveillance area there are the following settlements:

- the town of Voznesensk: the distance to SU NPP is 30 km, population is 47 000 people;
- Kostiantynivka (township): the distance to SU NPP is 4 km, population is 2 300 people;
- Arbuzynka (township): the distance to SU NPP is 12 km, population is 6 500 people;
- Olexandrivka (township): the distance to SU NPP is 16 km, population is 5 500 people;
- Domanivka (township): the distance to SU NPP is 26 km, population is 6 300 people;
- Bratske (township): the distance to SU NPP is 29 km, population is 5 500 people,

As well as a number of villages with total population of about 30 thousand people.

Mykolaiv is a regional center with the population of about 450 thousand people which is located at the distance of 112 km from the NPP, the town of Pervomaisk with population 60 thousand people located at the distance of 34 km from the NPP.

It is expected that the planned activities namely the extension of SU NPP power units operation will have a favorable impact on a social sector of Yuzhnoukrainsk and other settlements which belong to SU NPP affected area:

- maintaining of employment;
- support and development for allied industries,communications and infrastructure;
- maintaining and development of social and medical support;
- payments to the budget and payments to non-budgetary funds.

The adverse impacts maybe related with the radiological impact in case of unexpected accidents, for example in case of a terroristic attack. However its likelihood is very low under the normal performance of physical protection and monitoring system. In other cases public exposure which may lead to significant doses are excluded. Maximum exposure doses caused by the design basis accident (DBA) assessed at the boundary of the buffer area show that even in case of DBA the levels of potential exposure are appeared to be significantly below the specified limit justified for population evacuation – 50 mSv for whole body.

Taking into account the abovementioned information, it is possible to state that the assessment of the impact of SU NPP operation extension on social environment clearly shows that there are no restrictions for the planned activities. Instead, the extension of the plant operation maintains employment of the population, have a favorable impact on social and economical development of the region and country in general as well as it neither require significant resources for the decommissioning of the power units and the plant or raise the question about the need to search for the substitution of the power generation source.

Cardiovascular diseases take the first place among causes of death. The disease incidence varied little from the relevant national indicators. In accordance with the previous predictive assessments in the midterm noticeable changes in population health are not expected within SU NPP affected area which may differ from general national trends. All these changes will depend on Health Protection System and social welfare standards.

The results of the previous analytical investigation of SU NPP impact on population health show that there is no noticeable adverse effect related to the plant operation under the normal conditions that give grounds for the prediction of the similar situation in future during the extension of operation life.

The population of SU NPP location area use environmental resources for small number of industrial facilities therefore there is no significant impact on the environment by industrial pollution. South-Ukraine NPP is a major industrial facility of the region and in accordance with the design release limits the population exposure dose under SU NPP rated operating conditions does not exceed dose constraints for the population. (40 mSv/year).

Therefore South-Ukraine NPP operation does not have and under normal operating conditions it will not have an adverse impact on the public health in future as well.

The estimated maximum exposure doses resulted from DBA at the boundary of the buffer area are presented in Table 4.1.

Table 4.1. – Estimated maximum radiation doses resulted from Design Basis Accidents

Design Basis Accident	**External cloud-penetrating radiation dose, Sv**	**External radiation dose through the ground sediments at the lowest weather conditions, Sv**	**A dose for a thyroid gland through inspiration by a child, Sv**
An accident caused by double ended pipe rupture (DBA, Loss-of-coolant accident)	0,0008	0,091	0,063
SG header cover leakage	0,0007	0,075	0,163
Accidents related to: - SF storage pool leakage; - FA drop into the SF storage pool; - water gate drop into the SF storage pool.	**effective body dose, mSv**	**a dose for a thyroid gland, mGy**	**a dose for a skin, mGy**
	3,44	9,25	66,3

In accordance with the current legislation of Ukraine, residents of 30 km surveillance area obtain social and economic compensation of the risk which includes establishing and maintaining specific social infrastructure and payment privileges for the consumed electric power according the tariff specified according to the Law of Ukraine «On Electric-Power Industry».

Social and economic compensation of the risk is made from the special purpose fund of National Budget of Ukraine. NNEGC «Energoatom» pays a fee in the amount of 1% of the electric power output which is generated at the NPP for the relevant period (without VAT).

Funds obtained from social and economic compensation of the risk are granted to special purpose funds of regional, district budgets as well as to the budget of the borough council of multifunctional satellite towns covered by the relevant levy payer surveillance areas and they are distributed in the percentage ratio as follows:

- regional budgets - 30%;

- districts budget and budgets of the towns of region subordination of the surveillance area (except multifunctional satellite towns) – 55%;
- budgets of multifunctional satellite towns – 15%.

Funds are allocated between special purpose funds of regional, district budgets as well as the budgets of the borough council of the towns of region subordination with account taken of the density of population that live in the surveillance area of these administrative territorial entities in accordance with the procedure established by the Cabinet of Ministers of Ukraine. Funds for social and economic compensation of the risk taken from special purpose funds of local budgets are used for areas and in accordance with the procedure established by the Cabinet of Ministers of Ukraine.

Target use by state municipal authorities of resources envisaged for social and economic compensation of the risk is controlled according to the Law. Regional, district and local councils report to the public every three months about the use of resources envisaged for social and economic compensation of the risk taken from special purpose funds of the relevant local budgets by publication of reports in periodical local council editions.

5. IMPACT ON ANTHROPOGENIC ENVIRONMENT

Planned activity impacts on the facilities of anthropogenic environment

Within SUNPP surveillance area the following elements of anthropogenic environment are located: lines of communication, population life support facilities, local industrial enterprises, collective and private farms, etc. Buffer areas for such facilities do not exceed 100 m. The largest industrial facilities are SUNPP and Tashlyk PSP that are part of the South-Ukraine Power Complex.

At a distance of 2,2 km from SUNPP site the rail track section Odesa-Pomichna is laid and the national highway Ulianivka-Mykolaiv is from the plant at 0,95 km. Several petrol stations are also situated within SUNPP surveillance area.

Besides these facilities and the South-Ukraine Power Complex mentioned above there are no other installations of increased environmental hazard in SUNPP buffer area (such as chemical plants, oil refineries, mines, open pits, oil pipelines, etc.).

Among recreational institutions the nearest one is SUNPP Rehabilitation and Recreation Complex which is situated from the plant at 2,8 km on the river Pivdennyi Buh.

A number of social objects such as cultic buildings, architectural and archeological monuments, historical and cultural landmarks are located in the surveillance area.

The previous assessments have been brought to the conclusion that economic activity limitation in the vicinity of the plant site can be considered as a factor of NPP impact on anthropogenic environment even under normal operation of the power units. For safety reasons these limitations are related to potentially dangerous facilities and activity types, recreation, flying, transport of hazardous materials, etc.

At the same time, assistance in development of small and medium enterprises providing direct and indirect services related to NPP activity and investment in infrastructure development are considered the factors of positive influence.

Ecological impact of SUNPP in particular water withdrawal from the Pivdennyi Buh does not materially affect the activity of anthropogenic environment facilities.

There are no risks of natural flooding or dam failure in the Oleksandrivka reservoir. The Tashlyk reservoir adjacent to the NPP is bounded by the dam. In case of its failure the procedure of the power unit shutdown and cooling using only spray ponds will be performed at SUNPP.

Probability and potential risks of terrorist attacks have not been addressed in the reports on SUNPP safety analysis. Physical protection, threat prevention and warning system operates at the plant.

Impacts of the anthropogenic environment facilities on the planned activity

Impacts of economic activity and man-made facilities on SUNPP safety related to fire safety and explosion risks.

Risk of accidental explosions and fires at the industrial enterprises of infrastructure located at the distance of 10 km from the plant is systematically reviewed as a part of the Safety Analysis Report. The main potential sources of explosion on the plant site can be rooms for storage of liquid gases and calcium carbide, tanks with fuel and lubricants. In the area of 10 km from the plant such facilities are diesel fuel storage (2000 m^3) located at the distance of 2350 m, high-pressure gas duct (1000 mm) located at the distance of 8 km to south-west of the NPP, the rail track Odesa-Pomichna and the national highway Ulianivka-Mykolaiv by which the explosive cargos can be transported. It has been confirmed previously that all potential sources of accidental explosion mentioned above would produce an additional pressure that is lower than the regulatory limit of 10 kPa.

There are no pipelines, oil pipelines, chemical plants or oil refineries within SUNPP 30 km area.

The nearest airports are situated in Mykolaiv at 110 km from SUNPP and in Kirovograd at 110 km from it.

None of the air routes crosses 10 km area. The assessed probability of reactor core damage caused by the air crash is 10^{-7} per year.

Risk of accidental explosions at the industrial enterprises of infrastructure located at the distance of 10 km from SUNPP is systematically reviewed in the framework of the Safety Analysis Reports that are prepared at the plant.

It is confirmed at the moment that all potential sources of accidental explosions located nearer than at 10 km from NPP or on the plant site will produce an additional pressure which will be lower than the regulatory limit of 10 kPa. These facilities are as follows: diesel fuel storage (2000 m^3) located at the distance of 2350 m, high-pressure gas duct (1000 mm) located at the distance of 8 km to south-west of the NPP, the rail track Odesa-Pomichna (2,2 km from the plant fence) and the national highway Ulianivka-Mykolaiv (0,95 km from NPP) by which the explosive cargos can be transported.

SUNPP is not exposed to risk of natural flooding or dam failure on the Pivdennyi Buh.

The Tashlyk reservoir adjacent to the NPP is bounded by the dam. In case of its failure the procedure of the power unit shutdown and cooling using only spray ponds will be performed at SUNPP.

6 EVALUATION OF ENVIRONMENTAL IMPACT IN A TRANS-BODER CONTEXT

The potential trans-border radiation effects of SUNNP

Preliminary analysis, based on the results of the long-years complex environmental monitoring are reflected in the numerous technical reports and in a number of scientific studies shows that the impact of all non-radiation factors hardly extends beyond the buffer area and in no circumstances (even if the potential accidents) do not extend beyond the surveillance area. Parameters of these impacts do not exceed the limit of national and international levels, at least, such cases were recorded during the period of observation. Thus non-radiation impacts are excluded from the consideration in a trans-border context

The radiation background and concentration of radionuclides ^{90}Sr, ^{137}Cs, ^{134}C, ^{60}Co, ^{54}Mn in the air and atmospheric precipitations, according to the observations are at the level of values, measured before NPP's commissioning. That is, the NPP's impact on atmospheric environment during the period of its operation was not significant even for the surveillance area. As with distance from the source of emission the density of contamination with radionuclides decreases rapidly, then under normal operation even for the closest countries - Republic of Moldova (the distance from NPP to the border ~ 130 km) and Romania (~ 250 km) the significant trans-body impact which is related to the life time extension of NPP is not expected.

Trans-border impact under normal operation

Below are the results of calculations of radionuclide activity in surface air from a distance and density deposition on the surface of the soil. To simulate the spread of radioactive substances in the atmosphere and the formation of the doses caused by releases of radionuclides from South-Ukrainian NPP in normal operation the software package PC CREAM, developed at the National Radiological Protection Board (National Committee on Radiation Protection, England) was used.

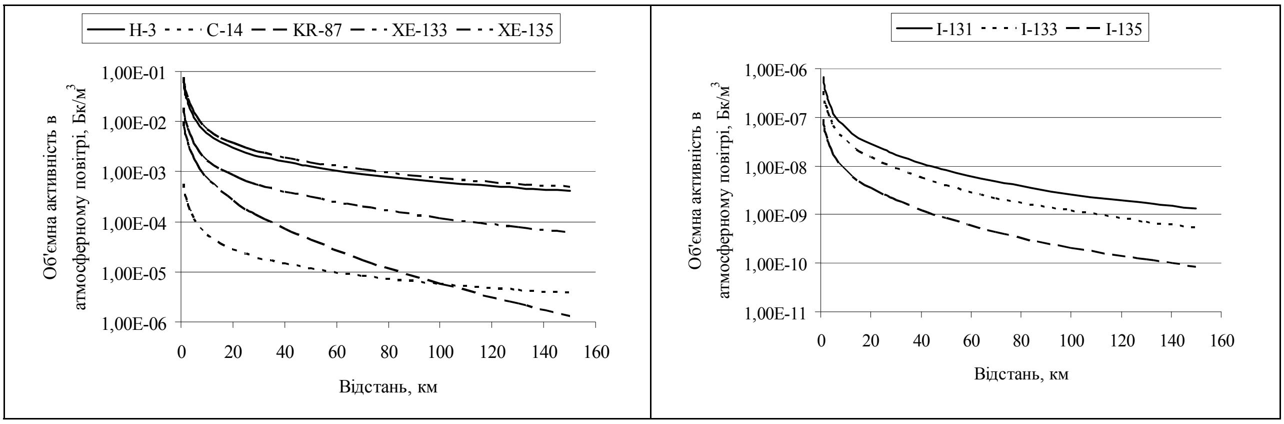


Fig. 6.1. – Dependence on the distance of the expected volumetric activities of inert radioactive gases, tritium, carbon and iodine isotopes in the surface air.

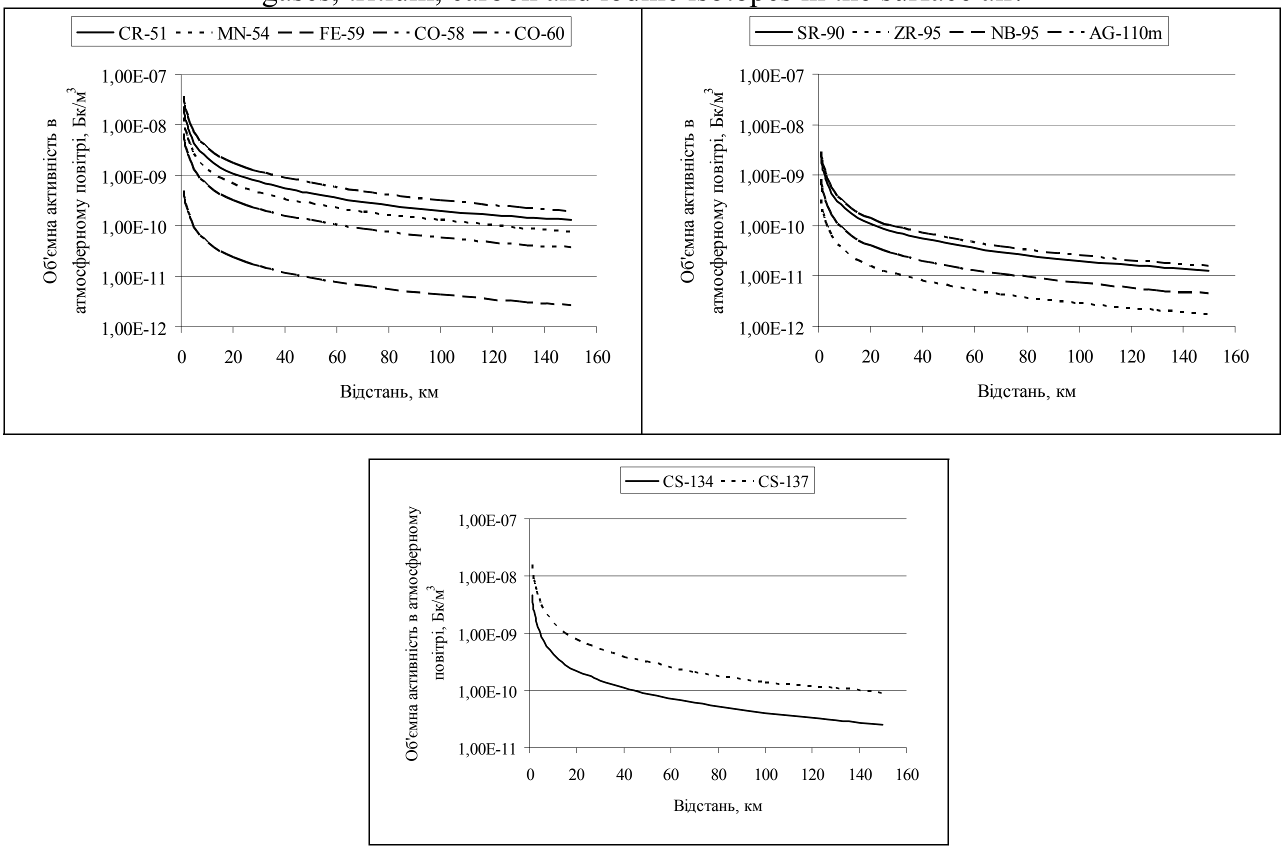


Fig. 6.2. − Dependence on the distance of the expected volumetric activities of the long-lived aerosols in the surface air

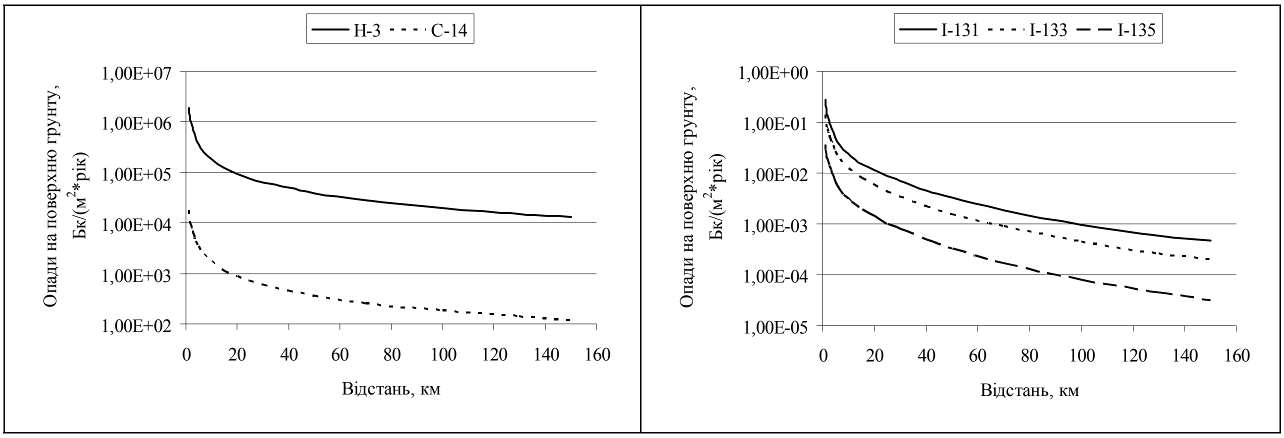


Fig 6.3. – Dependence on the distance of the expected precipitations of tritium, carbon and isotopes of iodine on the soil surface.

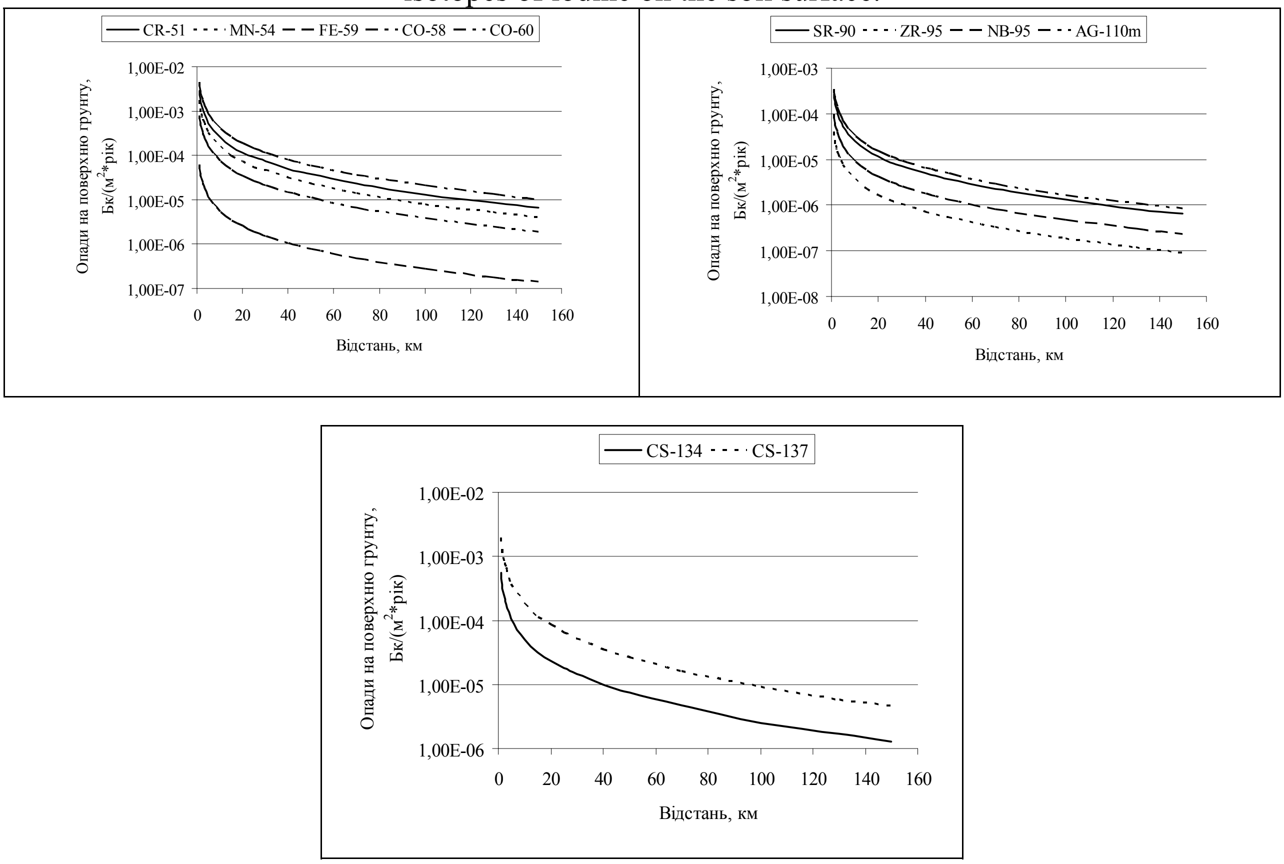


Fig. 6.4. − Dependence on the distance of the expected volumetric activities of the long-lived aerosols on the soil surface.

As seen from the figures shown above maximum volumetric activity in the air at the border of the buffer area (2500 m) is expected for ^{133}Xe - 0,03 Bq/m^3 and tritium - 0,024 Bq/m^3. On the border with the closest country - Moldova, which is in a distance of 130 km, the value of the volumetric activity of radionuclides released from the NPP in the air do not exceed 0.00057 Bq/m^3.

Maximum values of precipitations on the ground at the border of the buffer area (2500 m) is expected for tritium - 781 kBq/(m^2*year) and carbon - 7.2 kBq /(m^2 *year). On the border with Moldova the value of radionuclides precipitations released from SUNPP on the ground will not exceed 15 kBq / (m^2 * year)

Fig. 6.5. shows calculations of the maximum expected population exposure doses upon distance. The results are shown for three age groups: children under 1 year, children up to 10 years and adults.

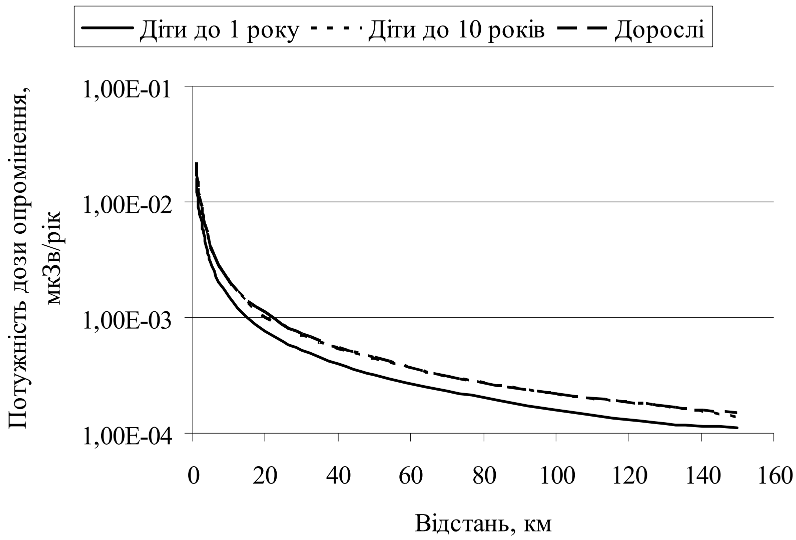


Fig. 6.5. – Dependence on the distance of the expected population exposure doses.

As shown on the figure the dose limit quota of 40 mSv /year according НРБУ-97 (NRBU- 97) for SUNPP's emissions is not exceeded (regardless of the location of the critical group of population). Maximum doses at the boundary of the buffer area do not exceed 8.6 nSv /year. On the border with the closest country - Moldova, the distance to which is 140 km, the doses of radioactive substances which were released from SUNPP will not exceed 0.17 nSv /year.

Trans-border impact in case of accident

Below are the results of calculations radioactive releases into environment at various types of accidents. The software package PC COSYMA, developed at the National Radiological Protection Board (National Committee on Radiation Protection, England) for emergency situations was used for calculations. All calculations are done for the conservative conditions of the impurity propagation and formation of doses (maximum doses).

Table 6.1. – Radioactive releases during the design basis accident

Radionuclide	**Release into environment**, Bq
Kr-88	2,00E+13
Sr-90	3,10E+11
Ru-103	4,50E+12
Ru-106	6,60E+11
I-131	4,98E+12
I-132	2,70E+12
I-133	4,00E+12
I-135	2,30E+12
Cs-134	7,80E+11
Cs-137	5,00E+11
La-140	8,40E+12
Ce-141	1,40E+13
Ce-144	8,60E+12
Total activity	7,17E+13

Table 6.2. – Radionuclide release during accident "Steam generator header cover lift-up – emergency spike".

Radionuclide	Release into environment, Bq
Kr-87	6,50E+13
Kr-88	2,00E+14
I-131	2,53E+13
I-132	9,20E+13
I-133	8,44E+13
I-134	1,00E+14
I-135	7,90E+13
Cs-134	2,10E+11
Cs-137	5,30E+11
La-140	2,60E+12
Xe-133	2,00E+15
Xe-135	1,70E+15
Total activity	4,35E+15

Table 6.3. − Radionuclide release during accident “Steam generator header cover lift-up – emergency spike”

Radionuclide	Release into environment, Bq
Kr-88	2,00E+13
I-131	4,50E+12
I-132	1,60E+13
I-133	1,54E+13
I-134	1,70E+13
I-135	1,30E+13
Cs-134	2,10E+11
Cs-137	5,30E+11
La-140	2,60E+12
Xe-135	1,70E+14
Total activity	2,59E+14

Table 6.4. − Radionuclide release during accident “Hydraulic lock drop into the spent fuel pool”

Radionuclide	Release into environment, Bq
Sr-90	4,70E+11
Ru-103	3,60E+12
Ru-106	4,10E+11
I-131	1,65E+13
I-133	1,50E+12
Cs-134	9,30E+11
Cs-137	5,80E+11
La-140	1,90E+12
Ce-141	6,60E+12
Ce-144	1,40E+12
Xe-133	5,00E+14
Total activity	5,34E+14

Table 6.5. − Radionuclide release during accident “Fuel assembly drop on the reactor core and FA top nozzles in the spent fuel pool”

Radionuclide	Release into environment, Bq
Kr-87	1,10E+13

Radionuclide	**Release into environment**, Bq
Kr-88	1,70E+13
Sr-90	3,90E+10
Ru-103	4,50E+11
Ru-106	6,90E+10
I-131	3,80E+11
I-133	2,60E+11
Cs-134	8,30E+10
Cs-137	6,50E+10
La-140	8,40E+11
Ce-144	9,70E+11
Xe-133	7,40E+13
Total activity	1,05E+14

Table 6.6. − Radionuclide release during accident “Drop of the container with the spent fuel from height of more than 9 miters”

Radionuclide	**Release into environment**, Bq
Sr-90	4,40E+11
Ru-106	1,00E+11
Cs-134	3,50E+11
Cs-137	7,30E+11
Ce-144	8,30E+11
Total activity	2,45E+12

Table 6.7. − Radionuclide release during accident “Fuel assembly drop on the reactor core in the rector”

Radionuclide	**Release into environment**, Bq
Sr-90	1,20E+12
Ru-103	2,30E+12
Ru-106	4,30E+11
I-131	4,63E+12
Cs-134	1,60E+12
Cs-137	8,20E+11
Ce-144	4,10E+10
Xe-133	1,10E+14
Total activity	1,21E+14

Table 6.8. − Radionuclide release during accident “Impulse tube rupture beyond the containment”

Radionuclide	**Release into environment**, Bq
Kr-88	7,10E+11
I-131	6,70E+12
I-132	1,70E+13
I-133	1,30E+13
I-134	9,60E+12
I-135	1,10E+13
Cs-137	7,40E+09
Xe-133	6,40E+13

Radionuclide	**Release into environment**, Bq
Xe-135	9,80E+12
Total activity	1,32E+14

Table 6.9. − Radionuclide release during accident “Planed cool down line rupture ”

Radionuclide	**Release into environment**, Bq
I-131	6,42E+07
Cs-134	2,50E+07
Cs-137	3,70E+07
Xe-133	6,80E+12
Total activity	6,80E+12

Table 6.10. − Radionuclide release during accident “Rupture of the process blow off pipeline for cleaning in the process blow off system of the reactor building”

Radionuclide	**Release into environment**, Bq
Ar-41	4,00E+11
Kr-85m	7,20E+11
Kr-88	2,20E+11
Xe-133	2,90E+13
Xe-135	4,00E+12
Xe-138	7,90E+10
Total activity	3,44E+13

Analysis of the results shows that the volume of potential accident releases do not exceed levels, and maximum allowable values of radiation criteria of the equivalent and absorbed doses at the border and outside the buffer defined by documents СП АС-88 and НРБУ-97 (SP AS 88 and NRBU 97) are within the specified limits. Thus, for all types of design and beyond design-basis accidents the maximum doses are lower than the level of unconditional justification. Trans-border spread of radiation releases during accidents, considering distance of SUNPP from the borders with other countries, it will differ slightly from the values of normal operation.

The analysis results of the considered beyond design-basis accidents confirm the size of the surveillance area (30 km) defined by project, which limit the territory of the unconditional justification of the urgent countermeasures.

Probable environmental pollution due to trans-border air transfer of SUNPP’s releases.

Distribution of releases depends on their volume and intensity of atmospheric transfer - speed and wind direction. Below the probable effects of SUNPP on the adjacent territory are shown which calculated from the wind rose average of 2014 in the town Yuzhnoukrainsk for tritium radionuclide, the release of which is most significant and exposure dose rate.

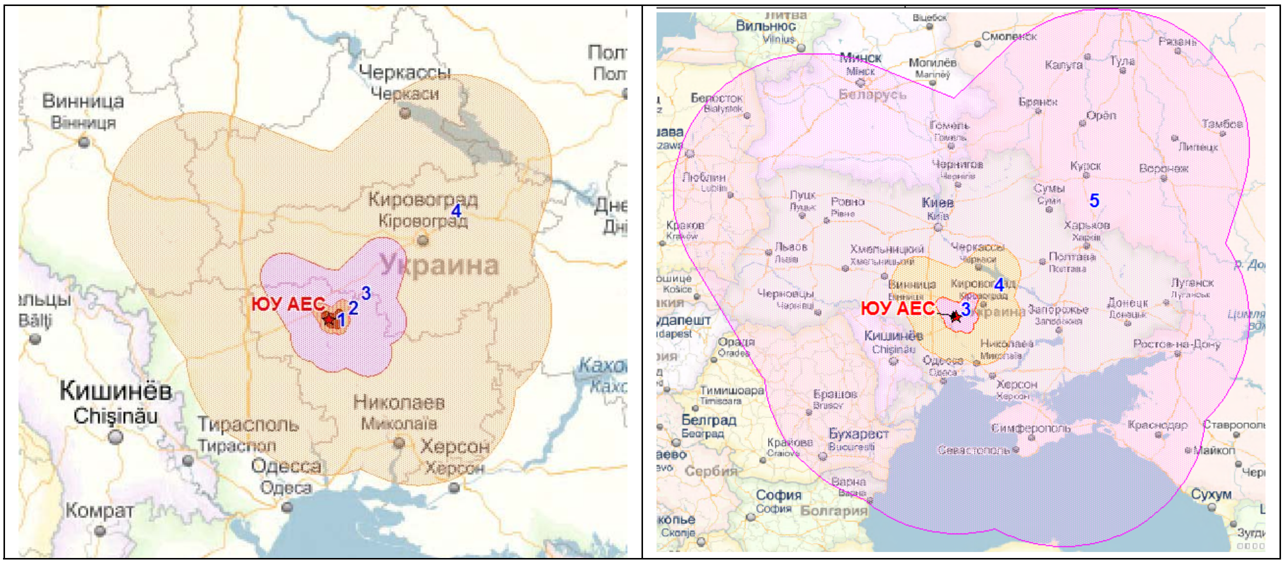


Fig. 6.6. – Probable activity of tritium radionuclide in the surface air due to atmospheric transfer of SUNPP's releases

Areas of contamination, Bq/m^3:

1 - ≥ 0,01; **2** - ≤ 0,01, ≥ 0,005; **3** - ≤ 0,005, ≥ 0,001; **4** - ≤ 0,001, ≥ 0,0005; **5** - ≤ 0,0005, ≥ 0,0001

Global value of tritium activity in the air is 0,12 Bq/m^3.

As shown in Fig. 6.6., the content of tritium in the air of neighboring countries through the emission of SUNPP power units in 2014 led to the probable activity increase, which does not exceed 0.4% of the average of the global rate.

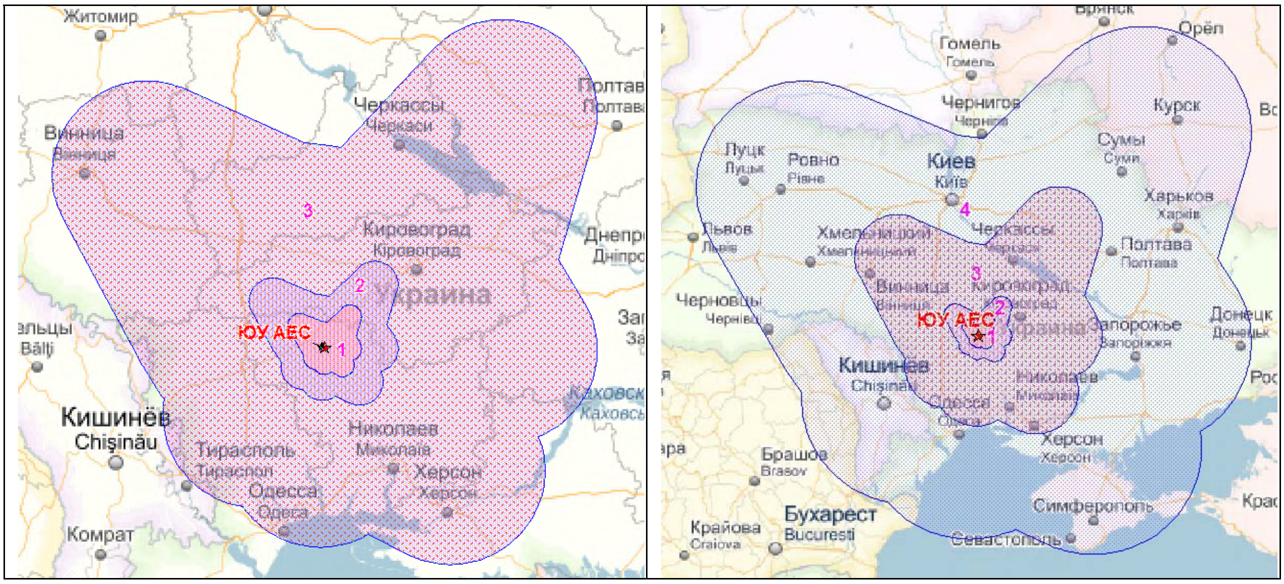


Fig. 6.7. – Probable activity of tritium radionuclides fall outs on the ground due to the transfer of atmospheric emissions of SUNPP.

Areas of contamination, kBq/(m^2 a year):

1 - ≥ 100; **2** - ≤ 100, ≥ 50; **3** - ≤ 50, ≥ 10; **4** - ≤ 10, ≥ 5.

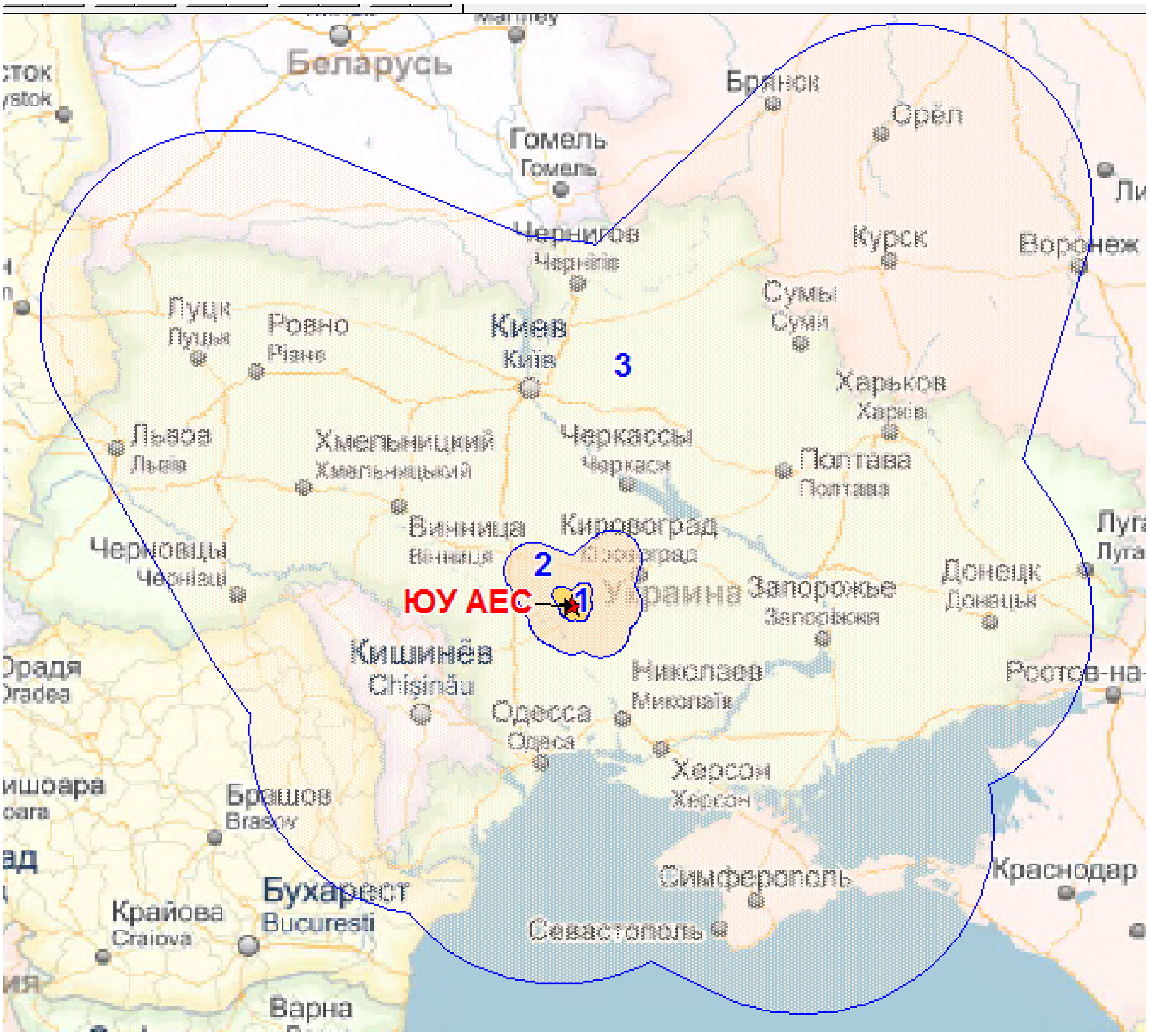


Fig. 6.8. – Probable additional exposure dose due to the transfer of atmospheric emissions of SUNPP

Areas of contamination, mcSv/year:
1 - ≥ 0,001; **2** - ≤ 0,001, ≥ 0,0005; **3** - ≤ 0,0005, ≥ 0,0001.
Global average of the exposure dose is 2,4 mSv/year.

As shown in the last figure, the effect of the emissions of SUNPP power units on the neighboring countries virtually negligible (is 2 E - 5% of the global value average).

Considering the nature of the planned activities, one can state that the analyzed effects of the radioactive emissions of SUNPP remain at the existing level.

The analysis performed suggests that the harmful effect associated with the life time extension of SUNPP power units during normal operation or in case of design basis accidents or beyond design basis accidents is virtually absent.

7 COMPREHENSIVE MEASURES TO ENSURE STANDARD ENVIRONMENTAL CONDITIONS AND ENVIRONMENTAL SAFETY

SU NPP performs environmental protection measures pursuant to both plant's internal environmental management plans, mitigation measure programs and within the "Program for environmental protection and natural resource management in Mykolaiv Region".

7.1 Resource-saving measures

Resource-saving measures implemented by SU NPP include energy saving and Southern Buh water resource management.

SU NPP consumers for its in-house needs 6 – 7 % of electricity generated in total. These costs can be reduced using some reserves in terms of the replacement of existing obsolete equipment, i.e. by replacing traditional incandescent bulbs with newer energy-saving lightbulbs, by replacing existing pumps with energy efficient pumps.

The resources can be reserved by reducing fuel consumption by vehicles.

Water is saved by a run-around service water system using Tashlyk cooling water pond. Water is also saved by an improved accounting system of water resources. An indirect impact on reduction in consumed water size may be achieved by decreasing polluted discharge volume.

Resource-saving measures are listed in the "Program for environmental protection and natural resource management in Mykolaiv Region" that is being implemented at SU NPP as well.

7.2 Protective measures

One important element of guaranteeing the NPP safety is the tightness of premises where radioactive material is held. SU NPP has a reactor containment system around the primary equipment to prevent the release of radioactive materials in the event of breaks or leaks and to prevent the primary circuit against extreme external hazards.

SU NPP structures and territory are zoned depending on their functionality. All the industrial buildings and premises are divided into two zones depending on their functionality by the nature of processes and the level of radiation effects on personnel: a RCA and normally occupied area. The industrial site is divided into conditionally "contaminated" and "clean" areas in order to prevent uncontrolled spreading of radioactive contamination both in-site and off-site.

To prevent or mitigate radioactive releases, the following engineering decisions have been elaborated:

- radioactive air purification with filters;
- absorbtion and filtration of gases containing radioactive isotopes (xenon, krypton) of noble gases;
- installation of safety barriers to confine radioactive materials;
- use of closed loops to prevent radioactive liquid leaking;
- introduced special system for liquid radwaste and solid radwaste collection and storage.

The plant performs routine monitoring of releases and levels of radioactive ground contamination, flora and water contamination within the buffer area and surveillance area.

7.3 Restoration measures

Lands for the construction of four South-Ukraine Power Units were transferred considering social, economic, processing, resource, logistics principles, etc. At that time, an environmental issue was not the spotlight while making a final decision regarding site selection for a nuclear power plant. (It is worth noting that Ukraine has no environmentally friendly territories for NPP siting).

Thereby, after construction the restoration measures were connected with revegetation of the territory that underwent changes, and these measures had been implemented before the NPP was commissioned. The territory was planned, site improvements were performed and the site was vegetated.

Later restoration measures are connected with the construction and commissioning of a pumped storage plant and raising of levels in Tashlyk cooling water pond – transplanting of rare species of flora in the higher dry land areas to prevent their submergence, in other words – the formation of new biocenoses. These measures also belong to compensatory measures.

Reserves related to the improvement of restoration measures, primarily, consist in implementation of soil degradation counter-measures and mitigation of an impact of exogenous geological processes on land and water resources.

7.4 Compensatory measures

The following compensatory measures have been and are being implemented at SU NPP:

- compensatory payments for occupied acres;
- payments by standards of limits for the use of natural resources, releases and discharges, waste disposition.

The above payments are forwarded to implement, on the regional level, measures to compensate for environmental damages caused by economic activity.

Measures of social and economic compensation for public risk are financed by the Special Ukraine National Fund. NNEGC "Energoatom" pays levies for social and economic compensation for risks in the amount of 1% of sales volume of the electricity generated by the nuclear power plant. These finances are transferred to local budgets of 30-km surveillance populated areas and allocated in the following ratio:

- region's budget - 30%;
- district budget – 55%;
- Yuzhnoukrainsk town budget – 15%.

Finances are allocated considering the share of population within the surveillance area, and they are used under the procedure established by the CMU. Every three months regional, district and town councils report on use of funds through reports published in local authorities periodicals.

Radwaste management fund

The State Radwaste Management Fund is an integral part of the Ukraine State Fund, and it is formed from finances of emission charges collected for radwastes generation and temporary wastes storage by their generators according to Ukraine Law No.515-VI "On Amendments of Some Laws of Ukraine in the Field of Radioactive Waste Management" dated September 17, 2008. The key Fund owner is the State Agency of Ukraine on the Exclusion Zone Management whose activity is directed and coordinated by the CMU through a Minister for Environment and Natural Resources of Ukraine.

Radwastes generators pay *Eco Tax* - a fine for harming the environment in terms of radwastes generation including existing and newly built radwastes and their temporary storage. An operating organization (operator) pays a tax which is to be proportional to the generated electricity indictors and already built radwastes volumes and activity. Eco Tax is calculated by the NPP Operators every three months based on: generated electricity indicators considering the tax rate per 1 kW h of the electricity generated and proportionally to the volume and activity of radwastes generated over three months and actual volume of built radwastes. The key payer of finances to the Fund is "Energoatom".

Since May, 2009 NNEGC "Energoatom" has been paying charges to the Radwaste Fund for environment pollution caused by radwastes generation including existing radwastes. At the same time, actual transfer of radwastes to specialized facility "Ukrainian State Association "Radon" for long-term storage and disposal is not performed due to the storage Operator unavailability to accept them.

7.5 Measures related to radiation and environmental safety

The issue of radiation and environmental safety is a priority aspect of the plant's activity.

Protection measures include: a well-defined buffer area and surveillance area; an integrated (environmental and radiation) monitoring system.

The size of buffer and surveillance areas and location of radiation monitoring stations – fixed monitoring stations – were defined on the SU NPP design phase (fig. 7.1).

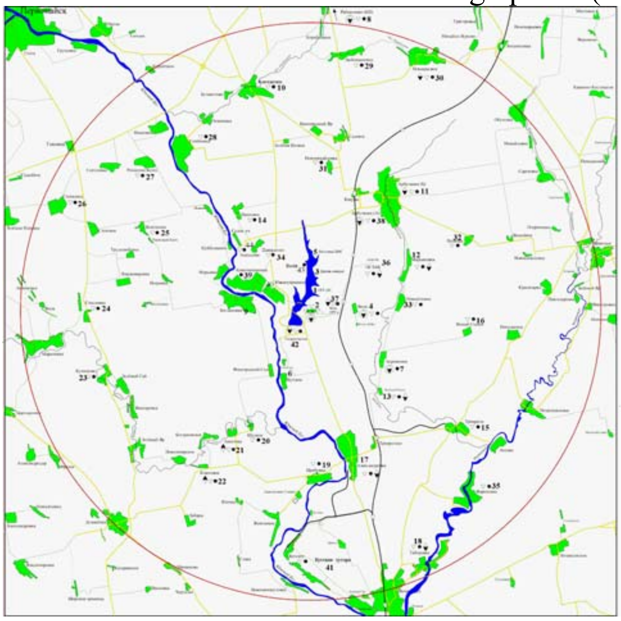


Fig. 7.1. – Plan of radiation monitoring stations in the plant's surveillance area

Radiation monitoring at SU NPP is performed by a special division – Radiation Protection Department.

Radiological situation in the SU NPP site, buffer area and surveillance area is monitored using a continuous and periodic radiation monitoring system. All types of radiation control at SU NPP is conducted according to the "Radiation Control Regulations for SU NPP" RG.0.0026.0120.

Environmental radiation monitoring within the SU NPP surveillance area and buffer area include the following control:

- rate of exposure dose and radiation dose;
- radioactive substances spreading into atmospheric air, precipitation, soil, water, bottom sediments, upland and aquatic vegetation;
- radioactive contamination of releases and discharges;
- activity and radionuclide composition of radioactive substances leakages from storage facility for solid radioactive waste and liquid radioactive waste.

Constant monitoring is conducted at the network of stationary surveillance points located in the radiation control area around SU NPP.

Periodic monitoring is conducted at the stationary surveillance station and at the checkpoints intended for sampling with further analysis in laboratory and measurement of:

- radiation condition of surface ponds (total beta-activity and radionuclide composition of water, bottom sediment, aquatic vegetation) - 3 surveillance stations (Southern Buh river – Olexandrivka settlement, Buzke settlement, Tashlyk storage pond);
- total activity of ground water of SU NPP site (quarterly);
- radionuclide composition of soil and vegetation.

At SU NPP buffer area and radiation control area they put into commercial and research operation the automated radiation situation monitoring system (ASKRO) to constantly control the radiation situation and meteorological indicators on-site. The purpose of ASKRO functioning is assessment and radiation situation prediction during NPP normal operation, design-basis accidents, beyound design-basis accidents as well as in case of NPP decommissioning.

Environmental monitoring at SU NPP is conducted by Environmental protection department that is a part of Internal Supervision Department. The department activity provides constant and periodic monitoring within the framework of buffer area and radiation control area:

- content of harmful chemical substances in the surface water, underground water, industrial water and sewage water;
- content of harmful chemical substances in atmospheric precipitations;
- content of chemical substances in the releases from plant sources.

Monitoring of atmospheric air contamination

SU NPP releases of pollutants into atmospheric air is based on the “Permit for pollutants’ releases into the atmospheric air by SU NPP stationary sources”. Environmental protection department constantly carries out instrument inspection of pollutants’ releases into atmospheric air according to the standards “Volume of instrument inspection for sources of stationary releases of pollutants into atmospheric air” and keeps initial reporting documentation.

According to the “Report on inventory of sources of pollutant releases into the atmospheric air” the SU NPP releases into the atmospheric air pollutant from 189 releases sources, 31 among them are fugitive emmisions. 24 pollutants’ emission sources are equipped with gas purification plants. Their average efficiency is 90%.

There are 341 mobile emission sources of the atmospheric air: 203 carburettor based and 138 diesel based.

Water bodies monitoring

Environmental protection department conducts control of water quality for Tashlyk cooling pond and Olexandrivka storage pond as well as blowdown water discharges. Blowdown water discharging to the Olexandrivka storage pond belongs to the category of normative clean water.

Water in the Southern Buh river has the following characteristics: average salinity, bicarbonate class water, calcium group, moderate hardness, average oxidation. As a rule there is an excessive content of phosphates and indicator of chemical oxygen demand is out of the range according to requirements for maximum permissible concentration for fishery ponds.

Tashlyk water storage pond is of high salinity, hard water, belongs to sulfate class, sodium group.

Chemical researches are carried out according to the standard “Amount of chemical inspection of surface water ” near the gates of:

- dam;
- low-level water intake;
- discharge canals;
- mixing zone of cooling pond water with water of the 3rd maturation pond relating to the sewage treatment plants of the industrial storm sewage;
- upper part of storage pond.

Thermal control of water quality for Tashlyk cooling pond is conducted quarterly on 24 thermal diagrams.

Results of environmental and radiation monitoring are given in the annual reports that have been issued starting from SU NPP commissioning. Data on radiation safety and antirad protection are published in “Report on radiation protection at the enterprise” and the results of non-radiation impact monitoring are published in “Report on assessment of non-radiation factors’ impact”.

7.6 Radioactive waste handling

At all the subdivisions of NNEGC “Energoatom” the radioactive waste handling is realized according to the following documents:

- Ukrainian Law “On radioactive waste handling”;
- Updated energy strategy of Ukraine for the period to 2030;
- Strategy of radioactive waste handling in Ukraine;
- State environmental special-purpose programme on radioactive waste handling;

- “Comprehensive program on order handling for 2015-2016. SE “NNEGC ‘Energoatom’”.

Management of liquid and solid radioactive waste at SU NPP includes:
- waste collecting;
- pretreatment;
- processing and temporary storage at the design storage facility.

Actual status of radioactive waste handling at the Ukrainian NPPs is related with the lack of closed nuclear fuel cycle starting with reprocessing to the end product that will be applicable for the further long-term storage or disposal.

Liquid and solid radioactive waste generating in the course of NPP operation are reprocessing at the existing facilities and are storaged at the special storages for liquid and solid radioactive waste.

At the present time storages’ Operator is State specialized enterprise “Central enterprise on radioactive waste handling” of the State agency on exclusion zone management. This Operator isn’t ready to receive radioactive waste for long-term storage or disposal.

At NPP the liquid radioactive waste storage is ensured by the system of liquid radioactive waste storages. Liquid radioactive waste is stored at metal sealed tanks made of resistant to corrosion steel and equipped with automated system for detection of liquid radioactive waste and alarming in case of leakages. To prevent an emergency leakage of liquid radioactive waste into environment all the tanks are located in concrete premises lined with sheets of resistant to corrosion steel to the height of emergency outflow of tanks.

At SU NPP generated liquid radioactive waste and residuum decantate from tanks of liquid radioactive waste storages are re-evaporated at evaporating devices and are returned to the residuum tanks as product with high concentration of salts. At the present time at SU NPP there are no aciliteis for deep reprocessing of liquid radioactive waste. Topical issue is implementation of technology for residuum reprocessing with elimination of salt melt.

Used filtering material and sludge are selecting and storaged in the tanks for liquid radioactive waste storage under water layer. Filtering materials are not reprocessing.

At SU NPP the used contaminated oil is not reprocessed it is accumulated.

Solid radioactive waste is accumulated in the places of their generation and is classified based on the categories (emission power of gamma radiation) after this it is transported to the solid radioactive waste storage for temporary storage. Before the temporary storage the low-level solid radioactive waste is prepressed.

Solid radioactive waste storage is composed of reinforced concrete constructions made of separate sections for solid radioactive waste location based on the activity group. Sections are equipped with fire alarm system, automatic firefighting system, exhaust ventilation with air cleaning. Certain sections have additional system of moisture detection and extraction.

Further *strategy for radioactive waste (RAW) handling* is based on the following main principles:
- adequate safety level assurance at all stages of RAW handling;
- RAW generation minimizing;
- selection of optimum RAW processing technologies;
- arrangement of RAW processing and temporary storage under the power units lifetime extension;
- RAW final disposal.

Engineering policy in the area of RAW handling shall provide:
- reduction of temporary stored RAW volume;
- interim storage clean up by means of solid radioactive waste processing and liquid radioactive waste conditioning;

- radioactive waste transporting to the specialized plant for long-term storage or final disposal.

NPP design did not envisage equipment for radioactive waste processing and transporting to be disposed. RAW management system improvement shall ensure waste processing until it is acceptable for transporting to the specialized plant to be stored in central storage with subsequent disposal.

Comprehensive radioactive waste management program was established instead of "Nationwide purpose-oriented environmental program regarding radioactive waste management" within which the "SE NNEGC "Energoatom" program regarding radioactive waste management at the "Operations" stage" was fulfilled. The implementation of the Comprehensive program was planned until 2016; the implementation started in October 2012.

The implementation of the Comprehensive program provides for:

- improvement of engineering policy in the area of RAW management;
- improvement of manageability and operation control level when fulfilling planned measures;
- providing adequate financing for planned measures to be fulfilled;
- improvement of operational availability and safety level;

The implementation of the Comprehensive program at SUNPP and other subdivisions of SE NNEGC "Energoatom" is provided by fulfillment of the following principal planned objectives:

- coordination of requirements imposed to the processing end-product containing acceptance criteria for disposal;
- construction and commissioning of the complexes for RAW processing generated during power units operation and RAW earlier accumulated in the plant storages;
- construction of light storages to keep conditioned radioactive waste in the protective containers at NPP sites;
- implementation of the complex technology of liquid radioactive waste (LRAW) processing without salt-melt generating to get a product acceptable for disposal;
- modernization of the existing at the plants decontamination sections by providing advanced equipment including ultrasonic and electrochemical decontamination;
- NPP supply with containers for RAW controlled temporary storage and transportation to specialized plant;
- development of unified database on RAW management and its implementation in the NNEGC "Energoatom" subdivisions;
- improvement of regulatory and procedural basis in the RAW handling area;
- assurance of adequate financing of the measures related to RAW handling.

Organizational and administrative measures as well as technical measures related to RAW management system modernization have been planned and are under implementation now at SUNPP.

Main organizational and administrative measures are as follows:

- improvement of work planning (rating of RAW generation) in the "controlled access" area;
- improvement of personnel's qualification regarding minimization of RAW generation and RAW handling issues;
- establishment and review of solid radioactive waste (SRAW) and LRAW generation/input control levels and their generation rate;
- development of the personnel material encouragement system when minimizing RAW generation volume.

Main technical measures:

- modernization of RAW storage systems and equipment;
- improvement of RAW processing facilities operating modes;
- modernization of ways of RAW accumulation, transportation and storage;

- construction and commissioning of RAW handling complexes;
- improvement of RAW administration system;
- improvement of work planning, RAW generating/input rating in the departments (establishment of RAW input limits);
- application of protective coverings for equipment and premises surfaces;
- decontamination of the materials and their reuse;
- implementation of modern decontaminating technologies and reduction of premises, equipment and individual protection equipment decontamination cycles number;
- separation of waste stream into conventionally "clean" and contaminated to avoid waste mixing at an early stage;
- equipment lifetime extension;
- following the liquid utilization rate to determine liquid radioactive waste generation sources;
- analysis of sources and quantity of RAW generation under normal reactor operation and during outage;
- development and implementation of measures aimed at RAW minimization based on the results of performed analysis of sources and RAW generation during operation;
- implementation of technology and equipment for spent filter medium and sludge withdrawal from liquid radioactive waste storage containers;
- selection and implementation of liquid radioactive waste processing technologies without salt-melt generation;
- selection of technology to process salt-melt in order to assure processed products compliance with acceptance criteria for disposal;
- selection of spent filter medium and sludge processing technology;
- supply of containers for RAW handling at all stages, implementation of single container type.

Future development of liquid radioactive waste handling system at SUNPP

The following measures to reduce liquid radioactive waste generation are considered to be the most efficient:

- elimination of spent fuel pool leakage;
- change of special water purification installation filters regeneration mode;
- separation of liquid radioactive medium streams;
- implementation of advanced technologies of equipment, premises and personnel individual protection equipment decontamination;
- administration of flow drains input from NPP departments etc.

Te main issue related to modernization of liquid radioactive waste handling system at SUNPP is to establish liquid radioactive waste processing system.

SUNPP has no liquid radioactive waste conditioning systems with salt-melt generation. The current optimum solution is the implementation of direct solidification of evaporator sludge by means of cementation which would allow to make the LRAW handling issue not so crucial. For this purpose the equipment of LRAW processing system is implemented on the basis of deep evaporation installation and system of solid deposits and sludge withdrawal from the LRAW storage tanks.

Future development of solid radioactive waste handling system at SUNPP

The main objective of solid radioactive waste handling system modernization at SUNPP is to establish the complex for waste processing.

Schedule for core measures regarding solid radioactive waste processing complex establishment has been developed and approved; according to the schedule the implementation of the complex is planned on 2018.

Within the frame of solid radioactive waste processing complex establishment (consisting of withdrawal, segregation with pre-pressing, super-pressing, internal transport, conditioning installations) the design and engineering documentation has been developed and received State expert appraisal.

The work has started regarding implementation of the system of solid radioactive waste withdrawal from the storages.

In order to improve storage system the Comprehensive program envisages the construction of light storage to keep reinforced concrete containers with radioactive wastes. The period of action implementation regarding storage construction is 2017.

To reduce the volume of radioactive waste at SUNPP the Comprehensive program plans to improve the decontamination section by the implementation of contaminated materials ultrasonic decontamination technology.

The following measures aimed at reduction of solid radioactive waste generation are planned and being implemented:

- improvement of work planning in the controlled access area (restriction to bring packing materials, to use metal scaffold instead of wooden one, to separately collect clean and contaminated turnings in the turning shops in the controlled access area);
- decontamination and reuse of contaminated equipment, materials etc.

High radiation waste handling

Spent fuel from VVER-1000 reactors are transported for temporary storage and subsequent processing to Federal State Unitary Enterprise "Mining and Chemical Plant" (Krasnoyarsk, RF). Spent fuel processing products return to Ukraine may start in 2020.

The process of preparation and approval of necessary output data on VVER-100 spent fuel processing products subject to be returned to Ukraine is ongoing now. There is a vital necessity to take deliberate decisions regarding these types of radioactive waste integration into general radioactive waste handling system adopted on the Complex "Vektor" site.

7.7 Environment protection activity management at SUNPP

The certification audit of Quality Management System was carried out at SUNPP in 2006 after which the ISO 9001:2001 certificate was received.

In 2009 SUNPP Quality Management System was recertified for compliance with the requirements stated in ISO 9001:2008.

In 2012 within the plant environmental audit SUNPP published the statements regarding principles of safety and environmental policy: "SUNPP management statement regarding safety policy" and "SUNPP management statement regarding environmental policy".

Main tasks and principles of environmental safety assurance were stated, in particular:

- fulfillment of environment protection legislation requirements;
- work planning regarding environmental protection;
- environmental support of NPP power units and HP and PSP hydraulic units operation;
- implementation of environmental management system;
- complete stocktaking and continuous monitoring of all the environment effecting factors;
- personnel environmental training level improvement;
- informing of the public, interaction between state authorities and non-government organizations.

Preparation for certification in the system of the enterprise environmental management ДСТУ ISO 14001-2006 (DSTU ISO 14001-2006) "Environmental management systems. Requirements with guidance to use." is defined as an immediate objective.

Coordination of work regarding environment protection activity in SE NNEGC "Energoatom" is carried out according to the "Program of SE NNEGC "Energoatom" environment protection activity". In order to implement this Program SUNPP developed "Measures for implementation of the "Program of SE NNEGC "Energoatom" environment protection activity”.

Besides, the measures regarding environmental safety, environmental protection and efficient use of nature resources are included in “Annual comprehensive plans of organizational and technical measures at SUNPP ”.

The development and implementation of measures aimed at fulfillment of the legislation requirements regarding regulations and rules observation in the area of environmental protection, efficient use of nature resources, non-radioactive waste handling etc. is carried out by the Environmental protection department of SUNPP Internal Supervision Service.

7.8 Residual impacts

Residual radioactive impact

As to the radiation safety reports and environmental audit results the main radiological impact on the population within the surveillance area during NPP normal operation is mainly caused by the effects of naturally radioactive nuclides ^{40}K, ^{238}U, and ^{232}Th and their decay products.

Among man-made radionuclides the potential impact sources are ^{90}Sr and ^{137}Cs of the global fallout, in particular of Chernobyl nature.

The role of SUNPP accidental releases (^{90}Sr та ^{137}Cs and other radioactive nuclides containing in the NPP releases) is relatively insignificant. Maximum effective dose for the population within 30 kilometer area is estimated in the Comprehensive (Integrated) Safety Upgrade Program to be within 5.77 mSv/year that does not exceed 15% of boundary parameter level (40 mSv/year) specified in Radiation Safety Standard of Ukraine.

Residual chemical impact

SUNPP environmental reports state that during the period of observation water quality in the Southern Buh river in the upstream and downstream gates meets the effective requirements to ponds used for fishery, in particular in the location of Tashlyk water storage pond outlet gate.

Difference of water quality in the controlled gates is estimated to be non-significant thus confirming the absence of noticeable residual chemical impact on the water resources quality.

Stationary and mobile sources available at SUNPP site annually release approximately 6 ton of pollutants into the atmosphere. Release volumes do not exceed the established limits and concentrations of pollutants in the aboveground atmosphere in the settlements within SUNPP surveillance area due to release emission and are within effective sanitary norms.

Residual thermal impact

Residual thermal impact is the most significant factor of environmental pollution during SUNPP normal operation. Heat removal parameters are about $17,4\times10^6$ W. In case of emergency core cooling the parameters rise up to 64.0×10^6 W during first three hours, and then go down to 17.4×10^6 W.

Water temperature rise is observed on the surface of Tashlyk water storage pond with the area of 1.2 km^2. In winter the constant water temperature in the cooling pond is approximately 5 to 9ºC. The temperature difference of Tashlyk water storage pond and the Southern Buh river results in surface water evaporating and creating of fogs.

CONCLUSIONS
on the possibility to further operate DS “South-Ukraine NPP” power units

Non-technical summery regarding safety justification for DS “South-Ukraine NPP” power units operational lifetime extension over the designed lifetime period has been prepared based on data analysis of periodic reports drawn up by SE NNEGC "Energoatom" and SUNPP supervision services, scientific and technical reports provided by external agencies and organizations which performed environmental research during different years, years-long monitoring study materials, archive materials etc.

The main conclusions of this analysis are as follows:

1. The construction of SUNPP power units resulted in nonreversible change of the local landscapes, reliefs, surface and underground waters, ground covering and vegetation etc. During the NPP operation period the environmental changes has been connected with the construction completion, commissioning and development of Tashlyk PSP and Oleksandrivka water storage pond. Other additional nonreversible changes haven't been observed.
2. The current state of environment in terms of climate, adjacent landscape, flora and fauna, geological environment does not differ fundamentally from the situation at the beginning of the power units construction. No complementary to the existing nonreversible environmental changes related to planned activities aimed at SUNPP power units lifetime extension implementation are expected.
3. In case of refusal to implement the planned activity the significant nonreversible environmental changes can be expected to happen as a result of necessary power units decommissioning; character and scope of these changes will be estimated using the chosen strategy for isolation or elimination of the infrastructure developed at SUNPP site.
4. Currently it is defined that general environmental components state within SUNPP surveillance area is considered stable. Abnormal effects from power units operation processes and related infrastructure are not observed. Evaluation of some environmental components state has shown the following:
   4.1. *Microclimate* – at the current study level it is impossible to define and distinguish microclimate condition changes that could be related to the impact of SUNPP from the global climatic trend. The consequences of heavy evaporation and thermal impact are leveled by convective atmospheric overturn.
   4.2. *Atmospheric air* – the impacts occur in a form of thermal, chemical and radiological contamination, water steam generation etc. According to any controlled ingredient data the levels of atmosphere pollution beyond the buffer area do not exceed the approved national and international sanitary, environmental and radiological limits.
   4.3. *Geological environment* – earlier observed and existing now impacts are connected with exogenous geological process occurring in the area affected by Tashlyk and Oleksandrivka water storage ponds which are partially activated when rising ponds level. It is expected that the specified processes will gradually achieve dynamic balance features and their negative impact on the pond state and PSP and HPP pumps and hydraulic units operation will not be of major significance. Neotectonic, geodynamic and seismic impacts do not cause any problems for SUNPP operation.
   4.4. *Aquatic environment* – experiences constant thermal, chemical and radiological impacts the levels of which according to any controlled ingredient data do not exceed the approved national and international sanitary, environmental and radiological limits. Changes of flow conditions and surface and ground water level modes related to South-Ukraine power complex facilities operation do not cause difficulties which require intervention.
   4.5. *Soils* – levels of chemical and radiological contamination of soils does not exceed boundary values established by national and international standards. Planned activity does not envisage additional soil withdrawal; any impacts on area agroecological characteristics are not expected.
   4.6. *Flora and fauna, objects and territories of nature reserve fund* – the territory where South-Ukraine power complex is located and adjacent to it territories have unique floristic and landscape features that preconditioned the creation of National

nature park “Buzkyi Gard”. The impact on flora and fauna related to PSP, Oleksandrivka water storage pond, HPP, and Tashlyk water storage pond operation is currently stabilized. Additional impacts after the extension of SUNPP operational lifetime are expected to be non-significant.

5. During the SUNPP operation period no cases of noticeable radiological impact on the environment related to plant operation have been registered. Observed in 1986…1992 abnormal on the general background radiological parameters were the consequences of fallouts transmitted by air from Chornobyl area. Personnel and population radiation dose is significantly below the levels permitted by the effective regulations. Levels of gamma dose exposure do not differ from the natural background. Soil radiological contamination is caused by natural radionucledes, primarily by radiopotassium; the contamination of water bodies, precipitation, vegetation and other environmental components does not show any NPP releases impacts which levels would require a response.

6. Non-radiological impact factors – chemical and physical (thermal) pollution, non-significant according to the scale and consequences for the environment and population, are within the approved limits, do not exceed effective permitted boundary sanitary and ecological levels, almost unperceivable within the established plant buffer area, do not lead to consequences requiring additional intervention.

7. Possible consequences from the potential different type design and beyond design basis accidents, modeling of number of cases regarding the assessment of accidental release impacts on the environment and population; it is demonstrated that under any accident scenario beyond buffer area the effective regulations will not be violated. In case of SUNPP power units lifetime extension the transboundary impacts potentially requiring a response are excluded.

8. DS SUNPP carries out a policy regarding environmental processes control and management which in the first instance involves the implementation of the comprehensive radioecological monitoring system of all the effecting factors, sources and objects occurring as a result of power units and other facilities of South-Ukraine power complex operation. Besides, protective, recovering, compensatory measures aimed at environmental impacts mitigation, resources and energy saving are planned and implemented at the plant, waste management system is in place. Further handling of liquid and solid radioactive waste as well as spent fuel requires centralized solutions of the appropriate level and depends on strategic state policy regarding this issue. Currently SUNPP has reserves to continue running the existing waste management system.

9. SUNPP management pays adequate attention to the issues regarding population informing and carrying out the periodic measures to provide advisory work with interested people.

10. Planned activity – SUNPP power units lifetime extension – is not connected with new construction, restructuring, process line changing, main equipment replacement etc. It is planned to replace particular auxiliary exhausted or outmoded mechanisms and their parts with new ones (analogue or more advanced) that assures improvement of performance reliability and safety levels of these mechanisms and the whole plant. It allows to state that planned activity will not result in adverse effects to the environment and will positively effect social and economic areas at the state level and will be ecologically acceptable.

11. This analysis shows that currently no reasons to be concerned about possible SUNPP negative impact on the neighboring countries in case of any accident scenario, as well as assumptions for such concern in future can be identified.

In general, planned activity regarding SUNPP power units lifetime extension is ecologically, economically and socially approved and in future will not cause negative impact on the environment and the population of Ukraine and other countries which can be estimated as non-acceptable. It is planned to implement a preparatory measures

package regarding power units safety improvement involving environmental mitigating measures, it will also reduce the existing levels of environmental impacts.