COMMISSION
FOR EVALUATION OF THE IMPACT OF TEMELIN NUCLEAR POWER PLANT
ON THE ENVIRONMENT

ASSESSMENT

OF IMPACTS OF TEMELIN NUCLEAR POWER PLANT
ON THE ENVIROMENT, SUBMITTED IN CONNECTION
WITH THE VOLUNTARY AND ABOVE-STANDARD PROCEDURE
ACCORDING TO PART V OF THE MELK PROTOCOL

DOCUMENTATION FOR PUBLIC ASSESSMENT AND USE BY AFFECTED AUTHORITIES PURSUANT TO ARTICLE 6 OF THE EUROPEAN COMMISSION DIRECTIVE NO. 97/11/EC

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Other documentation:
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The submitted material comes from the Protocol from the meeting between the Czech and Austrian government with the attendance of the Prime Minister Miloš Zeman and the Federal Chancellor Wolfgang Schüssel and Commissioner Günter Verheugen on 12.12.2000 in Melk. By political agreement the Czech government agreed to above-standard and voluntary "Assessment of the impact of the Temelín nuclear power plant on the environment" (hereinafter "Assessment").

Institutional and methodical assurance of work on the Assessment comes from the Czech government decree from 17.1.2001 No. 65. This government decree was used to establish the "Commission for assessment of the impact of Temelín nuclear power plant" (hereinafter "Commission") and appointing 4 members of the Commission, who are authorised persons for assessing impacts on the environment pursuant to valid Czech legal amendments (CNC Act No.244/1992 Coll., regulation of the Ministry of the Environment No. 499/92 Coll.) or legal experts for this action pursuant to Act No. 36/1967 Coll. The European Commission nominated its two expert consultants to this Commission. At the same time two observers from Austria and two observers (without political mandate of the government) from Germany were appointed to this Commission by relevant authorities of their countries.

The background materials for the above-mentioned Assessment was prepared by the construction investor in the structure corresponding to valid Czech law about assessment of impacts on the environment (244/1992 Coll.). A previously carried out expert assessment was also considered. The submitted assessment was processed pursuant to relevant points of the Council Directive 97/11/EC as it is stated in part V of the Protocol. The outline of the scope and content of the Assessment comes from Appendix No IV of the mentioned Directive. It respects the version of the Directive for assessing nuclear installations given by Euroatom and takes the demands of the Austrian and German sides into consideration. On the basis of negotiation of the content and scope of the Assessment by members of the Commission and foreign observers defined altogether 7 areas of assessment, which included 220 items significant from the point of view evaluation of the impact of the stated construction and technology on the environment.

The European and Czech legal form assume assessment of the impacts of the construction and technology on the environment in the stage of plannning or design. In the case of assessment of Temelín NPP it was however necessary to take into consideration that the construction is already almost complete and technology has been already verified in trial operation. From the stated reasons it is not possible to make a full-scale assessment of impacts on the environment that occurred during construction of the power plant. Alternatives of the solution are considered pursuant to article 5 of the Council Directive No. 97/11/EC, and particularly in relation to recent concepts (prepared for a Czech government discussion) and to conceptual material discussed by the Czech government.

The problem of so-called severe accidents was included, after agreement with the Austrian side, for a discussion at a separate expert forum, outside the activity of the Commission. So-called serious accidents, in essence, lie outside the process of assessment of impacts on the environment pursuant to European and Czech law – assessment of the impact on the environment is possible for aspects contained in the assessed design plan. The so-called severe (beyond design basis) accidents are not – and in principle cannot be – the subject of the design. In the above-mentioned expert forum this area has been discussed by relevant specialists of all interested parties with regards to methodology, resulting assessment and related measures as a new tool for strengthening of defence in depth safety measures of nuclear power plants, and in the time frame given by the protocol from Melk and according to a common declaration by Ministers J. Kavan and W. Molterer from 12.2.2001 on the bilateral and multilateral level (MAAE, NEA/OECD).

1. Basic information about the Temelín NPP

1.1

1.1.1.

Applicant

CEZ, a. s.

1.1.2

Developer

Energoprojekt Praha., a. s.

1.1.3

Operator

CEZ, a. s.

1.2. The outline of alternative solutions which the applicant took into consideration and the statement of the main reasons of his choice with respect to the environmental impact

A decision concerning nuclear power and the use of the energy of the nuclear fission for the production of electricity as a basic direction of the further development was made by the government of the former CSSR in the 70s on the basis of an analysis of the access to the primary sources of energy and environmental impact of the individual technologies. In accordance with this state policy, the construction of the nuclear power plants Jaslovské Bohunice, Dukovany, Mochovce and Temelín was gradually launched and implemented.

While choosing the site for the Temelín Nuclear power plant in the second half of the 70s in the south of Bohemia, the following factors were taken into consideration:

- High concentration of the coal power plants in the north of Bohemia and necessity of their gradual replacement
- Need for a power facility in the south of Bohemia
- Small industrialisation in this region and sufficiency of labour force
- Availability of cooling water from the river Vltava

The choice of the sites was carried out by the Czech specialised organisations for territorial planning. The choice of the sites in the south of Bohemia was carried out in accordance with the Decree of the Czechoslovakian Commission for Atomic Energy No. 4/1979 concerning the siting of nuclear facilities as regards the nuclear safety which contains more than 30 selection criteria. Out of the original approx. 10 localities, in 1980 the site near the village of Temelín was finally recommended in 1980. The Czechoslovakian Commission for Atomic Energy – the body of the government supervision - on the basis of the Act No. 28/1984 Coll. concerning the state supervision over the nuclear safety of nuclear facilities gave a consent with the site and set a protection zone of the Temelín Nuclear power plant by the decisions No. 25/1985 from 14/03/1985, No. 36/1985 from 04/05/1985. On the basis of the same law, the Czechoslovakian Commission for Atomic Energy gave a consent with the issue of the construction permit for the 1st and 2nd units of the Temelín Nuclear power plant by the decisions No. 115/1986 from 31/10/1986 and No. 78/1987 from 28/05/1987. An integral part of the assessment, in accordance with Construction Act No. 50/1976 Coll., was consideration of the nuclear power plant environmental impacts. To this effect about 40 expert and scientific studies were drawn up by renowned workplaces and research institutes of the state, which stated insignificant impact of the construction on the environment.

The approving and licensing process for nuclear facilities was legally embedded in our legislation already in 1976 in the Construction Act No. 50/1976 Coll. (§ 126) and in its executive ordinance No. 85/1976 (§ 5, 7, 20, 39). Consecutively the licensing process was transferred to the Act No. 28/1984 Coll. concerning the state supervision over nuclear safety of nuclear facilities which was replaced in 1997 by the current complex Act No. 18/1997 Coll. concerning the peaceful use of nuclear energy and ionising radiation. In all above-mentioned legal acts, the licensing process is defined as a three-stage one: the decision concerning the siting, construction permit and operational license. Apart from this there are many other partial approvals, especially between the second and third stage for the period of commissioning.

For each of the main stages the necessary safety documentation is prepared:

- Siting safety report (locality)
- Preliminary safety report (construction)
- Pre-operational safety report (operation)

On the basis of the reassessment of the decrease of the electricity consumption, the government of the Czech Republic decided by its resolution No. 109 from 1993 for the construction of only two units of the Temelín Nuclear power plant instead of originally considered four units.

In the following period in the years 1996-1998, a proposal of the state Energy policy was processed on the basis of several conceptual materials, which was, according to Act No. 244/1992, liable to the public process of assessment of the impacts on the environment (so-called Strategic Environmental Assessment). During the course of discussions 2 alternatives resulting directly from the assessed energy policy were formed and a third came about at the urge of participants in the process of public hearings. Evaluated variants of the Czech energetic concept were:

Variant A

The development of the energy sector is based especially on domestic fossil sources of the Czech Republic – coal and lignite. Neither development plan and environmental limits of mining are applied nor the economic charge of the energy processes is increasing due to the environmental impacts. The consumption of primary energy sources is slightly increasing, the increase of the electricity consumption is higher than the increase of the consumption of the primary power sources. Both units of Temelín will be gradually commissioned in the period to the year 2002.

Variant B

The energy sector is based especially on fossil resources but the domestic mining is tied by development plan and environmental mining limits. The substitute are the imported fuels and energies, especially natural gas and oil. Compared to variant A, the energy savings are used more and the share of renewable sources is also increased. The increase of the consumption of the imported natural gas is also influenced by the higher use of small co-generation units. The consumption of the primary power sources will not deflect considerably from the contemporary level of consumption, the electricity consumption might see even a slight increase. Both units of the Temelín NPP will be launched into full operation before 2005.

Variant C

Energy savings (or rather higher efficiency in the use of energy) and renewable sources have the fastest increases. The increase of efficiency and savings are supported both by the stimulation of enterprise in the energy savings and purposeful state activities (large savings in own facilities and expansion of state support programs) with the aim to reach an absolute decrease of the consumption of primary energy resources by up to 1.5 % a year, i.e. by 16 % until the year 2010. The consumption of electricity will not increase. The use of renewable sources will be increased especially in biomass (maximum by 90 PJ), small water sources (maximum by 4 PJ), wind power (up to 5 PJ), solar collectors (up to 3 PJ). Environmental externalities are gradually included in the prices. High prices of energy will contribute to faster increase in the use of co-generation (up to 1500 MWe of new sources). Domestic coal mining will be long-term limited by development plan and environmental limits. The variant counted on not commissioning the Temelín Nuclear power plant.

Common requirements for the three mentioned variants:

- The increase of GDP is expected in the extent of 2 to 4 % a year
- Power demand of the economy expressed by the proportion share of the primary energy sources / GDP constantly decreases.
- All international obligations are met including the obligations accepted within the Convention concerning the change of climate in Kyoto in December 1997
- The variants are in agreement with the legislation of European Community

Calculations showed that all three alternatives are realistic, nevertheless they differ in the level of risk, which is connected with its implementation and also in the costs on necessary technology. The highest risk is connected with implementation of variant C owing to non-traditional and so far non-verified procedures, which would need to be used for fundamental turnover in the energy strategy. Also this variant showed the highest costs, because variants A and B use to a large extent existing energetic facilities and also the almost built Temelín Nuclear power plant, whereas variant C fiercely invests into renewable energy resources and savings.

All three variants went through the process of assessment of impacts on the environment assessed according to almost 30 criteria, which were selected in the public process of scoping. Results of environmental impact assessment were the most favourable for variant C and the worst for the conservative coal variant A.

After elections which took place in the middle of 1998, however, the mentioned study was not, as a relevant conception material, negotiated in the government of the Czech Republic.

The new government prepared a new version of the Energy policy, which in its main principles corresponded to variant B from the above assessment. Within the scope of this variant the next step towards completing Temelín Nuclear power plant is envisaged. The government approached the probing of the situation around Temelín Nuclear power plant very responsibly and had an independent assessment of the design of its completion done by an international expert team. The expert team did not find any serious doubts in relation to the environment and repeated in this field known problems, such as the problem of a permanent spent fuel repository and associated risks. In the concluding summary of the expert report, which the government did not discuss in 1999, the following is stated:

- *"On the assumption that new capacity of the nuclear power plant will be used without surplus, which means that the sale of electricity will not restrict production in other CEZ resources, it is possible, with expected costs of completion, to consider completion of the Temelín Nuclear power plant design as an economically suitable variant for the production of electricity for the band of basic load (i.e. not the full investment but only its completion).*

- *In the case that it is not possible to find an outlet for this electricity on the domestic or foreign market within several years the completion of the Temelín Nuclear power plant becomes uneconomical…"*

On the basis of this and other analysing conception materials of the Ministry of Industry and Trade and of the Ministry of Environment, the Czech government decided by its resolution No. 472 from 1999 about the final completion of the construction of the Temelín Nuclear power plant. Basic arguments for this decision were especially the following:

- The Czech Republic does not have important primary power sources which it could rely on in the long-term context.
- The completion of the construction of the Temelín Nuclear power plant is solely a business plan of the company CEZ and there are no financial risks arising from it for the state budget. The CEZ power plant company will be able to meet all financial obligations without a direct participation of the state.
- The subject of the decision process of the government of the Czech Republic is to gain the capacity of 1962 MW with the expenditure of 16.4 billion CZK, i.e. in the specific value 8.4 million CZK/MW.
- With the necessary revitalisation of industry the increase of the demand for electricity can expected until the year 2010. Any of the EC countries does not count on the stagnation or decrease of the demand for electricity with prospect to the year 2005. This expectation is confirmed by the development in 2000, which was characterised by the gradual reactivation of Czech industry and led to an increase of the consumption of electricity by 2 %.[1]
- In accordance with the evaluation of European Commission, the Temelín Nuclear power plant is an energy source, which does not emit any serious harmful substances to the atmosphere. As regards the release of radioactive substances, it is virtually negligible quantity. It does not produce any greenhouse gases and it does not use oxygen.

[1] Nevertheless fairly simple calculations coming from the current loading of the system show that for justification of the necessity of the Temelín Nuclear power plant for the Czech Republic before 2010 it would be necessary to achieve average growth of electricity consumption by at least 3 % annually this decade.

- Concurrent operation of the Nuclear power plants Temelín and Dukovany preserve, and for more rational use, more than one third of the existing reserve of lignite in the Czech Republic, prevent breaching development plan mining limits in northern Bohemia (according to the Czech government decree 331/1991, government decree No. 444/1991, government decree No. 490/1991) and reduces emissions of greenhouse gases by 17 %. With the expected international trade with emissions of greenhouse gases after the year 2002 the Czech Republic can gain an income by up to 13 billion CZK by the reduction of exhalations by approx. 17 mil. tons CO_2 . year $^{-1}$ (Synergy Programme, contract No. 4.1041/D/98-05). Any other way of producing electricity is burdened with higher environmental risks (agreement with the Academy of Sciences of the Czech Republic). This is stated about this fact:
  According to the conception material negotiated on 12/10/2000 in the Council of Economic and Social Agreement of the Czech Republic, by commissioning the Nuclear power plant in 2002 and with the gradual liberalisation of the market with electricity in the Czech Republic coal mining in the northern Bohemia will be decreased by 8 – 10 million tons, perspectively pursuant to fulfilment of the EU guideline 96/62/EC on assessing the quality of the atmosphere in areas with sensitive ecosystems. It counts in possible reduction of output of desulphured thermal power stations outside the basin area. The positive environmental aspect will result in the decrease of mining jobs by 3 500 to 6 000. The implementation of an industrial zone which takes into consideration a consequential launching of the construction of a motorway and a speedway in this region together with large repairs of pre-fabricated blocks, faster elimination of the consequences of mining activities and creation of new industrial activities will increase the demand for labour force by approx. 8 500 jobs.
- According to the statement of the State Office for Nuclear Safety from 22nd April 1999, no such facts are known that would represent from the point of view of nuclear safety a serious obstacle for granting the relevant permits of the State Office for Nuclear Safety necessary for commissioning the Temelín Nuclear power plant. At the same time continuous evaluations of the International Agency for Nuclear Power in Vienna are carried out, which were carried out within the mission Review of WWER – 1000 Safety Issues Resolution at Temelin Nuclear power plant.
- The risks of an accident in the Temelín Nuclear power plant are very low and they are on the level of 2.6×10^{-5}.reactor year^{-1} (the safety goal of the International Agency for Nuclear Power is the value of 10^{-4}.reactor year^{-1}, when it is not necessary to take any measures).
- The completion of the construction of he Temelín Nuclear power plant will have a considerable significance even for the revitalisation of the orders of Czech industrial engineering during the supplies of nuclear technologies abroad.

By another connected government resolution No. 50/2000 the Energy policy of the Czech Republic was approved, which states that the Temelín Nuclear power plant will be commissioned and further development of nuclear power energy in the CR will be assessed in the context of economic and ecological use of coal deposits and prognosis of the demand of the final energy consumption.

If in the case of Temelín Nuclear power plant 2 x 1000 MW being commissioned, shutdown of the corresponding power of coal resources really takes place, the following changes to impacts to the environment can be expected:

A. *Positive impacts*

- consumption of non-renewable natural sources (especially lignite and limestone for de-sulphuring technologies) falls
- production of ash falls,
- emissions of the greenhouse gas carbon dioxide fall
- emissions of SO_2 and NO_x and contamination of environmental components by heavy metals falls.

- *Consecutively the following will decrease:*
  - mining and transport of coal and limestone,
  - transport, modification and depositing of solid waste and land confiscation,
  - consumption of non-renewable energy sources needed for the above-mentioned activities and induced emissions of pollutants.

- It will also make it possible for the Czech Republic to meet the obligation to decrease the emissions of greenhouse gas carbon dioxide according to the agreement from Kyoto:

1. The considered annual operation of the Temelín Nuclear power plant prevents the release of around 14 million t . $year^{-1}$ of greenhouse gases to the atmosphere (approx. 12 % of its production in the CR in 1999). Nationwide the Czech nuclear power plants Dukovany and Temelín will reduce the emissions of CO_2 by about 27 Mt . $year^{-1}$, i.e. by 16 % of the nationwide production in 1999.
2. The Czech Republic will reach the standard of developed countries as regards the level of the specific emission of CO_2 per a unit of produced energy.

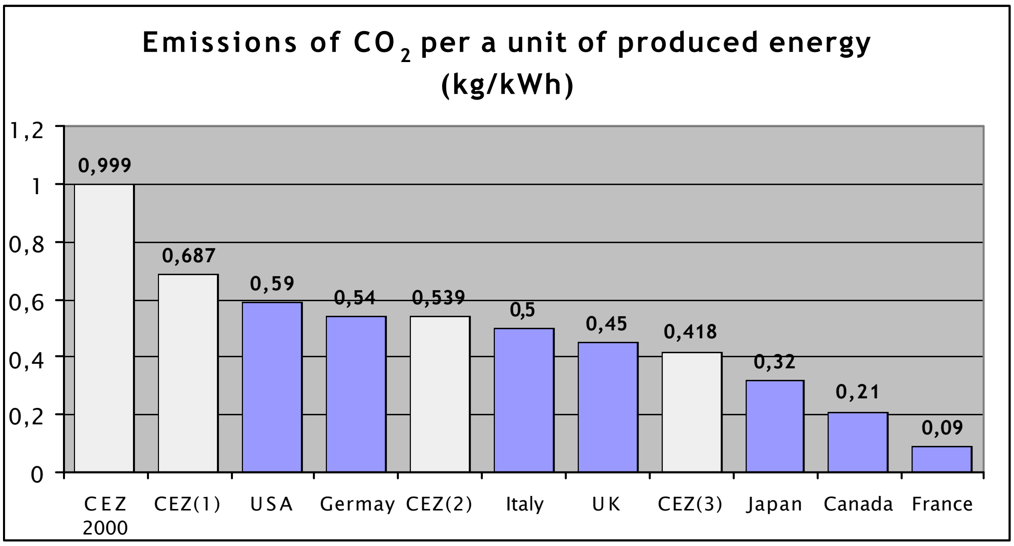
- Decrease of the emissions of main pollutants with the replacement of the electricity production in coal power plants after commissioning the Temelín Nuclear power plant are given in the following table:

Table No. 1: Reduction of the emissions after commissioning Temelín Nuclear power plant

	Reductions of emissions $t.year^{-1}$	% of emissions in the CR in 1999
SO_2	28,504	10.4
Solid substances	910	1.3
NO_x	24,500	15.6
CO_2	$14,000.10^3$	11.9

Source: Report concerning the environment in the CR in 1999, Ministry of the Environment CR, CEZ, a.s.
Note: nationwide emissions of NO_x include only stationary sources
Assumed use of Temelín Nuclear power plant is 7000 hours .$year^{-1}$

Graph No. 1



Source: Energy Balances of OECD Countries 1997 – 1998, Japan: survey by the Federation of Electric Power Companies; data for CEZ(1), CEZ2000: CEZ 2000; data CEZ(2)(3) – CEMC 2001 calculation
Explanations: CEZ 2000 – The emissions from coal power plants CEZ; CEZ(1) – average emissions from all the power plants of CEZ in 2000; CEZ(2) – average emissions of all the power plants of CEZ after the connection of Temelín Nuclear power plant; CEZ(3) – average emissions of all the power plants CEZ if replacement of the corresponding output of the coal power plants by the production of the Temelín Nuclear power plant took place.

B. Negative impacts

- Annual consumption of nuclear fuel in a volume of 40 – 50 t per year develops corresponding costs on treatment of nuclear waste and its long term storage.

Temelín Nuclear power plant went through a whole range of various evaluations and its fate was decided upon many times during its construction with full knowledge of documents available at that time. From the point of view of direct impacts on the environment it has not been so far shown that the Temelín Nuclear power plant would be worse in any direction than generally operated nuclear sources in European Union countries. The question however still remains of its economic effectiveness and often declared positive impacts on the environment. It shows that operation of Temelín Nuclear power plant cannot fulfil all positive expectations. Either it really leads to a reduction of the above mentioned negative impacts of the coal power industry on the environment by the impact of replacement by nuclear production or the sale of Temelín Nuclear power plant production is made possible above the level of current CEZ output (especially abroad) and completion of Temelín Nuclear power plant is paid for in this way. Current attainment of both of these aims, i.e. benefits for the environment and economic return on investment to completion (the whole investment is already unreturnable according to the expert team), is unrealistic in this decade. Both aims cannot be attained at the same time.

1.3 Geographical, topographical and geological features of the site and the region

1.3.1 A map of the region showing the location and geographical features of the site and region

1.3.2 Relevant features of the region

For geomorphological features see chapter No. 2.3.2, for biogeographical features see chapter 2.5.1.1.3.

1.3.3 The location of the installation in relation to other installations, the discharges from which need to be considered in conjunction with those from the installation in question

There are no very significant sources of ionising radiation located within a distance of 100 km.

1.3.4 The location of the site with regard to other Member States giving the distances from frontiers and closest conurbations, together with their populations

In the close vicinity (to 5 km) of the power plant there are five communities with a total 9328 residents. The town of Ceské Budejovice is at a distance of 25 km SSE from the power plant with up to 100 000 residents. The shortest distance to the border with Austria in a SE direction is 59 km, SSE 63 km in a southerly direction 64 km, SSW 69 km, and SW 59 km. The shortest distance to the border with Germany in a south-west direction is 59 km.

1.4 Project description

1.4.1 Location

Middle Europe, 14º 22’ longitude, 49º 11’ latitude.

1.4.2 Description of the schedule for planning, redesigning, and implementation of the project

The construction is in the stage of gradual commissioning. Trial operation of unit 1 is expected in the summer of 2001. Trial operation of unit 2 by the end 2002.

1.4.3 Description of the procedure in consideration of administrative procedures accompanying implementation (concluded proceedings, pending proceedings, proceedings to be expected – authority, legal issues, parties, reference number of official notice)

Permission for the construction of two nuclear units was issued by the District Committee – construction and planning section, Ceské Budejovice on 12. 7. 1985 under ref. No. Temelín Nuclear power plant 35/85/328/1-Má. The basic construction permit for the construction of two units of the Temelín Nuclear power plant was issued partly by the municipal building authority (District Committee Ceské Budejovice – construction and planning section under ref. No. Temelín Nuclear power plant 161/186/332/4-Má from 22. 11. 1986) and partly by the special building authority (South-Bohemian County council in Ceské Budejovice, ref. No. VLHZ/2379/86-Rd from 11. 11. 1986).

At the present time the construction is in the phase of gradual commissioning of the 1st reactor unit, which is running under the supervision of the State Office for Nuclear Safety. After completing all tests the process directed towards issuing an operating license.

1.4.4 Date of start-up and completion of the construction

Construction of the actual reactor units was started in 1987. Completion of the construction by operational license of the 2nd unit is expected in 2004.

1.4.5 Decommissioning and disassembly

The study “Proposal of the method and estimation of the costs involved in decommissioning Temelín NPP” was processed for the Temelín nuclear power (Energoprojekt Praha, November 1999), which was subsequently approved by the State Office for Nuclear Safety. The study tracks three options: immediate decommissioning, protective storage, and closure with supervision. The study demonstrates the reality of decommissioning the power plant and does not presume any extraordinary risk connected with this action. It will probably lead to certain forms of industrial buildings being preserved. There will be a decision about the final form upon consideration in the period hereafter of possible developed circumstances at a suitable time.

1.4.6 Expected time of exploitation of the Temelín NPP

Peculiarities of state supervision of nuclear safety performed by the State Office for Nuclear Safety pursuant to Act No. 18/1997 Coll. are the issuing of time limited permits for operation. The lifetime presumed by the applicant is approx. 25 years. This however can be significantly revised in both directions following the results of safety evaluation of operation as is common around the world.

1.4.7 Attention applied to decommissioning and disassembly

See point 1.4.5. Further details are given in „Documentation“ in chapter A.9.5 on page 78 and 79.

1.4.8 Description of administrative and regulatory measures for decommissioning and disassembly

Czech laws presume a three-stage legislative procedure for decommissioning and disassembly of the nuclear power plant:

- assessment of the disassembly plan and the process of environmental impact assessment according to special laws
- issuing permission for decommissioning by the State Office for Nuclear Safety
- issuing permission for elimination of the construction by the State Office

1.5 Total capital expenditure

98.6 billion CZK.

1.6 Short description of the installation (main features of the production process, capacity, number of employees etc.)

The Temelín power plant is a construction with two VVER - 1000 heterogeneous pressurised water reactors, type V320 with nominal reactor thermal power of 3 000 MW. Transformation of thermal power to electrical output is managed for each reactor by a turbogenerator of conventional design with electrical output of 1 100

MVA. The number of employees in the power plant after completing construction is assumed to be approx. 1 500.

1.7. A description of the entire plant about to start operating

A description of the plant as well as a description of its components and necessary drawings illustrating necessary matters is given in „Documentation“ in chapter A.9 and A.10 (page37 to 80).

1.9 Use of resources

Data about energy sources and raw materials, data about shipment and transportation of persons and materials is given in „Documentation“ on page 90 to 92. In the area around the Temelín Nuclear power plant there are no activities whose impact would require investigation or assessment together with the relevant impacts of the Temelín Nuclear power plant. Details are given in „Documentation“ on page 296 to 298.

2.1. Atmosphere and climate

2.1.1. Atmosphere

2.1.1.1. Background contamination of atmosphere

The Nuclear Power Plant Temelín is situated in the southern part of the Czech Republic where neither industry nor power energy is considerably present (with the exception of hydro-electric power plants on the river Vltava). This fact favourably influences the quality of the atmosphere of the whole region which is ranked into the class I, clean – almost clean atmosphere. The only exception is a part of the area in the locality of Týn nad Vltavou where the atmosphere is ranked into the class II, i.e. slightly polluted atmosphere.

Map of the atmosphere quality in the Czech Republic

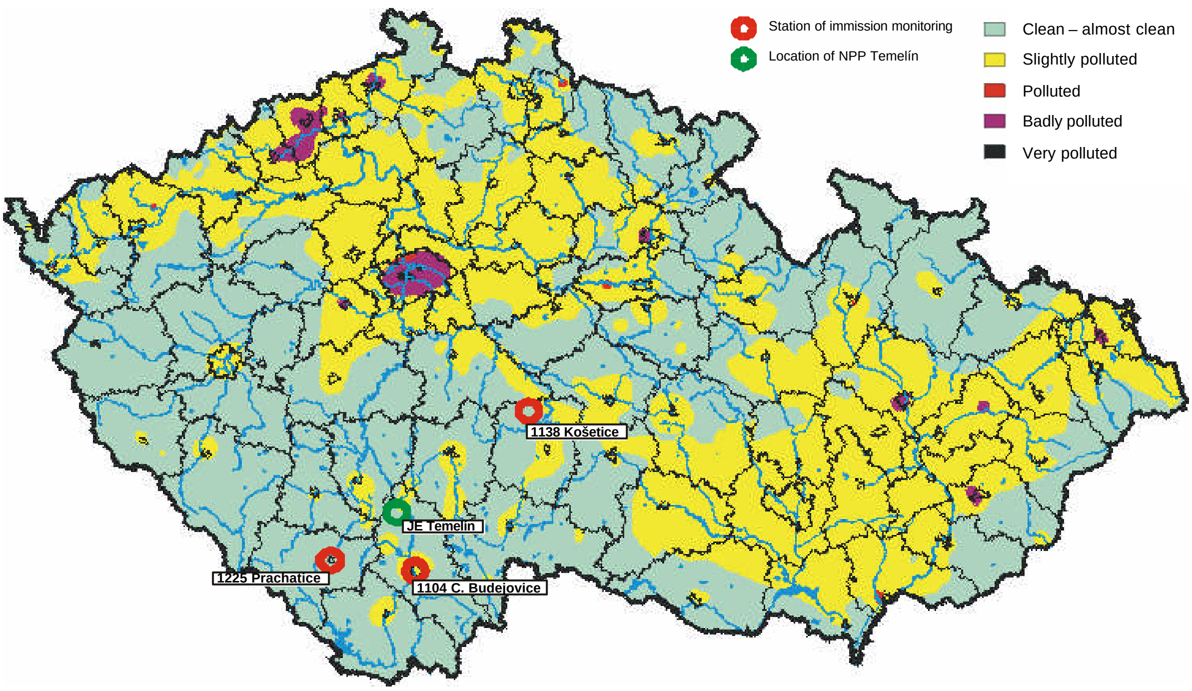


Table no. 2: Measured immissions of main harmful substances

Station number Name of the station	Year	Annual average SO2 µg.m^{-3}	Annual average NOx µg.m^{-3}	Annual average dust particles (PM10) µg.m^{-3}
1225 Prachatice	1999	6	18	10
	1998	7	18	12
	1997	16	-	15
	1996	21	24	13
	1995	16	22	19
1104 Ceské Budejovice	1999	7	28	14
	1998	9	34	22
	1997	16	39	29
	1996	20	35	37
	1995	12	34	-
1138 Košetice	1999	3	10	19
	1998	5	11	20
	1997	11	13	25
	1996	17	14	30
	1995	13	8	-

Annual limit IHr
SO_2…………………………………..60 µg.m^{3}
NOx ………………………………80 µg.m^{-3}
Dust particles PM 10…………...150 µg.m^{-3}

In the proximity of the Nuclear Power Plant Temelín it is possible to use the data from the pre-operational monitoring carried out by the Radiation Control Laboratory in the locality of the power plant Temelín. The measurement is carried out in accordance with the directive No. 60 of the Ministry of Health and hygienic regulation No. 52/1981. The aim of this monitoring is to assess the existing situation of the atmosphere before launching the operation and to quantify the impacts of the power plant constructions. The measurement is carried out in the stations Temelín and Hluboká nad Vltavou.

2.1.1.2.1. Point sources of emissions

In the course of finishing the construction of the Nuclear Power Plant Temelín there is only one important point source of atmosphere pollution in operation – a gas boiler unit with the output of 100 MW. This source is ranked in the category of big sources. The gas boiler room serves for supplying the power plant and buildings of the installation with heat. Apart from that, the heat is delivered by a heat line to Týn nad Vltavou. The annual consumption of natural gas (with 8,760 working hours) is 16.2 mil m^{3}.year^{-1}.

Table no. 3: Amount of harmful substances from the gas boiler room

	Consumption of gas per year (mil. m^3/year)	Annual emissions of pollutants (t .$year^{-1}$)	
		Calculated[1]	Reality[2]
Solid substances	16.2	0.324	
NO_x		31.1	9.975
CO		5.18	
C_xH_y		2.074	

[1] ... according to the emission factors from the appendix of the ordinance of the Ministry of the Environment no. 117/1999 Sb.

[2] ... according to the Register of emissions of the CR for the year 1998

After the launch of the power plant into commercial operation the need of this source will disappear and the boiler unit will be put out of operation. The current contribution of the gas boiler room to the background pollution is not of an important character.

In the area of the power plant 8 diesel generator stations DGS are also installed with the output per unit 6.3 MWe. The purpose of these stations is to ensure the emergency supply of electricity to the important appliances of the home consumption of the reactor block (DSG), or important appliances in the secondary part of the power plant and selected appliances of the primary circuit of the 1st and 2nd block (Back-up Diesel Generator Station). Relatively high installed capacity results from the safety requirements. The output of one DGS is sufficient for backing up the operation of one block, the remaining two serve as a back-up. Due to these reasons, in case of an outage, the operation of one or the parallel operation of two DGS is expected (the occurrence and time of duration of such situations is accidental, in the optimum case it does not occur at all).

The time of the operation of the individual DGS is considered only several hours per year in the normal operation of the power plant when the prescribed operational checks will be carried out. The frequency and time of the operation during the checks is regulated by the regulations of the producer:

Table no. 4: Maximum hourly emitted amount from one DGS

NO_x	CO	Solid substances	SC
83.4 kg	27.1 kg	5.4 kg	6.2 kg

Table no. 5: Maximum yearly emitted amount from all DGS

NO_x	CO	Solid substances	SC
6672 kg	2168 kg	432 kg	496 kg

The emissions of hydrocarbon steam happens during the bottling fuel and heating, transformer and turbine oil from transport cisterns to the tanks in the warehouse of oil management. While bottling 1,000 m^3 (maximum stored amount of Diesel oil) approx. 170 kg of hydrocarbon steam is released to the atmosphere.

In the power plant there are four cooling towers with the height of 154.8 m and diameter in the crown of 82.6 m. The towers serve for cooling the water of the circulation cooling circuit. The towers will be in operation during all the time of the reactor operation, for the purposes of this documentation we thus consider the operation of 8,760 hours a year. The heat output of one tower is 1,100 MWt, the evaporation from one tower will be up to 413 $l.s^{-1}$ (normally, however, smaller). By means of four cooling towers approx. 4,000 MWt of waste heat will be released to the atmosphere.

Also the airborne radioactive effluents, which are a part of the separate chapter 2.1.1.3., can be included among the point sources.

2.1.1.2.2. Linear sources of emissions

In the power plant no important linear sources of atmosphere pollution will be operated. Possible movement of motor vehicles on the roads inside the grounds will be irregular and occasional and as regards the environmental impacts unimportant. The same can be said also as regards the railway transport on the railway siding system of the power plant.

Table no. 6: Traffic intensity and emissions of harmful substances from the transport of employees

	Weekdays		Saturday and Sunday		Annual emission of harmful substances from 1 km of the road ($t.year^{-1}$)			
	number[1]	passages[2]	number	passages	dust	NO_x	CO	C_xH_y
Buses	180	360	80	160	0.27	0.93	0.84	0.5
Cars	500	1000	100	200	0.01	0.52	1.4	0.14
Total					0.28	1.45	2.24	0.64

1 ... average number of vehicles that come per day

2 ... average number of both arrivals and departures per day

It was found out from the carried out calculations of the emissions of the harmful substances from the passenger transport (on the basis of the relevant emission factors for the year 2 000) that in the distance of 10 m from the road centre line, the contribution of NO_x to the current immission burden is on the level of 3 % of the valid limit and with increasing distance this concentration is falling. The contribution of the passenger traffic to the background immission burden is not of an important character.

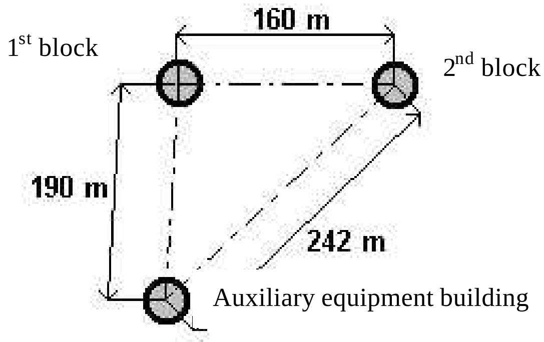
It was also found from the carried out calculations of the emissions of harmful substances from the goods transport (on the basis of the relevant emission factors for the year 2 000) that in the distance 10 m from the road centre line, the contribution of NO_x to the current immission burden is on the level of 0.5 % of the valid limit and with increasing distance this concentration is falling. The contribution of the passenger traffic to the background immission burden is not of an important character. (After launching the power plant into operation, the number of workers present in the grounds will decrease and proportionally even the car transport will be decreased).

The railway connection of the Nuclear Power Plant Temelín is carried out by a siding rail from the station Temelín located on the railway track no. 192 Cicenice – Týn nad Vltavou. All railway traffic connected with the power plant is carried out on this siding. Other railway tracks are not situated in the area of interest.
River traffic on the river Vltava is not important and it is only of a seasonal holiday character.
In the area of interest there are no airports situated and even above it there are no civil skyways. The locality of the power plant is protected by a forbidden area (announced world-wide by the Flight information manual). This forbidden area is of cylindrical shape with the diameter of 2 km and the height of 1,500m.

Above the power plant locality there is no training or working military area. Military operational directives include special measures and regulation of the operation in view of the Nuclear Power Plant Temelín. In the wider locality, civil air traffic, general aviation traffic as well as military training traffic is carried out in accordance with the relevant aviation regulations. Outside the area of interest there are also military, public and agricultural airports.

C. 2.1.1.3 Airborne radioactive effluents from the installation in normal conditions, dispersion study

The airborne radioactive effluents arise during the cleaning of the coolant of the primary circle, ventilation of small coolant discharges through the leaks of the primary circuit installation, during the refill or change of fuel in the reactor, from the ventilation of the auxiliary and active technological systems. The airborne radioactive effluents are released to the environment in the Nuclear Power Plant Temelín from 3 ventilation chimneys (one in each block and one at the active auxiliary equipment building). The chimneys are 100 meters high and they form a triangle with the sides of 160, 190, 242 m.



As regards the calculations, they are regarded to be a one point source. Before the release to the ventilation chimney, the airborne effluents go through a complicated system of cleaning. Water, hydrogen, aerosols and iodine are removed from them in aerosol and iodine filters. During these processes no inert gases are arrested. The decrease of their discharge is reached especially by their delay in the main production block and on the delay line. The effectiveness of arresting the aerosols in the filters is 99.95%, the effectiveness of arresting the iodine and its compounds is 99.5%.

By means of the programme “RDETE”, accepted by the State Office for Nuclear Safety, radiation doses for an individual from the critical group of people (this is defined from the people living within the distance of 5 km from the power plant) with consideration of these effluents and atmospheric conditions in the locality was calculated. On the basis of these results and with consideration of other factors, the State Office for Nuclear Safety set a limit, which cannot be exceeded by the power plant Temelín, i.e. the value of the effective dose for the discharges tot he atmosphere of **40 mSv for individuals** from the critical group of people per one year.

All living organisms are influenced by ionising radiation which is omnipresent, it comes both from the space and from the core of the Earth and all materials that are around us. It is in the air, in water, in food and it forms natural background. For the Czech Republic we can accept some mean value, which contributes to us with the equivalent dose of **1.8 mSv, i.e. 1800 mSv** every year.

Other details are given in the chapter 2.1.1.6.

2.1.1.4. Authorisation procedure in force and limit values for the release of radionuclides to the atmosphere

2.1.1.4.1 Outline of the procedure in force

In case that their radioactivity is higher than the values set by the Act no. 18/1997 concerning the peaceful use of nuclear energy and radiation, the releases of radionuclides to the environment in the form of discharges to the atmosphere is possible only on the basis of the permit which is issued at request by the State Office for Nuclear Safety in accordance with the section 9, clause 1, letter h of this Act.

In case of the Nuclear Power Plant Temelín this request was submitted by CEZ, a.s. – Nuclear Power Plant Temelín, on 27/09/1999 under the ref. no. 1000/295/99. The decision which permits the release of radionuclides to this applicant was issued by the State Office for Nuclear Safety on 04/07/2000 under the ref. no. 8871/2000. This decision permits the applicant for a limited time until 31/12/2002 to release radionuclides into the environment in the form of discharges to the atmosphere in the extent that does not exceed for an individual from the population the effective dose set in the limits and conditions of the safe operation of a nuclear installation by the decision of the State Office for Nuclear Safety ref. no. 10139/2000 from 04/07/2000.

The other permits of the State Office for Nuclear Safety issued in accordance with the Act No. 18/1997 Sb., concerning the peaceful use of nuclear energy and ionising radiation are not conditioned by the performance of the process of the environmental impact assessment. As regards the atmosphere they include the following permits:

- Permit for the construction of a nuclear installation or workplace with a very important source of ionising radiation,
- Permit for individual stages of commissioning a nuclear installation into operation,
- Permit for the operation of a nuclear installation or a workplace with a very important source of ionising radiation,
- Permit to put the nuclear reactor again to the critical state after the change of the nuclear fuel
- Permit to carry out a reconstruction or other changes influencing nuclear safety, radiation protection, physical protection or emergency preparedness of the nuclear installation or workplace with an important or a very importance source of ionising radiation,
- Permit for the release of radionuclides to the environment,

- Permit to handle with sources of ionising radiation in the extent and ways given in an operating regulation,
- Permit to handle with radioactive waste,
- Permit for the transport of nuclear materials and radionuclide emitters,
- Permit for professional preparation of selected employees of the nuclear installations and selected employees of the workplaces with the sources of ionising radiation,
- Permit for the import of radioactive waste arising during the processing of materials exported from the Czech Republic.

The State Office for Nuclear Safety issued the following decisions for the applicant CEZ, a.s.:

Decision No. 460/97 dated 30/12/1997 under the ref. no. 8575/3.3/97 in accordance with the section 9 clause 1 letter 1) of the Act no. 18/1997Sb., - Permit to handle nuclear waste.

- Enriched uranium with enriched isotope ^{235}U up to 5 % of the weight, in the fresh irradiated or spent nuclear fuel in the form of fuel rods and sets for the reactors of the type VVER – 1000
- Plutonium included in the above-mentioned fuel rods and sets of the type VVER – 1000
- Enriched uranium as a part of detection devices
- Depleted uranium in the form of envelope sets and shielding blocks

Decision No. 119/1998 dated 14/04/1997 under the ref. No. 1196/3.3/97 in accordance with the section 16 clause 3 of the Act No. 18/1997Sb., as a supplement to the Decision No. 460/97 dated 30/12/1997 as the Decision concerning the change of the permit to handle nuclear materials.

Decision dated 04/07/2000 under the ref. No. 10122/2000 in accordance with the section 3 clause 2 letters b) and d) of the Act No. 18/1997Sb., - where it is permitted to handle a very important source of ionising radiation – nuclear reactor of the first block and directly connected technological installation.

Decision dated 04/07/2000 under the ref. no. 8871/2000 in accordance with the provisions of the section 3 clause 2 letter b) of the Act no. 18/1997Sb., - where it is permitted to release the radionuclides to the environment in the form of discharges to the atmosphere in the extent which does not exceed for an individual from the population the load of the effective dose set in the limits and conditions of the safe operation of a nuclear installation by the decision of the State Office for Nuclear Safety ref. no. 10139/2000 dated 04/07/2000.

The decision of the State Office for Nuclear Safety dated 04/07/2000 ref. no. 10139/3.1/2000 in accordance with the section 3 clause 2 letter d) of the Act no. 18/1997 Sb. permits the Limits and conditions of the safety of the operation of a nuclear installation.

The release of radionuclides to the environment in the form of discharges to the atmosphere in the extent set in the decision applies for all the sources of airborne effluents of CEZ, a.s. – Nuclear Power Plant Temelín. The conversion of the individual radionuclides discharged to the atmosphere is carried out in accordance with the table no. 1 of the appendix “Assessment of irradiation of the critical group or population" of the supplement of the submission of the applicant ref. no. 4500/60 dated 31/03/2000, registration ref. no. of the State Office for Nuclear Safety B4687/2000. The period of validity of this decision is limited due to its connection to the programme of monitoring of the discharges approved by the decision of the State Office for Nuclear Safety ref. no. 4033/2000 dated 15/03/2000 with the same period of validity.

2.1.1.4.2 Discharge limits and associated requirements envisaged by the authorities, including the assumed radionuclide composition

The decision of the State Office for Nuclear Safety ref. No. 8871/2000 dated 04/07/2000 in connection with the decision of the State Office for Nuclear Safety ref. No. 10139/2000 dated 04/07/2000 permitted the release of radionuclides to the environment in the form of discharges to the atmosphere in the extent which does not exceed for an individual from the population the effective dose higher than **40 μSv.year^{-1}.**

Formerly the Limits and conditions specified the maximum activities of individual radionuclides that can be discharged to the atmosphere under normal conditions. In accordance with new legislation which came to effect simultaneously with the issue of the Act No. 18/1997 Sb., concerning the peaceful use of nuclear energy and ionising radiation (atomic law), an effective dose which corresponds to these activities is set during the issue of the permit for the release of radionuclides into the atmosphere. This procedure is in agreement with the international recommendations of IAEA.

2.1.1.5. Technical aspects

2.1.1.5.1 Annual discharges foreseen

With regard to the stage of commissioning the power plant into operation, the real discharges cannot be documented at the moment, the original project values are greatly exaggerated. Considering the similarity to the Nuclear Power Plant Dukovany (technology, installed capacity) the real discharges can be expected up to three orders of magnitude lower compared to these values. It is illustrated in the example of the Nuclear Power Plant Dukovany in the chapter 2.1.1.6.

2.1.1.5.2. Origins of the radioactive effluents, their composition and physico-chemical forms

The airborne radioactive effluents arise during the cleaning of the coolant of the primary circuit, ventilation of small coolant discharges through the leaks of the primary circle installation and during the refill or change of fuel in the reactor. Another source of airborne effluents is the ventilation of the operational and auxiliary active technological systems. Before the discharge to the ventilation chimney, the airborne effluents go through a complicated system of cleaning, water, hydrogen, aerosols and iodine is removed from them in aerosol and iodine filters. During these processes no inert gases are arrested. The decrease of their discharge is reached especially by their delay in the main production block and on the delay line.

The total activity of the airborne effluents consists of the activity of fission products, activating and corrosive products and from the tritium activity. The activity of the airborne effluents from the nuclear power plant is formed especially by ^{88}Kr, ^{133}Xe and ^{135}Xe. Iodine forms approx. 2.10^{-4} % of the total activity, the tritium activity less than 2 % of the activity.

The crucial share of these radioactive substances has its origin in the active zone of the reactor where the fission of the nuclei of uranium 235 happens and they are separated from the environment by barriers, which are gradually: crystal lattice of the fuel itself, hermetic cladding of fuel rods, tight primary circle and finally the tight protective envelope of the primary circuit – the containment.

The volume annual discharge of the airborne effluents from the chimneys of the buildings of the controlled zone with the real or potential occurrence of radioactive airborne effluents from se the chimneys of the buildings of the controlled zone is with regard to various operational situations calculated in the range of 5.10^9 to 6.10^9 m^3.

2.1.1.5.3. Management of effluents, methods and paths of release

The discharge is carried out solely by three chimneys (reactor building of the 1st block, reactor building of the 2nd block, auxiliary active equipment building).

Another potentially possible source of radioactivity is the ventilation from the turbine hall. Air-conditioning systems are divided in accordance with their importance to the safety ones, connected with the nuclear safety and others. As regards the kind of ventilation of the plant, the air-conditioning for the technological buildings is divided into the air-conditioning for non-active and active operations. A reliable operation of the air-conditioning is ensured by the connection of the air-conditioning device to the systems of the ensured feed, by ranking the device among the selected technical devices and seismically resistant devices. The prevention of the leak of radioactive substances through the air-conditioning systems to the atmosphere is ensured by means of the use of aerosol filters and iodine filters for the filtration of the air lead away from the area where the activity can occur. The main device of the air-conditioning systems are ventilators, feed units, exchangers, fast-closing hermetic flaps on the border of the hermetic zone, hermetic flaps for closing the pipes of the systems working with the air exhausted from the area with possible occurrence of the activity, air flaps on other pipe systems.

The fundamental attention must be paid to the ventilation and outlet of the air in the containment, where in case of a defect the escape of active substances can happen from the damaged tightness of the primary circuit to the containment area. During normal operation slight underpressure is kept in the containment (100 to 300 Pa) and the ventilation of the containment is thus carried out forcedly by ventilators. With any leak of the primary circle this underpressure turns to the overpressure, which is a signal for immediate hermetic separation of the containment area from the outside environment, which apart from other things happens by means of closing the hermetic flaps on the air-conditioning pipes coming out of the containment. The functionality and tightness of these flaps is checked in prescribed intervals. At the same time the reactor is automatically put out of operation (stopping of the fission reaction). Inside the containment dosimetric sensors are installed in many places which give a sufficiently exact image of the radiation situation inside the containment and the next action as regards the discharge of substances containing radionuclides would be directed according to the situation and under the supervision of the State Office for Nuclear Safety. In this connection it is important to point out that not even during so-called maximum design accident, i.e. during the rupture of the main circulation pipe, in accordance with the calculation the pressure inside the containment does not grow in such a way to be able to threaten its compactness and tightness as regards the pressure.

Outside the containment, i.e. in the enclosure and in the auxiliary equipment building a sudden release of airborne radioactive effluents cannot happen in such a volume and activity to be able to influence the environment in more important way including the health risks for people, because no such substances are found there.

2.1.1.5.4. The way of filtering of emissions and details of arrestment equipment and techniques

Before getting to the ventilation chimneys, all the airborne effluents from the area inside the containment, from the controlled zone of the enclosure and from the auxiliary equipment building are filtered by the system of air-conditioning filters which arrest aerosols containing radionuclides, iodine and its compounds. The effectiveness of these filters is for radioactive aerosols 99.95 %, for radioactive iodine and its compounds 99.5 %. Inert gases (krypton, xenon) are not arrested on these filters and that is why their share in the leaks to the environment is decisive in comparison with other radioactive substances. However, these are inert elements which do not enter other chemical bonds and as regards biological influence on humans their impact is of little importance.

2.1.1.5.5. Data on the system's operability in case of an accident

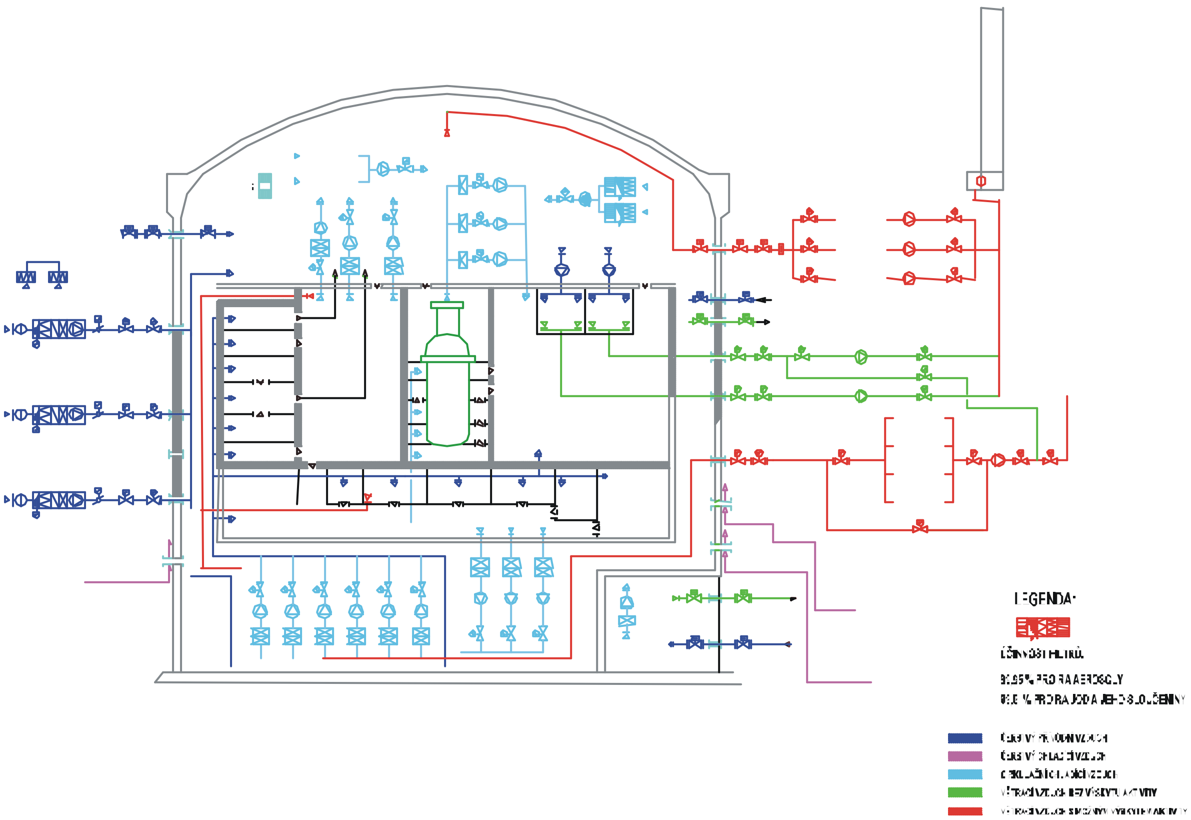
During any accident all the area of the containment is hermetically closed and from this area no airborne effluent is not released to the outside environment nor it can escape from there. The other air-conditioning systems important as regards maintaining the inside environment (provision of sufficient cooling etc.) are fed from the sources of the ensured electric feed and they remain functional.

As regards the filters for the arrestment of radioactive aerosols and iodine and its compounds fitted before the entry of the airborne effluents to the ventilation chimneys, it is stated that it is not one compact filter but a series parallel combination of more unites. This layout is resistant against any defect. In case of a fire in any of these units, the relevant section is separated from the others on both input and output by fire flaps or hermetic closures with guaranteed fire resistance which prevents the spread of the fire to the other sections.

2.1.1.5.6. Description of waste air system of the nuclear power plant, including filter and delay loops

The technological air-conditioning of the reactor building is lead through the system of filters with activated carbon which forms a delay line for inert gases (xenon, krypton), which are bound physically to the filling of the filters while passing through the filter and their passage through the filters is thus delayed compared with the other airborne effluent. This delay is in tens or hundreds of hours depending on the nuclide. Thus the nuclides with short half-life die off before their release to the atmosphere.

The conception of the protective envelope ventilation



Legend:
Filter effectiveness
99.95 % for radioactive Aerosols
99.5 % for radioactive iodine and its compounds

Fresh feed air
Fresh cooling air
Circulation coolin g air
Ventilation air without activity
Ventilation air with possible activity

2.1.1.6. Monitoring of radionuclide discharges to the atmosphere

2.1.1.6.1. Sampling, measurement and analysis of discharges, whether undertaken by the observer or by control authorities

The only potentially possible source of irradiation of the inhabitants in the locality of power plants are airborne and liquid effluents. Before they are discharged to the ventilation chimney, the airborne effluents go through a complicated system of cleaning, water, hydrogen, aerosols and iodine is removed from them in aerosol and iodine filters. Any possible impact of radioactive substances on the locality is calculated by means of mathematical models.

The discharge from the chimney of the reactor buildings and the auxiliary equipment building is measured continuously. The continuous taking of aerosols is carried out by large-scale aerosol sampler of the type AIM of the firm CANBERRA, USA, with the use of semiconductor detectors HPGE, which have a 100 % back-up, on a fixed filter with subsequent laboratory analysis. Similarly the continuous taking of iodine is carried out by a iodine sampler on a fixed filter with the evaluation on the semiconductor detectors HPGE, which have again a back-up. The continuous monitoring of aerosols and iodine is then solved by the continuous signalling measurement of the volume activity which are, apart from other things, used for emergency measurement in case of the outage of the samplers. After filtering off iodine and aerosols, the air sample goes to the continuous monitor of inert gases with the semiconductor detector HPGE. Both volume activity and total activity of the discharge is measured in $Bq.day^{-1}$. The back-up measurement in case of a defect is carried out by PIG monitor.

In accordance with Czech law concerning metrology, all the mentioned measuring equipment are subject to regular checks of measurement accuracy by the Czech Metrology Institute in the term stipulated by law. All data concerning the measurement are concentrated in the Radiation control room situated in the auxiliary active equipment building and they are further processed and filed. The public is regularly informed about the resulting values, both in the form of information released by the power plant, division of the radiation control of the locality, as well as by the State Office for Nuclear Safety, which in accordance with the provisions of the law issues annually “Report concerning the radiation situation in the territory of the Czech Republic”.

The State Office of Nuclear Safety does not carry out the monitoring of emissions directly in the nuclear power plant. However, by means of its inspection activity, the Office provides the checks of the fulfilment of the monitoring programme approved by it, the part of which are also the methods and system of the monitoring of discharges to the environment.

Limits for the discharge of radioactive substances to the atmosphere:

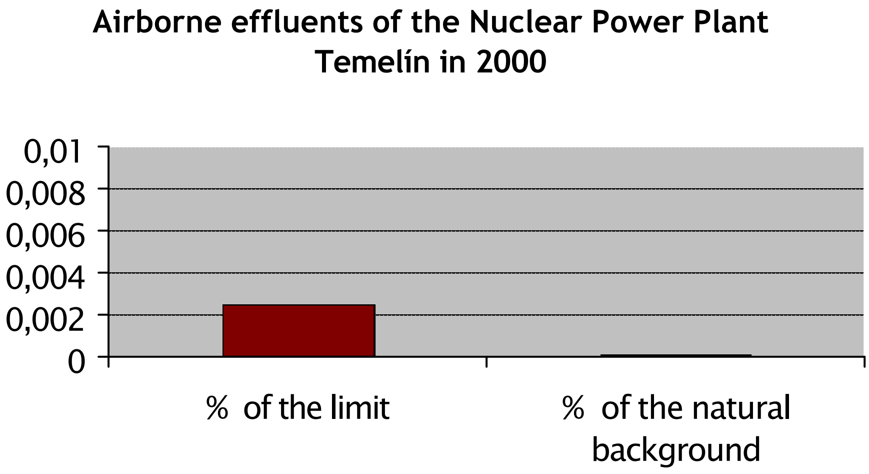
The activity of radionuclides arising in the nuclear power plant and discharged by means of the ventilation chimneys to the atmosphere in the course of one calendar year cannot cause to an individual from the population 50-year load higher than **40 mSv** during the operation of two units. The conversion of the activities to the 50-year load of the effective dose must be carried out in the way authorised by the State Office for Nuclear Safety.

The Nuclear Power Plant Temelín has not started commercial operation yet and thus the comparison of the operational result with the permitted limit for the part of the year 2000 (the activation of the fuel in the 1st block happened in September 2000) is not representative in comparison with the per cents of the limit. However, these are the first current measurements and thus we are mentioning them.

Table no. 7

Limit ($mSv.year^{-1}$)	**Reality** ($mSv.year^{-1}$)	**% of the limit**	**% of the natural background**
40	0.001	0.0025	0.000056

Graph no. 2



We would like to mention that the organisation Global 2000 installed two devices for the radioactivity measurement near the Nuclear Power Plant. Its spokeswoman Andrea Paukovitsová informed the media on 06/03/2001 "Thank God we have not measured anything so far". The mentioned announcement is identical for the time being with the temporary results of the measurement by the power plant operator.

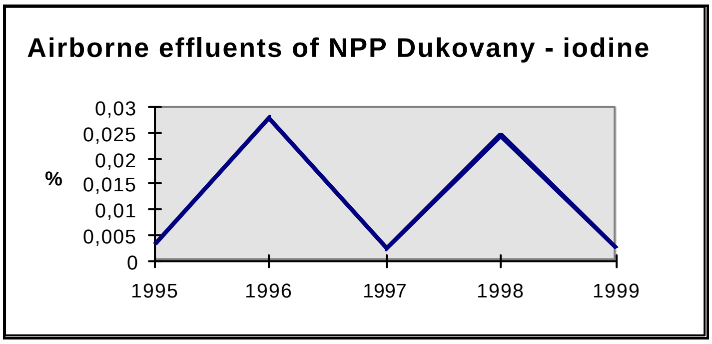
The Nuclear Power Plant Dukovany is very similar to the Nuclear Power Plant Temelín as regards the technology of operation and output. To give an outline and comparison the real measured discharges of the Nuclear Power Plant Dukovany for the years 1995-2000 are provided in comparison with the limits.

As it was mentioned before, until 1999 these limits were set not in the effective dose but in the activity of individual radionuclides contained in the discharges. For iodine the limit was set to 440 $GBq.year^{-1}$ and the real discharges in comparison with this limit in individual years were the following:

Table no. 8: Nuclear Power Plant Dukovany – the real discharges in comparison with the limit

Year	Limit ($GBq.year^{-1}$)	Reality ($GBq.year^{-1}$)	% of the limit
1995	440	0.0147	0.0033
1996	440	0.1221	0.0278
1997	440	0.0111	0.0025
1998	440	0.1081	0.0246
1999	440	0.0114	0.0026

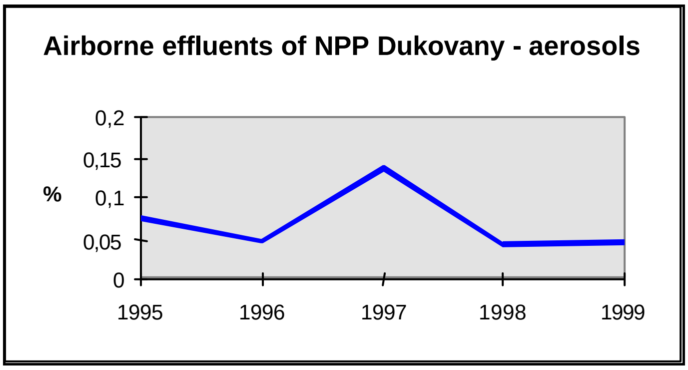
Graph no. 3



% of the limit

Set limit 440 GBq.year^{-1}.

Graph no. 4



% of the limit

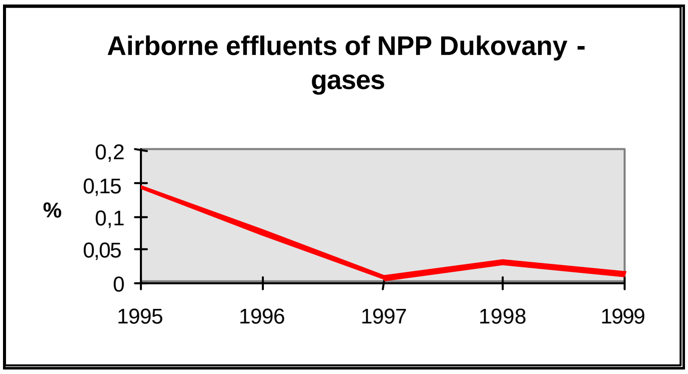
Set limit 180 GBq.year^{-1}.

For inert gases (mainly Xe, Kr) the limit was set to 4,100 TBq.year^{-1} and the real discharges in comparison with this limit in the individual years were the following:

Table no. 9: The Nuclear Power Plant Dukovany – real discharges in comparison with this limit

Year	Limit (TBq.year^{-1})	Reality (TBq.year^{-1})	% of the limit
1995	4100	5.846	0.1426
1996	4100	3.164	0.0772
1997	4100	0.417	0.0102
1998	4100	1.403	0.0342
1999	4100	0.618	0.0151

Graph no. 5



% of the limit

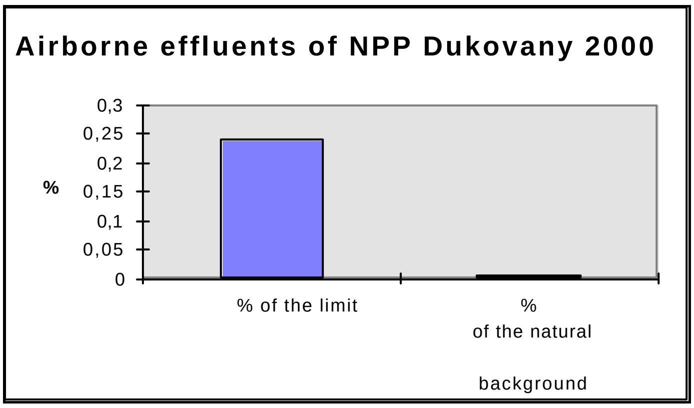
Set limit (mainly Xe, Kr) 4 100 TBq.year^{-1}.

Starting in 2000, the limit in the equivalent dose is set even for the Nuclear Power Plant Dukovany and it is **40 mSv.year^{-1}**. The real discharges in comparison with this limit and the equivalent dose from the natural background are clear from the following graph:

Table no. 10: The Nuclear Power Plant Dukovany – the real discharges in comparison with the limit and the equivalent dose from the natural background

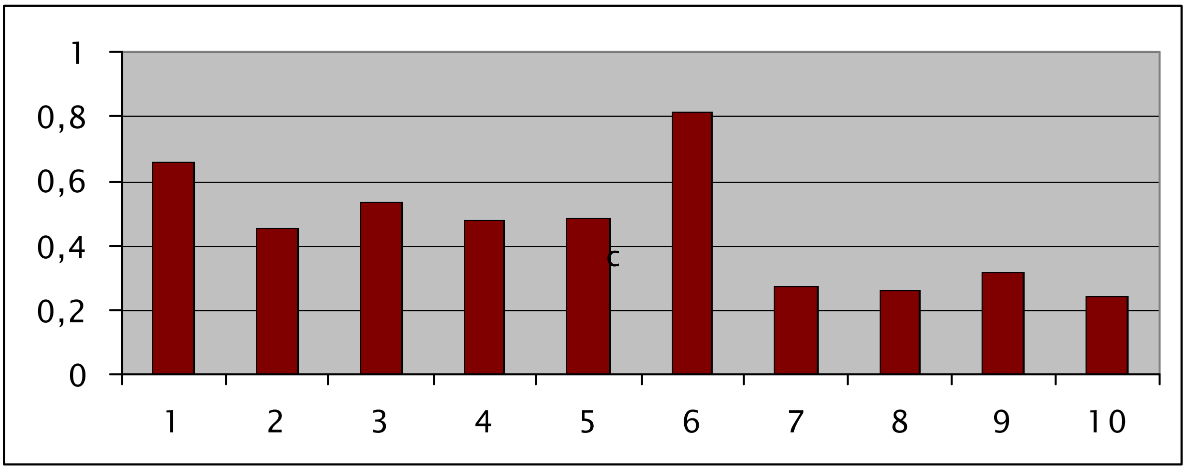
Year	Limit (mSv.year^{-1})	Reality (mSv.year^{-1})	% of the limit	% of the natural background
2000	40	0.096	0.24	0.005

Graph no. 6



Set limit 40 μSv.year^{-1}.

Graph no. 7: The Nuclear Power Plant Dukovany – the outline of annual values of taking the limit of all airborne effluents to the atmosphere



Legend:

Taking the effective dose (40 µSv) for an individual from the inhabitants of all airborne effluents in %.

Converted to the limit of doses which is valid from the year 2000

The annual dose of natural background **1.8 mSv, which equals to 1,800 mSv**, <u>absolutely overlaps the radioactive substances released to the atmosphere.</u> With comparability of the physical principle and the output we can expect that the airborne effluents from the Nuclear Power Plant Temelín will not be noticeably different from the Nuclear Power Plant Dukovany.

It is necessary to mention that the permitted limits of discharges for the operation of the nuclear power plant are set on the level of approx. 2 % of the doses that we receive constantly from the natural background. What we generally receive from the operation of nuclear power plants <u>will fit with a huge reserve into the normal fluctuation of natural background,</u> which varies from place to place on the Earth significantly.

The following parameters will be monitored in the Nuclear Power Plant Temelín after launching into operation:

Table no. 11: The Nuclear Power Plant Temelín – the outline of the discharge monitoring after launching into operation

Measurement	Aim	Method	Measured quantity	Period
Discharges to the atmosphere:				
Balance of inert gases in the ventilation chimneys of the main production unit (VC MPU)	Checks of meeting the limits and conditions	Setting the volume activity of inert gases	Volume activity of individual gamma nuclides	Continuously
Balance of inert gases in VC MPU	Checks of meeting the limits and conditions	Setting the volume activity of inert gases	Volume gamma activity of individual nuclides	Weekly
Balance of airborne iodine in VC MPU	Checks of meeting the limits and conditions	Setting the volume activity of iodine isotopes	Volume activity of radioisotopes of iodine	Weekly
Balance of aerosols in VC MPU	Checks of meeting the limits and conditions	Setting the volume activity of aerosol component	Volume gamma activity of individual nuclides	Weekly
Balance of strontium in aerosols from VC MPU	Checks of meeting the limits and conditions	Setting the volume activity of strontium in the aerosol component	Volume activity of radionuclides ^{89}Sr, ^{90}Sr	3 months (connected weekly samples for this period)
Balance of alpha-nuclides in aerosols from VC MPU	Checks of meeting the limits and conditions	Setting the volume activity of alpha-nuclides in the aerosol component	Volume activity of radionuclides ^{238}Pu, $^{239+240}$Pu, ^{241}Am, ^{242}Cm, ^{244}Cm	3 months (connected weekly samples for this period)
Balance of aerosols in the ventilation chimney of the Active Auxiliary Equipment Building (VC AAEB)	Checks of meeting the limits and conditions	Setting the volume activity of the aerosol component	Volume gamma activity of individual radionuclides	Weekly
Balance of ^{3}H in VC MPU	Checks of meeting the limits and conditions	Setting the tritium activity by liquid scintillation spectrometry	Volume activity of balanced tritium	Weekly
Balance of ^{3}H in VC AAEB	Checks of meeting the limits and conditions	Setting the tritium activity by liquid scintillation spectrometry	Volume activity of balanced tritium	Weekly
Balance of ^{14}C in VC MPU	Checks of meeting the limits and conditions	Setting the activity ^{14}C by liquid scintillation spectrometry	Volume activity ^{14}C (the sum of organic and inorganic	month (converged weekly samples)

Measurement	Aim	Method	Measured quantity	Period
			component)	
Control measurement ^{14}C in VC AAEB	Checks of meeting the limits and conditions	Setting the activity ^{14}C by liquid scintillation spectrometry	Volume activity ^{14}C	Operatively
Regulation of discharge of aerosols, iodine and gases from VC AAEB	Discharge regulation	I) setting the aerosol component II) setting iodine III) setting inert gases	I) ^{137}Cs equivalent volume activity of aerosols II) ^{131}I equivalent volume activity of iodine III) ^{133}Xe equivalent volume activity of inert gases	Continuously
Regulation of the discharge of aerosols, iodine and gases from the VC AAEB	Discharge regulation	I) setting the aerosol component II) setting iodine III) setting inert gases	I) ^{137}Cs equivalent volume activity of aerosols II) ^{131}I equivalent volume activity of iodine III) ^{133}Xe equivalent volume activity of inert gases	Continuously
Balance of radionuclides in the released steam through PVPG a PSA	Checks of meeting the limits and conditions	Setting the volume activity of steam behind the steam generator	^{137}Cs equivalent volume activity	Continuously
Balance of discharge behind the tank of air pump of the main turbine condensers	Checks of meeting the limits and conditions	Setting the volume activity of gases	^{133}Xe equivalent volume activity of gas	Continuously
Operative measurement of aerosols by means of cascade impactor	Setting the distribution of the size of aerosol particles in airborne effluents from MPU	Setting the volume activity of the aerosol component	Volume gamma activity of individual radionuclides	Continuously
Emergency measurement of the dose rate in VC MPU	Discharge regulation	Measurement of dose rate	Photon dose rate	Continuously

Measurement	Aim	Method	Measured quantity	Period
Emergency monitoring or inert gases from VC MPU	Emergency	Measurement of inert gas activity	Volume activity of inert gases	Continuously after launching from the intervention level of a PIG monitor

2.1.1.6.2. Principal features and locations of the monitoring equipment

The extent of monitoring in the Nuclear Power Plant Temelín in comparison with the situation in the similar nuclear power installations operated in Europe and in the United States is substantially above the standard.

In the territory of the Czech Republic there is a state-wide radiation monitoring network, which is co-ordinated by the State Office for Nuclear Safety. The network works in two modes. In the normal mode it is focused on the monitoring of the current radiation situation and on the timely detection of the radiation accident. In the possible emergency mode, all safety components are involved in the system.

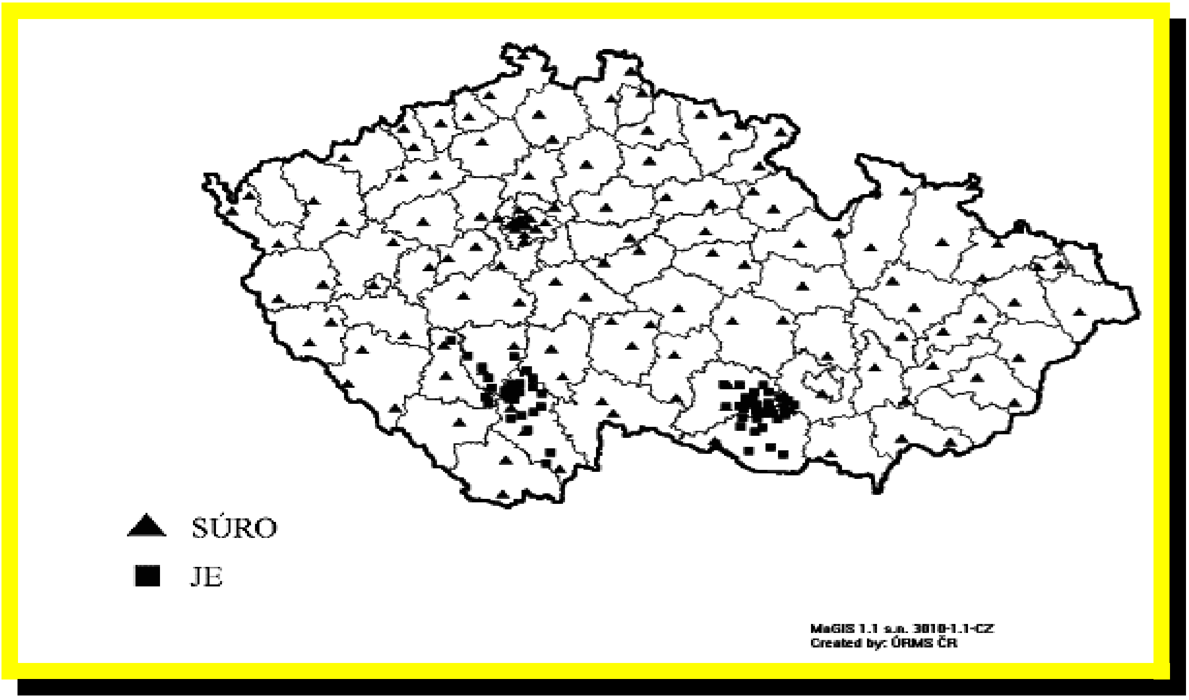
The purpose of the monitoring programme of the Nuclear Power Plant Temelín is to monitor the distributions of the radionuclide activity and doses of the ionising radiation in the territory of the state in the space and time, especially with the aim to get long-term time trends and to find out any deviations from them on time. The attention is paid to artificial radionuclides, from which the following are found in measurable values and are monitored in the atmosphere – ^{137}Cs, ^{90}Sr, $^{239\text{-}240}$Pu, ^{85}Kr, in food - ^{137}Cs, ^{90}Sr, ^{3}H, in human body – ^{137}Cs.

Apart from the monitoring carried out by the operator of the Nuclear Power Plant Temelín (see the previous chapter) generally they include:

- Timely detection network
- Territory network
- Local networks
- Stable places of the Army of the Czech Republic
- Territorial network of the measurement spots of the atmosphere contamination
- Network of laboratories

Due to the great importance, some more details are given.

- General monitoring of the dose equivalent from the earth radiation is ensured by means of the territorial network of 212 measurement places with thermolumuniscent dosimeters in the territory of the state. The results of the measurement in 1998 were on the level of 150 nSv.hour^{-1}.



Legend

SÚRO – National Radiation Protection Institute

JE – Nuclear Power Plant Temelín, Dukovany

- Monitoring network of the field semiconductor gamma-spectrometry, during which the dose input of the gamma radiation of the untreated land is set in 7 localities in comparison with 4 localities of the plough-land. The dose rate in the years 1992 – 1997 ranged from 85 nSv.hour^{-1} to 141 nSv.hour^{-1}.
- In two-weeks' intervals, the measurement of dose rate of the gamma radiation is carried out in the towns Týn nad Vltavou (dose input ranges between 84 –154 nSv.hour^{-1}), Ceské Budejovice (dose rate ranges between 99-142 nSv.hour^{-1}).
- The measurement of dose rate of the gamma radiation by portable devices of the field gamma-spectrometry is also carried out.

Table no. 12: Mean values of the input of dose equivalent [nSv.h^{-1}] of the untreated land in the locality Temelín measured in the years 1993 to 1999 by the field semiconductor gamma-spectrometry

Lokalita	1993	1994	1995	1996	1997	1998	1999
C. Budejovice	-	135.5	113.0	111.0	118.3	110.3	105.5
Bohunice	129.3	132.0	115.3	115.8	129.8	119.5	114.3
Litoradlice	112.3	114.5	112.5	101.5	112.3	104.5	96.0
Nová Ves	123.5	123.6	109.0	104.8	120.0	106.3	107.3
Písek - N. Dvur	144.3	152.0	122.5	120.5	126.3	118.5	116.0
Sedlec	116.0	119.0	106.8	99.3	113.3	102.0	99.8
Zverkovice	128.3	124.0	120.5	109.5	124.8	121.0	108.3

- Signalling monitoring of external irradiation consists of 58 measuring spots with automated transmission of the measured values. The operation is provided by the regional centres of the State Office for Nuclear Safety, National Radiation Protection Institute, Czech Hydrometeorological Institute and Civil Security of the Czech Republic.
- Stable network of the measuring places of the Army of the Czech Republic, which carries out spot measurements twice a day in 11 places in the normal radiation situation. The network is connected to the system of emergency places which would launch their activity in an emergency situation on the direction of the State Office for Nuclear Safety.
- The territorial network of 11 measurement places of the atmosphere contamination, which form a network in the neighbourhood of the Nuclear Power Plant Temelín and the Nuclear Power Plant Dukovany.
- Professional network of 9 laboratories of the radiation control in the neighbourhood of nuclear power plants equipped for gamma-spectrochemical or radiochemical analyses of the radionuclide content in aerosols, fall-out and other samples from the environment.

Table no. 13: The following values were recorded in the neighbourhood of the Nuclear Power Plant Temelín in the years 1997-99

Volume activity ^{137}Cs in aerosol in atmosphere	$0.4 .10^{-6}$ to 4.10^{-6} $Bg.m^{-3}$
Surface activity ^{137}Cs in fall-out	0.1 to 0.35 $Bg.m^{-2}$
Volume activity ^{7}Be in atmospheric aerosols	1.10^{-3} to 3.10^{-3} $Bg.m^{-3}$
Surface activity ^{7}Be in fall-out	10 to 150 $Bg.m^{-2}$
Values of volume activity ^{210}Pb in atmospheric aerosols	1.10^{-4} to 6.10^{-4} $Bg.m^{-3}$

2.1.1.6.3. Alarm and intervention levels (manual and automatic)

As regards airborne radioactive effluents, in accordance with the document "Limits and conditions" and decision of the State Office for Nuclear Safety, the activity of radionuclides arising in the nuclear power plant and discharged by ventilation chimneys to the atmosphere in the course of one calendar year cannot cause to an individual from the population 50-year load of the effective dose higher than 40 μSv during the operation of two units. The conversion of the radioactivity to the doses must be carried out in the way authorised by the State Office for Nuclear Safety. If such a limit value was reached, the reactor must be put out of operation within one hour and next operation can only be started after the issue of a new permit by the State Office for Nuclear Safety.

In the nuclear power plant there is an extensive system of internal monitoring which monitors the radiation situation in the individual technological systems and area of controlled zone of the nuclear power plant. When the usual values in these places are signalled, the exceeding of these operational levels is signalled, which is the signal for the activity of operators. These limits are given by law, they are suggested by the operator and approved by the State Office for Nuclear Safety within the scope of the monitoring plan. At the moment, when the installation is launched into operation, they will be again specified with the consent of the State Office for Nuclear Safety in such a way to reflect the real situation in the operation, and if any anomalies appear directly at the source to signal the situations defying a normal level.

The effort of the power plant cannot be reactions only to the situations that could have an impact to the environment, but already registering unusual situations directly in the place of their occurrence with the highest possible sensitivity.

2.1.1.7. Radioactive discharges to atmosphere from other installation

In the radius of 100 km from the Nuclear Power Plant Temelín there are no important sources of ionising radiation, apart from the closing down and sanitated workplace UP Mydlovary.

For the critical groups of inhabitants in the locality Mydlovary – sludge-drying bed after the uranium mining, the State Office for Nuclear Safety monitors in the villages of Olešník and Mydlovary the impact of radon, alpha radiation of the decay members of the U-Ra series and the external gamma in comparison with the reference points (Ceská Lhota and Hluboká nad Vltavou). Since 1999 the continuous measuring has been carried out (6 times in 24 hours) by means of the device ALPHAQUARD. As regards radon and external gamma, any differences above the scope of the fluctuation of the natural background are not found in the last two years in the measured places. The impact of the alpha radiation of the decay products of the U-Ra series in the monitoring points are in the range approx. 20 μSv.year^{-1} of the effective dose. It is clear from the comparison of the measurement results in the monitoring and reference points that the contribution of the sludge box impact towards the annual effective dose of the inhabitants of the villages Mydlovary and Olešník is even in a conservative assessment of the measurement results on the level of several dozens of μSv.year^{-1}. On 21/03/2000, the State Office for Nuclear Safety issued a decision concerning the release of radionuclides to the environment, ref. no. 28847/4.3/00, in accordance with which the limit of the effective dose was set to be 250 μSv.year^{-1} with the condition that it will be specified in more detail (very probably decreased) on the basis of the measurements carried out in accordance with the approved monitoring programme. Other objective data will be brought by the prepared environmental impact assessment (EIA in accordance with the Czech law).

2.1.1.7.1 Procedures for co-ordination with discharges from other installations

Due to the fact there in the neighbourhood of the nuclear power plant there are no important sources of ionising radiation, the co-ordination with discharges from other installations is not carried out.

Key problem: The release of radionuclides to the environment in the form of discharges to the atmosphere.

In accordance with the contemporary examination it is possible to state:

The impact of the Nuclear Power Plant Temelín on the atmosphere can be expected as not very important.

Recommendation:

1) **After launching the Nuclear Power Plant Temelín to the commercial operation it is necessary to ensure the continuous measurement of airborne radioactive effluents in the exact way in the existing measurement network of the operator.**
2) **To improve continuously the existing radiation monitoring network operated by the state authorities of the Czech Republic.**
3) **To inform the public in the Czech Republic, Austria and Federal Republic of Germany about all the results of the measurement.**

2.1.2. Climate

The climatological analysis of the situation of the lower part of the atmospheric boundary layer is focused on the analysis of the energy balance, flow proportion and vertical stability of temperature stratification. The measured values of the selected climatic components can be used directly for the climatic characteristics of the atmospheric boundary layer. However, these are only representative for strictly defined conditions of the measuring station – the meteorological observatory of the Nuclear Power Plant Temelín.

2.1.2.1. Local climatology with frequency distributions

The territory of interest is situated in the Atlantic – continental area of the temperate climatic zone of the northern hemisphere [O.3.1]. All year round air masses of the oceanic and continental origin alternate here which form mainly in the middle latitudes. The following characteristics were obtained from the statistic processing of data of climatic observatory stations of the Czech Hydrometeorological Institute, the observatory Temelín, which represents the macroclimatic conditions of the upland "Táborská pahorkatina", especially of its part "Bechynská pahorkatina".

Graph no. 8: Average temperature of the air in the years 1989 to 1999

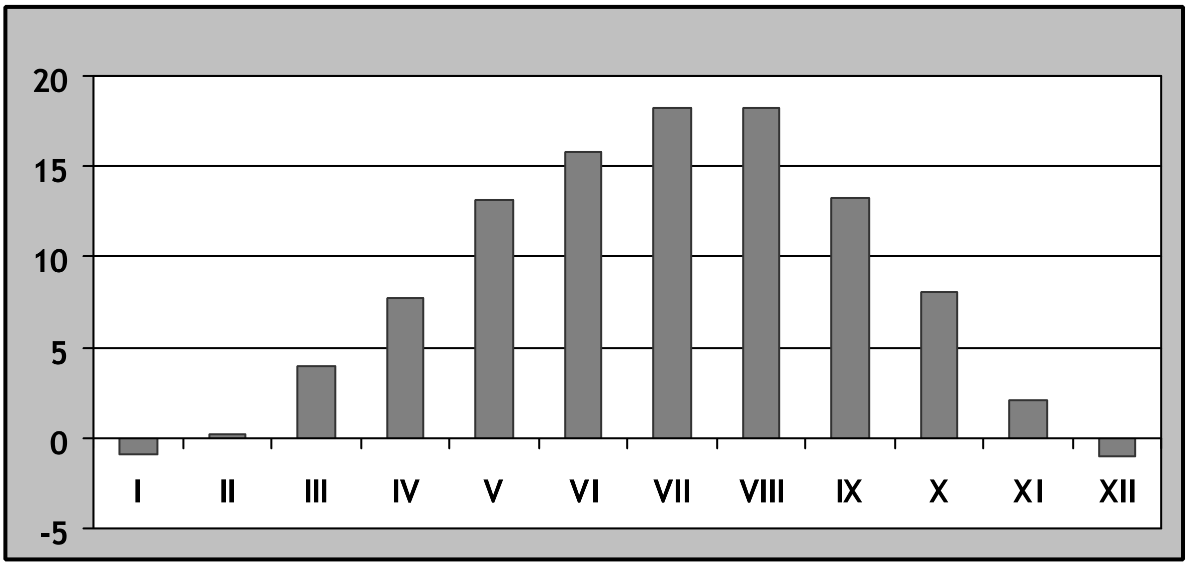


Table no. 14: Absolute maximum of the air temperature

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
17.5	19.8	25.3	26.9	29.0	34.3	35.2	36.4	27.8	22.5	20.3	16.0

Table no. 15: Absolute minimum of the air temperature

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
-18.5	-20.0	-13.3	-5.2	-1.5	0.2	5.6	4.8	0.2	-8.3	-13.1	-23

Table no. 16: Average relative humidity of air in %

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
85	80	76	72	68	72	69	68	78	82	88	87

An important climatic feature is number of foggy days. These are days when the horizontal visibility even for a short time was smaller than 1 km. The increased frequency of these days are noticed in Temelín in autumn and winter. There is about 68.3 these days per year.

Table no. 17: Average number of foggy days

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
9.3	5.4	4.2	3.0	2.4	3.3	3.5	3.5	7.4	9.3	9.5	7.7

Table no. 18: Average time of the duration of sunshine in hours

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
67.7	102.4	129.2	161.2	237.1	221.9	251.5	250.3	156.4	127.3	50.1	49.9

2.1. 2. 1. 1 Frequency distribution of the wind directions and speeds

Synoptic situations of western directions (39.9 %) prevail in the area. The frequency of the situations of eastern directions is 15.7 %, northern situations 16.0 % and southern situations 7.5 % [O.3.42]. The zonality of flow is the lowest in spring when in comparison to the other seasons the frequency of northern situations (20.3 %) and situations of eastern directions (21.6 %) is markedly increased.

The maximum gust in the best comparable station with anemographic observation in Prague - Ruzyne reached in winter 1993 - 1994 the value of 45 $m.s^{-1}$. Statistically approximated value of the hundred-year gust is 48 $m.s^{-1}$, thousand-year gust is 56 $m.s^{-1}$ and ten-thousand-year gust is 65$m.s^{-1}$. The last number is probably overrated by approx. 10 $m.s^{-1}$. However, in the Czech Republic the exceeding of only the hundred-year value have been measured so far. It happened on the hill Milešovka 160 km far away (50 $m.s^{-1}$), which, however, is ranked among mountain stations (833 m above sea level) with extreme wind speeds.

Table no. 19: Average annual frequency of wind directions in % of all the observations

N	NE	E	SE	S	SW	W	NW
9.2	12.1	11.9	7.3	7.1	17.8	20.1	9.3

In the annual average, the main prevailing wind direction in the locality of Temelín is south-west-west (249.7^0) with the frequency of about 37.9 %, the second prevailing direction in the annual average is north-east-east (61.2^0) which has the frequency of 24 %.

2. 1. 2. 1. 2 Frequency distribution of the precipitation intensity and duration

For most of the situations, the highest average daily precipitation amounts were recorded in summer, the lowest in winter. It does not apply for the north-east situations, during which the highest precipitation amounts appeared in autumn, and for the south-east situations, when in autumn similar average daily amounts were observed as in winter. The most precipitation was recorded during low pressure over Central Europe in summer and the least in winter during the pressure head over Central Europe. In spring and in autumn the average daily precipitation amounts during individual weather situations roughly even, with the exception of south-west and north-east situations. During south-west situations the average daily precipitation amounts in spring are higher than in autumn and they are only slightly higher than in summer. The autumn precipitation amounts in these situations are comparable to the winter ones. For the situations of generally cyclonic and anticyclonic character apply similar conclusions. The highest average daily amounts were recorded for both these groups of situations in summer and the lowest in winter. However, during generally cyclonic situations the precipitation amount is higher than during the generally anticyclonic situations (according to the data for the station Prague Klementinum in [O.3.42]).

Graph no. 9: Average precipitation amount in mm

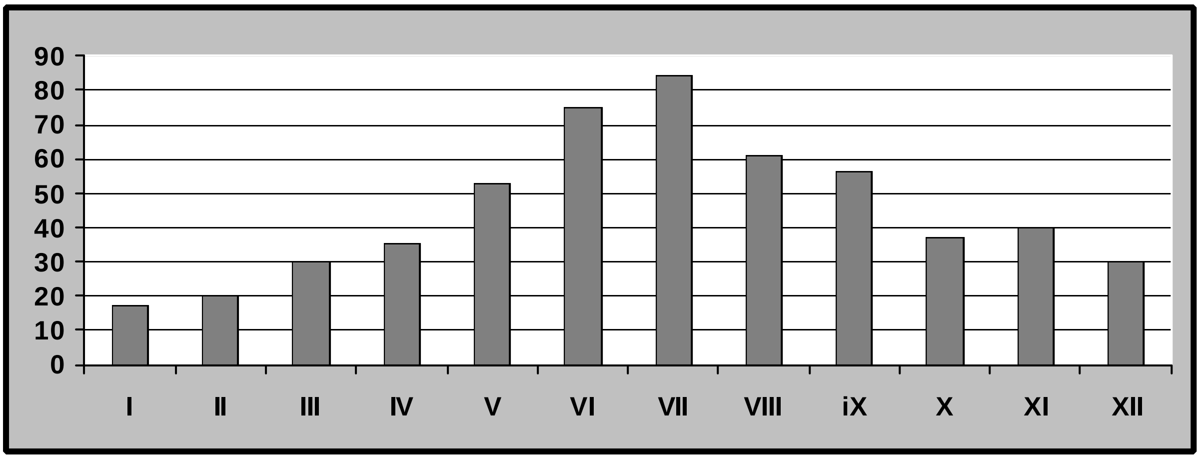


Table no. 20: Average number of days with precipitation 1 mm and more

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
5	5	8	8	8	11	10	10	8	7	7	7

Table no. 21: Average number of days with the precipitation of 10 mm and more

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0	0	0	1	1	2	2	2	2	1	1	1

Table no. 22: Average height of the snow cover in cm

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2.8	3.6	1.4	0.1	,,,	,,,	,,,	,,,	,,,	,,,	0.9	2.1

2. 1. 2. 1. 3 Local climatology - for each wind sector, atmospheric dispersion conditions, temperature inversions

The proportion of the situations of anticyclonic and cyclonic character is roughly levelled. The difference in frequency is approx. 3 % in favour of the cyclonic situations. The occurrence of pressure heads over Central Europe, however, markedly predominates over the occurrence of low pressures (the frequency of 30.3 and 14.5 % in all the situations). In comparison with anticyclonic situations, the cyclonic situations are more frequent, especially in spring and winter, in summer the proportion is balanced and in autumn the anticyclonic situations generally slightly prevail.

From the important influence on the atmosphere and climate it is necessary to mention especially the potential influence of the operation of cooling towers of the power plant on the climatic factors of the area.

The released waste heat from the nuclear power part, but also an extensive change of the original active surface formed by greenery will lead to an important impact on the distribution of the individual climatic elements in its surroundings. A massive source of the evident and latent heat will influence considerably the heat balance of the atmospheric boundary layer. The measurement at the nuclear power plant in Niederhausen showed the differences in air temperature in the distance of hundred meters between the windward and leeward side of the cooling towers in the range of 0.3 to 0.4 ^{0}C. At the nuclear power plant Liebstadt the increase of the annual average temperatures lower than 0.2 ^{0}C was found. However, the released heat from the cooling towers and especially the technogenic active surface of the whole power plant grounds is very contrastive as regards the temperature compared to the natural active greenery-covered surface in the neighbourhood. These temperature contrasts are most visible in clear, quiet weather and they lead to the development of the micro-circulation in the ground and lower part of the atmospheric boundary layer.

By means of the assessment of the vertical segmentation of the relief including the character of its active surface we will have to solve also another group of questions concerning the atmospheric protection. This is the classification of intensity, length of duration as well as the frequency for the dispersion of emissions of the most important processes under typical weather conditions in the ground layer of the atmosphere at night, i.e. katabatic processes and the subsequent occurrence of local radiation temperature inversions. In this case it is especially the assessment of the questions that are vital for setting the size of the potential of the dispersion of atmospheric admixtures in stable temperature layering.

In clear and quiet weather at night, cool air falling down the slopes gradually fills up the valley and all hollow shapes of the relief (including the slope ravines – delens). In accordance with the mechanism of the origin thus this part of inversions is of the alochtonous origin. Gradually with the filling up of the valley with cool air, the lower border of katabatic process shifts to higher and higher positions. In the place of the outlet of the concentrated outflow (usually at the bottom of the valley) we can then expect its negative effects. It can transmit atmospheric admixtures (pollution by solid or gas substances or annoying smells) under the inversion layer from bigger distances.

The intensity of micro-circulation or micro-advective processes in the wider locality of the nuclear power plant including the specification of the positions with the occurrence of the local radiation temperature inversions could not be taken into consideration in the input of the model calculations. This supplement could certainly significantly specify the presented results in greater detail. The mentioned characteristics can be supplemented, but at the moment they are not available. Thus it is possible to consider their preparation and gradual use for completing the model calculations.

During the operation of the cooling towers of the Nuclear Power Plan Temelín, the emitted water-saturated air will form a visible plume. The length and the rise of the plume depends especially on the meteorological conditions in the atmosphere boundary layer. It is clear from the long-term observation, that with the relative humidity up to 75 % there are usually short plumes up to 300 m, with the relative humidity between 75 and 90 % there is 40 % of plumes short up to 300 m, 40 % of them is medium between 70 to 900 m and only 20 % are longer than 900 m. Monitoring of the shading impact of the plume is important. The shading influences various places in the neighbourhood of the cooling towers. Due to a significant dependence of the shading on the Sun trajectory, in winter especially the northern quadrant is affected, in summer then it is also the eastern and the southern quadrants. As the plume is shorter in warm sunny days in summer, a smaller area is affected compared to the clear weather in winter. The total time of shading per month can range from several to 20 hours within the distance of 1 kilometre. Here it is necessary to mention that the plume casts a shadow on one side but on the other side it strongly reflects light due to its albedo between 50 and 60 %. The illumination is thus in the neighbourhood of the plume in clear weather by 5 to 10 % higher compared to the area distant from the plume. However, with a cloudy sky the loss of illumination under the plum reaches up to 20 %. Due to the fluctuation of the plume, the average time of shading effect in the near locality of the nuclear power plant per day will be about several minutes, which corresponds to the decrease of the total intensity of sunshine by about 3 to 4 %.

Under certain conditions we can consider the role of the plume in the cloud formation. The emissions from the cooling towers can induce the origin of convective clouds from which the precipitation can fall out occasionally or from which even stratified cloudiness can develop.

In accordance with the mathematical-physical model CT PLUME dealing with the duration of the shading of the earth surface by the impact of the plume of the nuclear power plant cooling towers, we can expect the time of shading within the distance of 5 km from the power plant 40 to 300 hours a year. With the distance of 5 to 15 km from the Nuclear Power Plant Temelín this time ranges up to 60 hours.

Processes influencing humidity conditions

The evaporation from the cooling towers of the Nuclear Power Plant Temelín together with the residual drops not removed by the separators and the increased evaporation from the surface of warm waste water significantly influences the humidity of the atmosphere boundary layer. However, on the other hand the decrease of humidity happens together with the change of the original active surface to the technogenic surface.

In accordance with the results of the mathematical-physical model CT PLUME dealing with the impact of the plume of the cooling towers on the humidity conditions in the lower part of the atmosphere boundary layer, we can expect the increase of the absolute air humidity by the maximum value in the order of magnitude 0.1 $kg.m^{-3}$. The average change of the annual average of the absolute humidity in 2 m in accordance to the model calculation, within the distance of 5 km from the nuclear power plant ranges between 0.000001 and 0.000006 $kg.m^{-3}$, in the distance of 5 to 10 km this value ranges between 0.000002 and 0.000006 $kg.m^{-3}$ and in the distance of 10 to 15 km then in accordance with the model drops to 0.000001 to 0.000006 $kg.m^{-3}$.

It is possible to state that the model calculation of the expected change of humidity conditions is totally unimportant and in the wider locality it is so far absolutely experimentally unnoticeable so far.

Processes influences precipitation conditions

The air current drifts small water drops from the cooling towers to the neighbourhood of the nuclear power plant, which, together with possible drops arising from the condensation of water steam in the plume, can fall on the surface and thus slightly increase the precipitation amount. Due to the size of the drops between 50 and 300 um it can be expected that overwhelming majority of them will evaporate even before they fall on the ground. Such precipitation can thus happen practically only in cold weather and with high air humidity. The maximum of precipitation arising in this way usually appears in the distance of 2 to 4 fold of the cooling tower height. Their annual amount does not exceed 20 mm and due to the density of the ombrometer network in the Temelín locality we cannot identify it objectively. Similarly it was not possible to prove the increase of the precipitation amount in the neighbourhood of the cooling towers of the power plant Pocerady by means of the comparison of the data before and after the construction.

However, the possible increase of precipitation can be higher than the amount of water emitted from the cooling towers. However, the usual modelling of these situations is very difficult, because it is a very complicated thermodynamic interaction of the cooling tower plume and of the cloudiness. Moreover, the input data is not available at the moment.

The possibilities of the assessment of the impact of precipitation in the wider locality of the Nuclear Power Plant Temelín are very limited, as the assessment of the power plant impact on the climate is complicated by the synergic action of anthropogenic, urban and technogenic factors, and recently even the influence of global extent.

Processes influencing wind conditions

In the meso-scale we should simulate especially the impact of topography and different warming of the active surface on the air current for the nuclear power plant. The impact of obstacles changes considerably not only the wind direction and speed but especially the structure of the current. Whirlwinds arise near the obstacles and the turbulence is increased. Immediately behind the obstacles there is a wind shade, where whirlwinds with horizontal axis often appear. Depending on the height of the obstacle, steepness of the slopes or walls and the wind speed, moving whirlwinds occur on the leeward side, which gradually die out (as a replacement new or stationary whirlwinds occur). The size and the character of these changes depends not only on the size and shape of the obstacles, but especially on the current speed and temperature stratification of the atmosphere. In larger valley systems, also their sewerage effect is important which significantly influences the processes in the lower part of the atmosphere boundary layer. The impact can be thus considered to be local, reaching to the distance of about 2 to 4 km from the power plant. Despite this it is necessary to mention that the nuclear power plant construction caused important non-omissible changes of the vertical segmentation of the relief (macro-roughness) as well as of the aerodynamic roughness of the active surface (micro-roughness).

Outside the power plant grounds it is possible to expect a sudden change of wind speed on the road adjacent to the cooling towers during western directions of current with the wind speed over 5 $m.s^{-1}$ as a result of the partitioning effect of the cooling towers and the increase of current speed around them.

In the so far mentioned cases the topography of the surface and the technogenic surface of the nuclear power plant acts as an obstacle for the synoptic current. However, the differences in the orientation and inclination of the slopes also cause an uneven supply of solar energy and thus an uneven warming. Temperature differences cause differences in air pressure and these can then lead to the occurrence of local circulation systems.

These facts showing especially in the lower part of the atmospheric boundary layer were not sufficiently documented during the construction. However, these are less important local changes of the character of micro-circulation so far. However, it can be expected that by the launching of the operation of the Nuclear Power Plant Temelín, these micro-circulation processes will have certain changes of their character and intensity due to the change of the spatial stratification. Thus it is necessary to consider the monitoring of these processes in the power plant grounds, but also outside within the radius of several kilometres.

Local influences and influences of near regional reach (within 30 km):

An extensive study was prepared by the Institute of Atmosphere Physics of the Academy of Sciences of the Czech Republic, assessing the impact of the cooling towers of the power plant Temelín on the weather and climate [Rezácová a kol., 2000]. This study includes an extensive search of existing knowledge in this area and it also presents the results of the mathematical-physical model of the plume from the cooling tower system. On the basis of the most modern world knowledge a model CT PLUME was prepared, which simulates the plume spread as well as the plume impact on some meteorological characteristics. The model was applied to the data from the locality Temelín and the assessment of the plumes on the temperature and humidity in the ground layer and on the shading by the plume was carried out. Also the possibility of the impact of precipitation, fog and frost was monitored.

The summary of the expected values of the changes of the natural climate as a result of the operation of the cooling towers is given in the following table:

Table no. 23: Average change of natural climate in two main directions from the cooling towers

Distance [km]	Direction from cooling towers	Factor	Change of annual value

5	East	Air temp. in 2 m above ground [°C]	0.04-0.06
		Absolute air humidity in 2 m [kg/m^3]	0.000002-0.000006
		Duration of surface shading [h]	240-300
	West	Air temp. in 2 m above ground [°C]	0.02-0.04
		Absolute air humidity in 2 m [kg/m^3]	0.000001-0.000003
		Duration of surface shading [h]	40-150
5-10	East	Air temp. in 2 m above ground [°C]	0.03-0.04
		Absolute air humidity in 2 m [kg/m^3]	0.000002-0.000006
		Duration of surface shading [h]	0-60
	West	Air temp. in 2 m above ground [°C]	0.02-0.03
		Absolute air humidity in 2 m [kg/m^3]	0.000001-0.000003
		Duration of surface shading [h]	0-60
10-15	East	Air temp. in 2 m above ground [°C]	0.03-0.04
		Absolute air humidity in 2 m [kg/m^3]	0.000002-0.000006
		Duration of surface shading [h]	0-60
	West	Air temp. in 2 m above ground [°C]	0.01-0.02
		Absolute air humidity in 2 m [kg/m^3]	0.000000-0.000001
		Duration of surface shading [h]	0-60

Summary to the expected changes in the climate as result of the operation of the cooling towers

On the basis of the presentation of the results of the mathematical-physical model CT PLUME interested in the impact of the plume from cooling towers on the temperature conditions in the lower part of the atmospheric boundary layer, it is possible to estimate the stratification of the maximum temperature increments in the order of magnitude 1 ^{0}C. The absolute maximum around 5 ^{0}C. The average change of the annual average of the air temperature in the distance of 5 km from the NPP Temelín in accordance with the model calculation ranges from 0.02 to 0.06 ^{0}C, in the distance of 5 km this value ranges from 0.02 to 0.04 ^{0}C and in the distance of 10 to 15 km then in accordance with the model drops to the amount of 0.01 to 0.04 ^{0}C. It is clear from the same model interested also in the duration of the shading of the surface by the impact of the plume from the cooling towers of the Nuclear Power Plant Temelín that within the distance 5 km from the Nuclear Power Plant Temelín we can expect the length of the shading from 40 to 300 hours a year. With the distance of 5 to 15 km from the Nuclear Power Plant Temelín this time ranges up to 60 hours. From the results of the mathematical-physical model interested in the impact of the cooling tower plume on the humidity situation in the lower part of the atmospheric boundary layer we can expect the change of the annual average of the absolute humidity in 2 m within 5 km from the Nuclear Power Plant Temelín between 0.000001 and 0.000006 kg.m^{-3}, in the distance 5 to 10 km it ranges between 0.000002 and 0.000006 kg.m^{-3}. In the distance of 10 to 15 km it then drops in accordance with the model to 0.000001 to 0.000006 kg.m^{-3}.

The influences of the regional reach bigger than 30 km:

The expected impact of the power plant Temelín is insignificant as regards the annual averages and their fluctuation and it does not lead to the negative change of climatic situation. From the point of view of the protection of the environment in the region we cannot speak in any case about negative or even devastating impact on the climate. At the same time, however, it is an important and long-lasting effect as regards the anthropogenic changes of the climate and as regards the individual weather effects. Anthropogenic changes of the climate are a result of a whole range of effects which do not have to seem important by themselves. However, the impact of the power plant Temelín from this point of view cannot be assessed in an isolated way, but from the point of view of the total energy demands of the society and from the point of view of the effects of the nuclear power plant compared to other energy sources and compared to other anthropogenic effects.

Here two situations can appear:

- Replacement of the existing energy source (only change of the source, not of the produced amount). In this case it is necessary to assess the difference of the impact on the climate (generally on anything) in comparison with the liquidated source.
- Need of a new energy source (increase of the so-far produced amount of energy). In this it is necessary to assess the difference of the impact in comparison with alternative energy sources.

In case that the replaced or alternative source is e.g. a thermal power plant, it is necessary to assess the difference compared to this power plant with an equivalent output (the amount of emissions, produced heat and water steam). From the regional point of view it is necessary to mention that in the past extensive anthorpogenic changes were carried out in the southern Bohemian region as well as in the whole republic (and not only there), such as distinct shortening of the length of watercourses, decrease of the forest area and solidification of large areas as a result of construction of many kinds (various housing estates, roads, factories etc.) It led to the distinct increase of outflow, decrease of the ground water level and decrease of evaporation. In our opinion, as regards the territory of Bohemia, this effect is comparable with the increased evaporation as a result of the power plant operation.

For the comparison with the evaporation from the cooling towers we used the annual values of the potential evaporation from the water surface, i.e. the situation, as if there was a lake with the area of 100 ha in the place of the power plant. This area roughly corresponds to the double of the solidified area in the power plant grounds. The average annual potential evaporation from the water surface with such area is 0.675 m.100 ha = $6.75.10^5$ $m^3.year^{-1}$. The projected evaporation from four cooling towers is on average 1.64 m^3s^{-1} = $5.17190.10^7$ $m^3.year^{-1}$. The operation of the cooling towers thus will increase the local evaporation by $5.1044.10^7$ $m^3.year^{-1}$, i.e. approx. 75 times. For medium heavy bleak soil the evaporation is 3.12 $.10^5$ $m^3.year^{-1}$. In comparison to it, the evaporation will increase 165 times. The output of the cooling towers roughly corresponds to the situation as if the medium heavy bleak soil was replaced by a lake with the size of 10 x 7.5 km. We can also say that the evaporation from the cooling towers equals the evaporation from the medium heavy soil if it is replaced by solidified surface on the area of 166 km^2 (the square of approx. 13 x 13 km).

In accordance with model studies, in the distances longer than 25-30 km it is possible to consider the impact of the power plant Temelín and water steam to be practically non-distinguishable from the background. The possibilities of estimating the separate impact of the power plant to the region wider than 30 km around the power plant are thus very limited, because the assessment of the power plant impact on the climate is complicated by the synergic operation of both anthropogenic and non-anthropogenic factors of different origin. It includes especially the fluctuation and changes of climate as a result of the impacts of the global extent and the impacts of anthropogenic activities in the close as well as distant neighbourhood of the power plant. The larger is the assessed region, the weaker are the impacts of the power plant Temelín and the more important are the impacts of other factors.

As regards any possible impacts on wider region, it is a question behind the border of the environmental impacts of the Nuclear Power Plant Temelín. The problem of large-scale effects of such large sources is connected rather with the problems of the regional to world-wide energy balances of the atmosphere.

2.1.2.1.4. Local climatology - monthly average

In accordance with the classification CHMÚ (Czech Hydrometeorological Institute) [O.3.32], the grounds of the power plant Temelín are situated in the climatic area B3 (moderately warm, moderately humid, with moderate winter, hilly, number of days with maximum daytime temperature >= 25 °C <50; average temperature in July > 15 °C, in January > -3 °C ; Koncek's moisture index Iz in the range of 0 - 60; height to 500 m above sea level)

In accordance with Quitt [O.3.79], the grounds of the power plant is in the area MT10 (long summer, warm and moderately dry, short transitional period, with moderately warm spring and moderately warm autumn, short winter, moderately warm and very dry, with a short duration of snow cover). The criteria of the area MT10 are given in the following table:

Table no. 24: Criteria of the area MT10

Number of summer days	40 - 50
Number of days with average temperature >=10 °C	140 - 160
Number of frosty days	110 - 130
Number of freezing days	30 - 40
Average temperature in January [°C]	-2 to -3
Average temperature in July [°C]	17 - 18
Average temperature in April [°C]	7 - 8
Average temperature in October [°C]	7 - 8
Average number of days with precipitation of 1 mm and more	100 - 120
Precipitation amount in vegetative period [mm]	400 - 450
Precipitation amount in winter period [mm]	200 - 250
Number of days with snow cover	50 - 60
Number of cloudy days	120 - 150
Number of clear days	40 - 50

Selected local meteorological features are given in the following table:

Table no. 25: Selected local meteorological features

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Absolute temperature maximum	17.5	19.8	25.3	29.6	33.4	34.4	37.5	37.0	33.2	28.0	20.3	17.2	37.5
Absolute temperature minimum	-32.0	-28.8	-23.1	-10.3	-4.7	0.9	3.8	2.0	-2.5	-9.1	-15.4	-28.1	-32.0

The data shown in the table are from the stations in the radius of within 30 km around Temelín in the period 1926-1950 and 1961-1999 and from the station Temelín for the period 1989 to 1999.

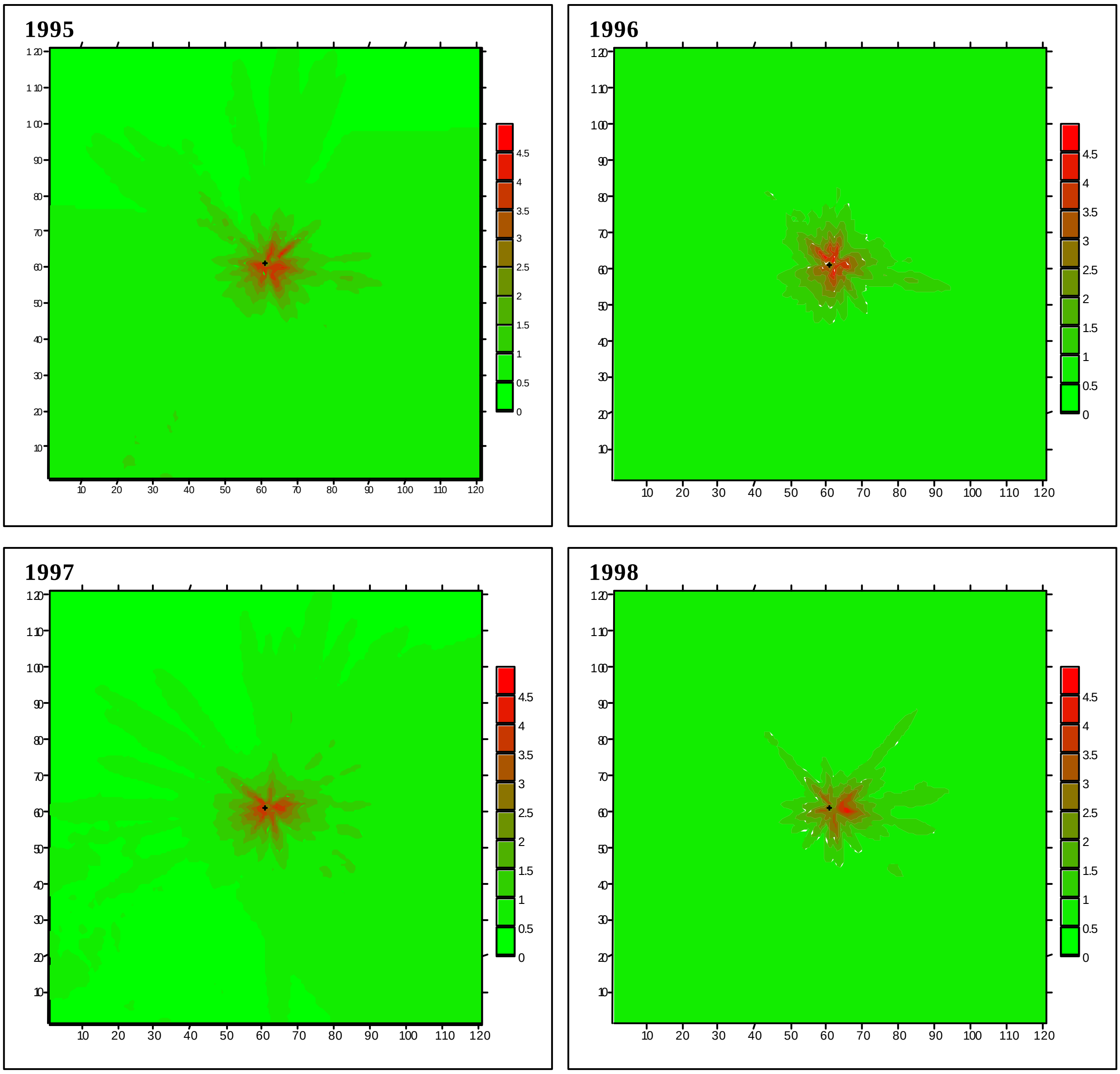
2.1.2.1.5 Local climatology - extreme weather conditions

In our territory it is not possible to exclude absolutely the opportunity of the occurrence of a very small tornado, even though its occurrence right in the monitored locality is not very probable. On the basis of the study of historic materials, about thirty cases of this phenomenon are documented in the territory of the Czech Republic. The extent of damage caused in the past by tornadoes in our territory is comparable to the impacts of gales and vortexes. It is often problematic, which of the mentioned phenomena caused the given damage. In the Czech literature the term “tornado” was not used for our territory, the whirlwind with other than horizontal axis was referred to as thrombus with regard to the significantly lower destructive power of the phenomenon than have the classical tornadoes as in the American continent.

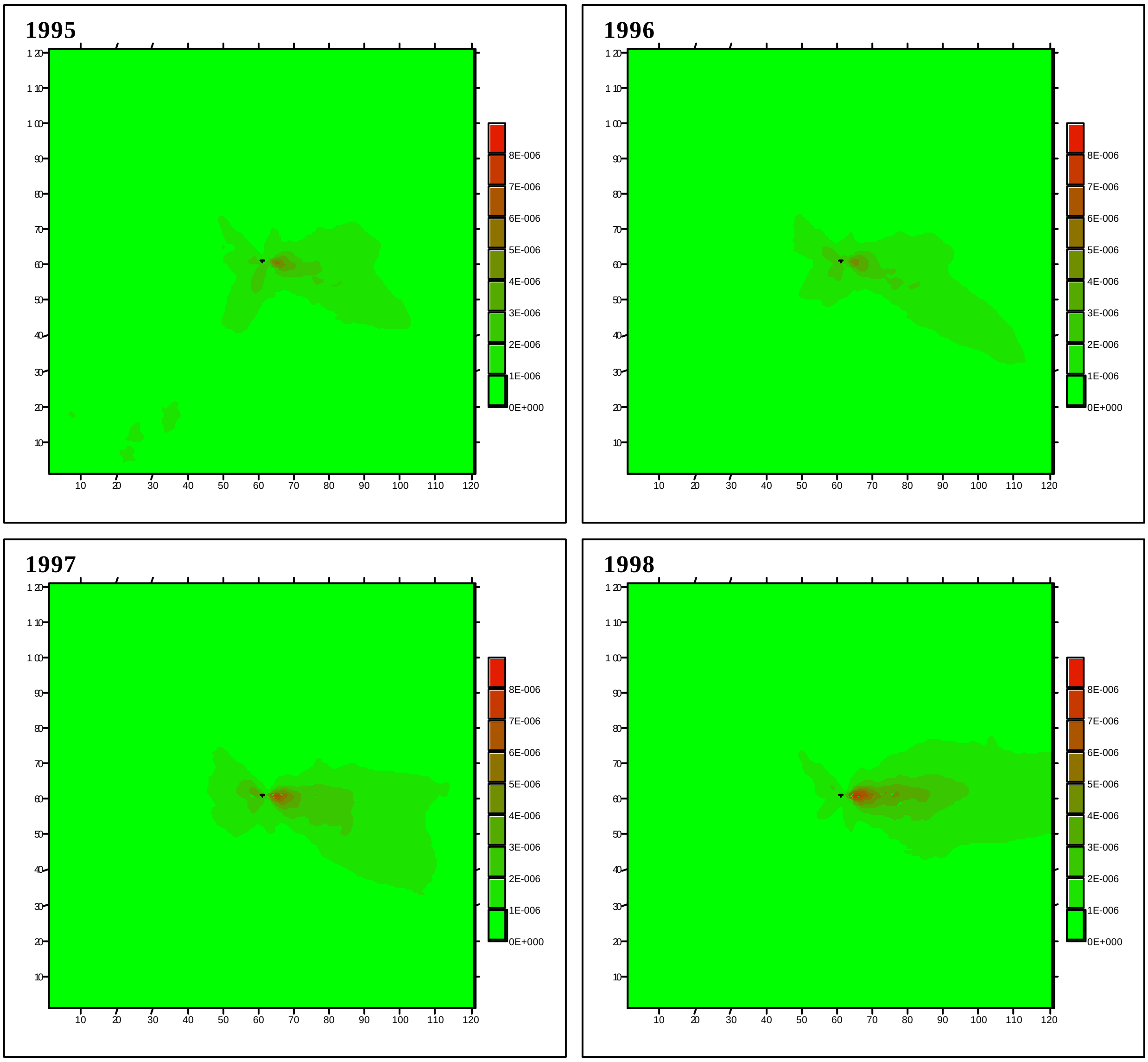
The maximum gust in the best comparable station with anemographic observation in Prague - Ruzyne reached in winter 1993 - 1994 the value of 45 $m.s^{-1}$. Statistically estimated value of the hundred-year gust is 48 $m.s^{-1}$, thousand-year gust is 56 $m.s^{-1}$ and ten-thousand-year gust is 65$m.s^{-1}$. The last number is probably overrated by approx. 10 $m.s^{-1}$. However, in the Czech Republic winds exceeding only the hundred-year value have been measured so far. This happened 160 km far away on the hill Milešovka (50 $m.s^{-1}$), which, however, is ranked among mountain stations (833 m above sea level) with extreme wind speeds.

The graphic outputs were chosen for the assessment of the surface impact of the plumes in the neighbourhood of the Nuclear Power Plant Temelín, which show the stratification of the impacts in the area of 60 x 60 km around the source locality. As an example we give the stratification of the maximums of the temperature increments and the average annual increment of the absolute humidity.

Graph no. 10: Distribution of the maximums of the temperature increments [K] calculated from the meteorological measurements for individual years



Graph no. 11: Average annual increment of the absolute humidity in individual years [kgm^{-3}]



Key problem: The potential impact of the operation of the cooling towers of the nuclear power plant on the climatic factors of the territory.

In accordance with the contemporary examination it is possible to state:

The impact of the Nuclear Power Plant Temelín on the climate can be said as being not very important.

Recommendation:

1. **After launching the Nuclear Power Plant Temelín into commercial operation it is necessary to monitor the impacts of the operation of the cooling towers of the Nuclear Power Plant Temelín even in the wider region by means of the existing network of meteorological stations of the Czech Hydrometeorological Institute, at least for the life-time of the power plant.**

2.2 Hydrology

2.2.1. Utilisation of natural resources

The problem of interaction of the Temelín Nuclear power plant and water is treated in terms of all-useful functions of water in the biosphere, i.e. as an irreplaceable source for human life and as a medium in a technological process. The complex problem is resolved against the background of water circulation in nature, i.e. hydrology and hydrogeology of surface and groundwater. If not stated otherwise the fundamental information is taken from *Documents for assessing the impact on the environment, authorised by INVESTprojekt s.r.o., Brno (03/2001)* and from the Decision for permission to treat water pursuant to *§ 8 of Act No. 138/1973 Coll. about water for Temelín Nuclear power plant (Ceské Budejovice District Office, 1993)*. Other documents used are continuously cited and stated in the "Reference" section.

2.2.1.1. Overall demands on water resources

The overall water demand under operating conditions for drinking water is on average 10.8 [m^3/h], i.e. on average 80 to 100 000 [m^3/year]; during shutdown periods and an increased number of personnel the max. is approx. 28.8 [m^3/h], i.e. max. approx. 230 000 [m^3/year].
For service water including water for cooling the average demand of 5850 [m^3/h] and 38.019 x 10^6 [m^3/year] is permitted.
Information about water demand during construction is further stated according to reality.

2.2.1.2. Description of water resources and water supply

Drinking water
The supply of **drinking water** to the power plant is from the public water supply, operated by Jihoceské vodovody a kanalizace. The connection to the public water supply is in the reservoir on Zdoba hill (storage capacity is 3x1000 m^3) in a NE direction above the power plant site at a distance of approx. 4.5 km as the crow flies; it is fed from the Rímov filter plant. Both the Temelín power plant and the town of Týn nad Vltavou are supplied from the reservoir. The bottom of the reservoir is set at a ground elevation of 555.0 m a.s.l. and creates a max. hydrostatic overpressure of approx. 0.6 MPa above the power plant site. The supply pipeline from the Zdoba reservoir to the power plant is designed as two DN 400 mm pipes laid parallel to each other. This is for the reason that if one pipe is damaged the supply of drinking water will still be ensured, especially to the hygienic loops for personnel in the restricted zone. The overall length of the pipes from the reservoir up to the water meter shaft by the power plant fencing is approx. 5300 m. The supply pipes of drinking water are terminated at the Northeast fence of the power plant in the water meter shaft, where overall measurement of the drinking water inlet takes place with integral recording. Drinking water distribution for the whole power plant is tied to this water meter shaft. It is designed as a loop water supply network of profile DN 100-300 mm with some separate branches to solitary power plant buildings. Internal drinking water distribution to buildings is connected to the external drinking water distribution line around the power plant by means of connectors. This brings drinking water to individual social facilities in the buildings. **The drinking water supply system is gravitational with pressure maintained by hydrostatic overpressure from the Zdoba reservoir. There are no pumping stations in the system.**
Drinking water can only be utilised for drinking purposes, the preparation of food, and washing and showering for power plant personnel. **By no means can this water be**

connected to any technological appliance in such a way that it could lead to contamination of the drinking water by other operational media.

The water mains enables a maximum demand of 86 l/s. Originally it was dimensioned for 4 power plant units and 3127 employees. For 2 power plant units maximum demand is assumed to be Q_{max} = 38 l/s and the average demand Q_{prum} = 5.6 l/s. At the start of 2000 the number of power plant employees was 1590. In 2001 this value is expected to be increased to approx. 1620 and in future years this value should slightly drop. At the start of 2000 altogether 4415 employees worked in the power plant (including external sub-contractors). An estimate of the number of external workers during nominal operation of two units is approx. 200, during shutdown up to approx. 3000 persons.
Development of actual water demand in the last years over the whole power plant site is given in the following overview; in [m^3/year]: 1996…236 919; 1997… 264 708; 1998 … 234 555; 1999… 225 987. From the mentioned data it follows that the current actual demand of drinking water is approx. 600 to 650 m^3/day (7 to 8 l/s; 230 000 m^3/year). The anticipated water demand will thus be analogically lower than designed for, namely to the level of 200 to 250 m^3/day (2.5 to 3 l/s; 80 to 100 000 m^3/year). During shutdown periods the demand will practically not differ from the current situation thanks to a higher number of external workers and will move around the interval of approx. 600 - 650 m^3/day.
The quality of drawn off drinking water is monitored in half yearly intervals partly at the input of the water mains to the power plant site and also inside the site at individual pipe branches. Values of monitored quality indicators in 1998 and 1999 complied with limit and recommended values in accordance with standards for drinking water, **with the exception of pH and in the power plant site with the exception of Fe**, whose content, in dependence on the actual flow through pipe branches, moves from 0.2 to 1 mg/l. See Table 26 for more details.

Table 26: Quality of drinking water at the water mains inlet to the power plant site

	NH_4^+	NO_3^-	NO_2^-	COD_{Mn}	Cl^-	pH	Ca+Mg	Fe (tot.)
Date	mg/l	mg/l	mg/l	Mg/l	mg/l		mmol/l	mg/l
14.10.1998	0.1	6.5	0.01	<0.5	8.5	7.6	1.12	0.3
12.05.1999	0.3	10	0.05	1.6	8.5	8.4	1.09	0.17
CSN 57 1111 Limit value	0.5	50	0.1	3	100	6-8	0.9-5[1)]	0.3

ad 1) recommended value

Microbiological investigation is also carried out, which is satisfactory longterm.

From the point of view of the content of radioactive material in supplied water analysis is carried out on the overall alpha volume activity and the overall beta volume activity by the Povodí Vltavy, a.s. radiological laboratory in Ceské Budejovice. Results of assessment of overall alpha volume activity in 1998 were less than 0.065 Bq/l and in 1999 less than 0.037 Bq/l, the overall beta volume activity in 1998 was 0.079 Bq/l and in 1999 0.060 Bq/l. A single analysis on radon 222, carried out by the company Vodní zdroje EKOMONITOR, s.r.o. Chrudim in 1998 was less than 20 Bq/l.

A ***special independent assessment*** of the safety of the supply of drinking water was processed by EKOAQUA-Ing. Václav Plechác, CSc., see the *Document for assessing the impact of Temelín Nuclear power plant on water management (03/2001).* In connection with this **the absence of two independent sources of drinking water for the power plant was ascertained**.

The reviewer sees the **dependence of drinking water on one water main** from the Plav drinking water filter plant by the Rímov basin at a distance of approx. 50 km from the Zdoba reservoir as a serious problem. In the case of an accident and a fault on the mains line or reservoir the supply of drinking water could be interrupted for an indefinite period. According to PRVKÚC (Project for development of water mains and canalisation of territorial units) of the district of Ceské Budejovice, which was processed in 1997 following the methodology of the Czech Ministry of Agriculture by Hydroprojekt a.s. Prague, Ceské Budejovice branch office, the east water mains from Rímov to Jindrichuv Hradec is not connected to the west branch leading to Týn nad Vltavou, from which Temelín NPP is also supplied, and neither the height conditions enable the supplying of Temelín NPP from Týn. At the same time Týn is able to be supplied from the west side by the water mains from the Bukovsko filter plant. However neither this mains enables connection to the east branch of the water mains from Rímov to Jindrichuv Hradec owing to the height conditions. The risk of the degree of not meeting the demands for drinking water for Temelín NPP **from two independent sources** should not be underestimated. Hence **the degree of meeting the demands for drinking water is low, reliability and risk can be evaluated as acceptable however the measure of uncertainty is large.**

Service water

Service water for the power plant is taken from the river Vltava. The main parts of the Temelín power plant water management system, ensuring supply of service water and drainage of waste water, are the water works of Hnevkovice with a concrete gravitational dam at river km 210,390 and Korensko with a weir structure at river km 200,41. The Hnevkovice water reservoir with a total capacity of 27.65 million m^3 of water simultaneously forms a buffer space for compensationally improving flow from the Lipno dam.

The raw water system design came from the assumption that the final capacity of Temelín power plant will be 4x1000 MW, and was built in advance, before the decision was made about not completing construction of the 3rd and 4th units. Requirements on dimensioning both the actual raw water pumping station (on the left bank of the Vltava at river km 210,46 i.e.. directly above the Hnevkovice waterworks dam), and two delivery pipelines 2 x DN 1600 of length 6.2 km to the end storage reservoirs 2 x 15000 m^3 within the power plant site, thus followed from these assumptions. The off-take point lies in catchment area number 1-06-03-076.

Water is partly utilised as **raw** directly without treatment in selected power plant systems, and partly after **chemical treatment.** The average output of water pre-treatment 281 m^3/h, the average output of demineralisation is 208 m^3/h, and the average output from the softening station is 70 m^3/h.

The amount of water taken from the Vltava is limited by the water management decision according to data in Table 27.

Table 27: admissible amount of drawn off water according to the decision of the district office Ceské Budejovice, Environmental Office ref. no. Vod.6804/93/Si, from 15.12.1993 for operation of 2 power plant units.

l/s (min.)	l/s (max.)	l/s (av.)	m^3/day (max.)	m^3/month	m^3/year (max.)
1228	1875	{⊙} 1625	162 000	5 022 000	38 019 000

When drawing off water the river administrator will ascertain, from cooperation between Lipno-Hnevkovice reservoirs, the minimum flow rate under the Hnevkovice waterworks, i.e. $Q_{min} = 6.5\ m^3.s^{-1}$ (under the junction with Lužnice $Q_{min} = 9.45\ m^3/s$). The supply of firewater is also included in the drawn off water mentioned above. The supply pipelines enable overall transportation of max. 4.16 m^3/s, from which one pipeline has 3.4 m^3/s. The system enables a significantly lower actual off-take of water according to immediate demand (e.g. season), i.e. pump raw water in an amount of 1.3 – 4.16 m^3/s.
The waterworks **Hnevkovice na Vltave** was designed for the function of at that time two envisaged stages – in the first stage for assuring the supply of water for two reactors of power 2000 MW, and in the second stage for the final previously envisaged power of 4000 MW. The dam at the Vltava river km 210,390 was built and put into operation **in 1991** with final parameters, with the height of overflow edges 20 m above the footing bottom. Modifications in the pools were however only carried out on the **surface of the first stage,** namely 370.50 m a.s.l. for a **total volume of the reservoir 21.1 million m^3**, from which 12.2 million m^3 storage. In the case of the second stage of construction, which is now not being considered, a second stage of modifications in the pools at an elevation of 372 m a.s.l. would be carried out, and the total volume would be increased to 27.65 million m^3 and the storage space of the reservoir would amount to 18.75 million m^3. In connection with this it is incorrect to label the overall volume of the reservoir 27.65 million m^3 as available, if so far **modifications in the pools have not been made, meaning this volume cannot be utilised**. The stated matter was mentioned in the ***special independent assessment*** done by EKOAQUA-Ing. Václav Plechác, CSc., see *Documentation for assessing the impact of Temelín Nuclear power plant on water management (03/2001).*

According to the operating regulations of the Hnevkovice and Korensko waterworks the capacity of the water source is greater than the demand of additional water in the Temelín power plant. The off-take of water for the Temelín power plant will be preferentially ascertained in cooperation between Lipno and Hnevkovice reservoirs.

In the case of **chemical treatment** the raw Vltava river water is fed through the pipeline 2 x DN 500 from the power plant reservoir. Treated water for individual buildings in the power plant area is distributed through pipelines over pipeline bridges.
For the primary and secondary circuits, the auxiliary equipment building and certain other operations **treated dimineralised water** is needed. For refilling hot-water systems **filtered softened water** is needed. Before actual demineralisation the raw water is **pre-treated by flocculation and subsequent filtration**, likewise for the preparation of softening water. Water flocculation (raw or surface blowdown from the towers) is carried out in the reactors, in front of which are flocculation chambers. For flocculation solutions of $Fe_2(SO_4)_3$, $Ca(OH)_2$ and PAA (polyacrylamide – auxiliary organic flocculant) are measured out. Flocculated water is filtered in the filters (dual double-layer filter) with silica sand beds. The demineralisation station for the treatment of demiwater is in a three-stage line arrangement. Three lines are installed, one of which is reserve. Regeneration of the filters of the demi-line is done with diluted sulphuric acid, sodium hydroxide and for sorptive filters with sodium

chloride. Demineralised water is stored is storage tanks and is finally treated on mixed filters. The aggressive waste water from regeneration of ion-exchange filter media, demi-lines and mixed filters is taken to the neutralisation station for neutralisation.

From the genesis of development and technical data it follows that the current and future state of demands on the source of drinking water is fully assured and the source of service water for the power plant with a power of 2000 MW is heavily overdesigned.

2.2.1.3. Emission to water media (routine operation) – liquid release

2.2.1.3.1. Total volume of discharged sewage, including water evaporated during cooling, water drained directly to the receiving stream (surface water); water released through the sewage treatment plant

Sewage is by default classified into **inactive** and **radioactive water**. Inactive water is formed from rain (precipitation) water, sewage water, service water, water containing oil products, and other sewage.

Rainwater is caught and drawn off by the gravitational system of the storm sewer. This is water from hard landscaping, building roofs and roads. Seepage water from drains and safety overflows from the clean water reservoir are also fed into the storm sewer. Besides this water pumped from drainage holes is led into the storm sewer (partly also sanitary sewer). This is implemented in order to remove irrigation from several buildings, or rather water seepage to their underground parts. Drainage of buildings in the form of lowering the level of groundwater over the whole area of the power plant would not be economical, owing to the low permeability of the rock media and dispersion of individual places of water seepage. Groundwater seepage is tied mainly to electrical distribution collectors and their connection to individual buildings and isolated equipment.

At the present time there are 45 drainage holes in operation within the confines of the power plant (until 1996 there were 30 holes in operation), and are of depth 25 m. The location of these drainage holes is obvious from appendix No. 8.10. Pumps are submerged in the holes at a depth of 20 m under the ground level. The level of the water table of individual holes or groups of holes is controlled in automatic mode by a pair of probes. The spacing of both probes (switching and tripping) is determined individually (yield of holes, depth of buildings foundations etc.). The level of the set water table is approximately at a depth of 20 m under the surface. Most drainage holes are discharged into the storm sewer, some into the sanitary sewer (holes OV 39, OV 43, OV 67, OV 79). Samples of pumped water are taken regularly from each hole. The chemical control centre takes samples once every 3 months. Holes are separated into groups and a sample is taken from each group of holes by an individual building on the condition that the quality of groundwater, pumped from holes to storm sewers, will be ascertained for each hole once a year. Chemical analysis is not carried out on those holes, which are pumped to the sanitary sewer (it is subsequently carried out on discharge from the sewage treatment plant).

Indicators, whose range was set on the basis of the requirements of water management authorities, KHS and Povodí Vltavy, are monitored in samples of pumped groundwater. These are: pH, conductivity, COD_{Mn}, NH_4^+,NO_3^-, NO_2^-, NEC, dissolved material.
The amount of pumped water is continuously monitored, and readings are taken 5 x monthly. Once a month a report about the number of pumped holes and the quantity of pumped water is submitted.
Rainwater is drawn off via the gravitational sewer (DN 300-1600 mm) to the main sewer (DN 2200 mm) and further to two safety (2x5500 m^3) reservoirs, lying outside the fenced off area of the power plant. The safety reservoirs are fitted with downflow baffles on the inflow side (mobile, 2 pcs on each reservoir) for catching floating impurities and oil products. A further concrete downflow baffle is located at the end of the reservoir in front of the overflow level. One of the reservoirs is operational and the second is reserve, so that shutdown of the reservoir is possible during cleaning, repair or a possible accident. Water flows from the safety reservoirs to the Býšov retention reservoir of capacity 183 000 m^3, which serves for storage or possible increased outflow.

Water flows from the retention reservoir via the local Strouha stream to the backwater of the Hnevkovice dam lake in the bight of the village of Jeznice (rainwater receiving stream).

The amount of drawn off rainwater is not measured. The quality of rainwater is monitored in 14-day cycles (samples) in safety reservoirs and at the outlet from the Býšov retention reservoir by indicators COD_{Cr}, NEC, NH_4^+, NL, NO_3^-, $P_{tot.}$, pH, DM, tensides, conductivity.
The yearly amount of drawn off rainwater according to the design of the District office Ceské Budejovice amounts to 400 000 m^3, a maximum of 103 200 m^3/day from the whole power plant area. Storm sewers are dimensioned for Q = 9.325 m^3/s, from which 7.025 m^3/s for actual rainwater and the remaining 2.3 m^3/s for safety overflow from the reservoirs

Sewage water from the power plant social facilities is fed to a mechanical-biological sewage treatment plant by the DN 250-400 mm sanitary sewer system. Two separate cleaning lines are implemented for the possibility of mechanical-biological cleaning of sewerage. One serves for sewerage from the area outside the restricted area and the second for water from social facilities, special wash rooms and hygienic loops in the restricted area. Sewage from the restricted area is taken to the treatment plant after checking the activity of individual sources so that their composition from the point of view of the content of radionuclides fulfils permission conditions of the water management authorities. The composition of sewerage water from power plant social facilities corresponds to common sewerage. Cleaned sewerage is then led to the reinforced concrete sewage water collection tank of capacity 500 m^3, located in the northwestern part of the site (part of the service water off-take system to Korensko). Sewage water is fed from this tank via the gravitational pipeline of profile 2 x DN 700 (1 in operation, 1 in reserve) of length approx. 6250 m to the discharging building in Korensko (building of gates and measuring). In this building the potential of the sewerage is utilised by its flow through a small water power station. Before inflow into the small water power station the quantity and quality of the sewerage is measured. **The outflow of sewerage is further led to the profile of weir level of the Korensko waterworks (sewage receiving stream)**, where sewerage is led into the suction pipe of the discharge turbines of this waterworks. If the water power plant in the Korensko weir is out of operation, sewerage will be discharged to the stilling pool area of the weir parts of the waterworks. The Korensko waterworks creates conditions for homogenisation of sewerage from the power plant with Vltava river water.

The amount of sewerage will correspond approximately to the demand of drinking water and the amount of water pumped from drainage holes to the sanitary sewer and will, according to the design, amount on average to a maximum of approx. 2 % of all sewerage from the power plant, which corresponds on average to a maximum of approx. 8 l/s. However from existing monitoring of the development of drinking water demand it follows that will amount on average to 3 l/s and water from drainage holes to approx. 0.02 l/s. Thus the amount of sewerage including water taken from the drainage holes can amount to approx. 1 % of all sewerage from the power plant.

As part of the operation of the **inactive zone** the following types of waste **service water** arise:

- surface blowdown from the cooling tower circuits (circulating cooling water).

  Water, which needs to be drawn off from the cooling system for maintaining its optimal chemical composition, is water containing basically only chemical elements contained in Vltava input water and in concentrations corresponding to the concentration level in the cooling circuit. Surface blowdown from the towers is led through the sewage water collection tank via waste water pipelines to Korensko (either directly or after flocculation), and the design enables temperature regulation of the drawn-off surface blowdown by selecting the draw-off point (hot/cold branch or the cooling tower bath).
- surface blowdown from cooling circuits of technically important appliances.

  Surface blowdown from cooling circuits of technically important appliances is fed via separate pipelines to the sewage water collection tank. The quality likewise corresponds to Vltava river water at the given level of concentration. Surface blowdown is drawn-off from the cooling tanks with spray. Off-take to Korensko via waste water pipelines.
- sewage from chemical filter plants, treatment of turbine condensate, and waste water from cleaning steam generators.

  Sewage water from chemical filter plants, treatment of turbine condensate and sewage from cleaning steam generators. This concerns sewage with high salt content. This sewage is neutralised before discharge or pumping to the sewage water collection tank. For minimising the impact of neutralised sewage on the resulting chemical composition of water drawn-off to the receiving stream its discharge is balanced by its longer term pumping.

Sewage containing **oil products** is water from the operation of machine rooms, compressor stations, from garages and locomotive yards. Oily industrial water is led through the industrial sewer to the gravitational deoiler and subsequently to repumped for final treatment by flocculation. Deoiled water is then led back to the technological process, not discharged.
The structure and proportion of individual types of water is given in Table 28.

Table 28: Amount of sewage

Type of sewage	Maximum		Average	
	[l/s]	[%] from all outflowing	[l/s]	[%] from all outflowing
Surface blowdown from cooling tower circuits	422.0	84.3	366.0	92.3
Surface blowdown from cooling circuits of technically important appliances	23.5	4.7	16.0	4.0
Sewage from chemical filter plants and other sewage	11.1	2.2	7.9	2.0

Total (including sanitary sewage)	500.8	100	{➲} 396.5	100

Note:
According to design documentation surface blowdown from cooling towers will be decisive from the point of view of non-radioactive material. Its quality corresponds to the composition of service water taken from the Hnevkovice reservoir and the measure of concentration by vaporisation. For 2 units with output 2000 MW with average demand {Table 2 ➲} 1625 l/s is counted on; concentration by vaporisation is assumed with a coefficient of 4.25; average discharge of sewage will be {Table 3 ➲} 396.5 l/s.
Cooling station condensate, water from wash rooms and hygienic loops (this water is cleaned separately) and service water from the auxiliary equipment buildings belong to the group of **other sewage** drawn-off to Korensko.

Within the scope of service water **sludge from water flocculation, from decarbonisation of water and used ion-exchange resins arises**. Drained off sludge from belt presses is transported by the belt conveyer to the hopper of the high-pressure piston pumps in the sludge processing building, from where it is transported via delivery piping to the Temlínec sludge dump (operated by Temelín NPP, or rather CEZ, a. s.). In the case of deteriorated passage through the delivery piping water will be injected into it by plunger pumps. Along the whole length of the piping running outside the piping is fitted with insulation and heated by a heating cable, to prevent freezing. Cleaning parts are located long the whole line for the need for discharge and cleaning. The dump is not designed for commercial use. Dump operation is adapted by the service regulations approved by the *Decision of the Environmental Office of the District office Ceské Budejovice ref.No. 119/99-249/PRRAD/1-Jz from 12.1.1999.* Pumping of sludge will take place approx. 2 to 3 times per week; before pumping it will be necessary to fill piping with water and to rinse with water again after the pumping cycle (2 x approx. 30 m^3).

The aim of processing technology and **treatment of liquid radioactive waste** is to **minimise the final amount**, i.e. to return the maximum amount of water back to the technological circuits of the power plant or after screening **discharge** to the receiving stream and **concentrate the remaining activity** to the smallest volume. Implementation of this aim starts by classifying water from the point where it originates according to quality and the subsequent method of processing and treatment. Potentially inactive water (from restricted area equipment and spaces, where contamination of media is not likely) is collected in tanks and after radiological control, if activity fulfils admissible limits, will be discharged into the receiving stream. In the case that limits will not be complied with the water will be returned for refining.
Certified procedures of mechanical and ion-exchange filtration, sorption, sedimentation, centrifugation, vaporisation and coagulation (reserve technology) are selected as methods for processing sewage in the Temelín power. Waste coming from these procedures is stored and treated by bitumenation.
The task of **special sewerage** is to collect all sewage with division into active sewage, water containing H_3BO_3, water conditionally active and water from hygienic loops before their varied subsequent forms of processing. From this point of view special sewerage water is separated and collected by the special sewerage system, refined in the systems of auxiliary equipment buildings and the final result is their repeated use in power plant systems. Special sewerage water is gathered in collection tanks from where it is led to sedimentation tanks and from there to centrifugal apparatus where sludge is separated off. Sewage with activity practically only in dissolved form continues to the vaporisation line where the concentrate is thickened. The condensate from the evaporators is finally treated on series connected ion-

exchange filters. The refined condensate is fed to the so-called control tanks. From there it is transported, after radiochemical control, to either the so-called own consumption water tanks for repeated use in the power plant or it is refined again on the filtration line. It can also be discharged after radiochemical control as overbalance water through the sewage tank to the receiving stream. The concentrate from vaporisers is fed to radioactive waste dump tanks. Radioactive sludge is fed directly to these tanks from collection tanks behind the centrifugal apparatus.

It is necessary to mention **wash room water** and water from **sanitary seals** as a special system. Only the introduction of separated water with an above-limit value of radioactive material from special wash rooms and from accident sanitary seals is counted into the radioactive waste system. This water is led to the centrifugal apparatus and separated water is then taken from the active media system after radiochemical control. Chemical precipitation (coagulation) technology will be available as a reserve processing line for this water.

The technological node of **hardening liquid radioactive waste** ensures fixing of concentrated forms of liquids into bitumen, as a matrix suitable for permanent storage of radioactive waste. Certified foreign bitumenation technology is used on a film rotor evaporator. The final form of waste will be 200 l steel barrels with a bitumenated product, which will be stored in SÚRAO active waste surface repository in Dukovany.

Solidified liquid radioactive waste in the amount of 335 m^3/year and dried sludge from wash room water in the amount of 1 m^3/year will come from the Temelín power plant.

In the case of **tritium**, when considering the contribution from discharged radionuclides owing to the operation the power plant according to the admissible limit of 20 TBq for one unit, there will be an increase in volume activity of tritium, for an annual average flow in the Vltava and a yearly limit of discharged sewage from Temelín NPP, by 13 Bq/l. For a minimum guaranteed flow there will be an increase by 66 Bq/l. The average volume activity of tritium was 1.5 Bq/l in surface water around the Temelín NPP site during the period of 1998 and 1999, which means that the resulting predicted volume activity of tritium for the two above mentioned cases will be 14 Bq/l and 67 Bq/l.

The unforgettable problem of the **balance of water demand and consumption** is directly related to the question of demand, i.e. assessment of the volume of water permanently displaced (lost) from local circulation. Part of the volume of drawn-off water returns as sewage to the receiving stream in the final phase after direct passage through technology (especially surface blowdown from cooling circuits of turbine condensers with cooling towers and surface blowdown from the cooling circuit of technically important appliances) or possibly after treatment (e.g. from the chemical filter plant, from treatment of turbine condensate and from cleaning steam generators). The **balance decrease** (difference between the amount of drawn-off raw water and the amount of discharged waste service water) is **given by losses and evaporated vapour** in operated power plant technology.

From the point of view of the balance decrease significant loss is by evaporated vapour and by entrainment of water droplets from the cooling towers of the turbine condenser cooling water circuit. Water consumption on average for 4 towers will amount to 1659 l/s (5973 m^3/h), from which:

- evap. vapour: 0.4130 m^3/s for one tower, i.e. 0.4130x3600x4 = 5947 m^3/h for 4 towers;
- entrainment: 0.0018 m^3/s for one tower, i.e. 0.0018x3600x4 = 26 m^3/h for 4 towers.

This concerns average design values. During real operation, according to the actual climatic conditions, different values can be expected.

In the service water, TVD, cooling circuit consumption of water will continue to take place in pools with spray. Water consumption will be as follows:

- evap. vapour: 14 - 19 m^3/h (winter - summer), 16.5 m^3/h (average);
- entrainment: 33.5 m^3/h (average).

It is also possible to include in water consumption water drawn-off from the system as part of the sludge from raw water flocculation. Sludge from water flocculation will contain about 20 % solids (thus 80 % moisture). The amount of sludge is proportionate to the contamination of Vltava inlet water. Owing to its improved quality it is assumed that during flocculation of all raw water the amount of sludge drops from the originally assumed value of approx. 12 825 t/year to approx. 4 150 t/year. Then outside the power plant (at the Temelínec inactive sludge dump) approx. 3 320 t of water would be drawn-off, i.e. on average 0.38 m^3/h. Surplus water (filling piping with water before pumping sludge, rinsing piping after pumping, batch water) is pumped back to the power plant after being drawn-off the sludge dump. Further water consumption is represented by refilling hot-water circuits with softened water 800 m^3/month, i.e. on average approx. 1.1 m^3/h. For refilling the primary and secondary circuit and cooling pipe demi-water is used which is produced on three lines of output 3x150 m^3/h. consumption of demi-water in the primary circuit is max. 10 m^3/h, in the secondary circuit max. 10 m^3/h and in the cooling pipe 1 m^3/day. The overall average consumption of demi-water is 200 to 400 m^3/day (including shutdowns, preparation of solutions, pipe discharging etc.). The **balance decrease in total amounts to 6033 to 6041.50 [m^3/h], i.e. to 1678 [l/s], whereas on average 1625 [l/s] is permitted;** specification according to type is given in Table 29:

The power plant water management system specifies individual **types of water**, especially,

- circulating cooling water (for cooling appliances in the machine rooms of individual units);
- system of important service water TVD (for heat removal from the equipment of safety systems and systems connected with nuclear safety; the system consists of three separate division, i.e. pumping station, system of steel connecting piping and a cooling tank with spray).
- system of non-important service water TNV (separate circuit with its own pumps in the cooling water pumping station building and cooling of water on circulating cooling water cooling towers);
- ***cold water system (for air-conditioning use);***
- fire water system.

Table 29: Balance decrease of water

Water losses according to type	Balance decrease [m^3/h]
Evaporation of water from cooling water circuit cooling towers	5947
Entrainment of water droplets from cooling water circuit cooling towers	26
Water evaporation in the cooling circuit from the ponds with spray	16.5
Entrainment of water droplets in the cooling circuit from the ponds with spray	33.5
Decreases of water as sludge moisture	0.4
Losses in the hot-water circuit	1.1
Refilling of demi-water to individual circuits total	8.5 - 17
Total	6033 to 6041.50

Note:

The system of important service water is a closed system, with refilling of losses in the circuit by treated water from the filter plant, or non-important service water. Part of the circulatory TVD is cleaned by filtration in the TVD side filtration building. Surface blowdown is fed via the gravitational piping to the waste service water system to Korensko.

The system of important service water is designed for removal of heat from appliances, located in these areas: containment, reactor outer structure, high-pressure compressor station, diesel generator station, air-conditioning of the diesel generator station. The **system of important service water as a whole is classified amongst safety systems**. The whole system of important service water, including its elements (pumps, fittings, piping, thermal exchangers) **is classified into the 1st category of seismic tolerance** and belongs amongst selected equipment.

Part of the power plant water management system are the **cooling towers** with natural draft; they draw-off low-potential heat from the production unit. Two towers are designed for each unit. The height of towers is 154.8 m, and the base diameter is 130.7 m. Tower cladding is from reinforced monolithic concrete shells supported by a system of slanted prefabricated reinforced concrete struts. The **cooling tank with spray** serves in a similar way for cooling service water for important primary circuit appliances. This is three tanks with external dimensions 270 x 60 m and depths of 3.3 to 3.75 m. The top edge of the tank is at an elevation of 507.30 m a.s.l., the operational level is then at an elevation of 506.45 m a.s.l. Each tank is split into two identical baths with floor dimensions of 130x60 m with a transfer lane between baths of width 10 m. Looking at a sectional view the baths have a trapezoidal profile. The bottoms are slanted towards drainage shafts where there are sumps for pumping sludge.

2.2.1.3.2. Technological processes causing sewage and specific contamination

*In the following sections the **function of water in the nuclear power plant system** and the controlled fission chain reaction is described.*

Radioactive liquid waste comes from nuclear power plant operation when refining service media containing radionuclides coming from the reactor core. As with radioactive waste it is preventively stored even with other liquids, which enter the **special restricted area sewerage**, irrespective of the actual content and representation of radionuclides.

Temperature needed for the production of electrical energy develops in the nuclear power plant by means of a controlled fission chain reaction, which takes place in the fission material - uranium 235 (235U). Fission is a physical process where the 235U core splits after capturing neutrons into two or more parts (so-called fission fragments) and releases 2-3 neutrons. In order for a neutron to be caught by the 235U core, it has to slow down to a so-called thermal energy. A moderator is used for slowing the neutrons down, which is demineralised water in the Temelín nuclear power plant reactor. The water also serves at the same time as a coolant, taking generated heat from the core. Heat in the core arises from the kinetic energy of fission products (fission fragments, neutrons, ionising radiation), which it gradually transfers to surrounding atoms and thus vibrating them. The result of greater vibration of the atoms is thus an increase in temperature of the respective material. Primary water (coolant) heated in the core is led to the steam generator, where secondary water changes into steam. This drives the turbogenerator, producing electrical current similar to any other thermal power station.

The two installed production units of the Temelín power plant are fitted with VVER 1000 type pressurised water reactors. The controlled fission reaction of uranium 235 takes place in the reactor core. Uranium 235 is contained in small amounts in the nuclear fuel, encapsulated in fuel assemblies, located in fuel assembly holders inserted into the core. Control absorption rods move in the spaces between fuel assemblies and regulate the amount of neutrons and thus the intensity of fission and amount of produced heat. Small changes in output are regulated by changing the concentration of boron (absorbs neutrons) in the coolant.

The main circulating pump provides circulation of coolant in the primary circuit, removing of heat from the reactor. The primary circuit coolant transfers heat in steam generators to secondary circuit water, which evaporates forming saturated steam, driving the turbine. An electrical current generator is installed on the common shaft with the turbine. Steam that has passed through the turbine is taken to the condenser where it is cooled into water and this again supplies the steam generators. Condensers are cooled by water from the power plant circulatory cooling circuit, from where residual heat is transferred to the atmosphere via cooling towers.

2.2.1.3.3. Principle, designed capacity and efficiency of sewage treatment plants

In the following section there is a brief description of the system for treating all types of sewage. It concerns a biological sewage treatment plant and special treatment systems.

The **biological sewage treatment plant** is composed of 3 branches (lines). The first unit forms line No. 1, into which sanitary sewage from the restricted area is drained after checking, the second unit forms line No. 2, into which other sanitary sewage is drained. The third line is reserve and was implemented only for the period of construction for ensuring operation of site equipment and serves as a reserve in case line 1 or 2 are in repair and for possible use during non-standard liquidation states.

Each biological line consists of Imhoff, aeration and final sedimentation tanks. This concerns standard "Vítkovice" above-ground metal tanks. The capacity of the the water treatment plant was dimensioned for a power output of 4x1000 MW for a capacity of 10 000 equivalent residents, with presumed residual contamination at the outflow for indicator $BOD_5 < 20$ mg/l, indicator IM < 30 mg/l.

- Line No. 1: number of associated employees 1285, consumption 300 l/person, $Q_{daily} = 386$ m^3/day, $Q_{24} = 16$ m^3/h, $Q_{max} = 120$ m^3/h.
- Line No. 2: number of associated employees 2380, consumption 300 l/person, $Q_{daily} = 642$ m^3/d, $Q_{24} = 27$ m^3/h, $Q_{max} = 204$ m^3/h.

Treated water is fed to specific shafts and from there **to sewage water collection tanks** (500 m^3) which serve for homogenising all sewage discharged from the power plant (with the exception of rainwater).

The sewage treatment plant includes a **gravitation deoiler** (separator) and **special water treatment systems**.

For maintaining optimum properties of technological media in the primary and secondary circuit of the power plant, for minimising liquid radioactive waste and reducing radiation load to power plant personnel treatment of media is carried out **in six basic types of treatment stations**, located in containment and in the auxiliary equipment building. Most of the water treated in the system (activity under 100 Bq/l) returns to operation, only part of the treated water is taken in the final stages to the sewage water tank (500 m^3). This inactive liquid media (with below-limit content of radionuclides) is fed from the systems through the control tank to the discharge point from the power plant through the biological treatment plant, or neutralising station, or over-balance treated water containing tritium is connected to sewage after the neutralising station. Individual systems and stations are:

SVO 1 - System of continuous treatment of primary circuit coolant.
SVO 2 - Treatment station for primary circuit drainage water.
SVO 3 - Sewage treatment station.
SVO 4 - System for treatment of water from ponds for storage and refuelling.
SVO 5 - System for treatment of surface blowdown from steam generators.
SVO 6 - Regeneration of boric acid.

E.g. in the sewage treatment station SVO-3 radioactive sewage from technological circuits of the power plant is collected and processed. The whole sewage treatment system is based on a line of consecutive processes, its collection in sewage tanks and pools, centrifuging before processing in the evaporator, thickening evaporation in the evaporator, condensing and deaeration of vapour in the condenser – deaerator, mechanical and ion exchanger filtration a collection of refined vapour condensate in clean condensate control tanks in the auxiliary equipment building. From here treated water is repumped after radiochemical control either to operation for repeated use, or is released as over-balance water to the sewage tanks. In the case that the quality of sewage does not comply with the established limit it returns to SVO-3 for treatment.

Design activity of tritium ^3H in treated water is approx. 10^9 Bq/m^3. Discharging is discontinuous, always one control tank filled and the second is controlled and discharged. A radiation control node is located on the sewage discharge path. **The amount of discharged radioactive sewage will be approx. 3000 m^3/year, i.e. load 30×10^{12} Bq/year** (40×10^{12} Bq/year is permitted).

The quality of discharged liquid waste is given by water treatment plant parameters and its **treatment efficiency**. Testing of efficiency in the pre-operational period between years 1998 and 1999 indicates an efficiency for various indicators: BOD_5 – 95.8 %; COD_{Cr} – 91.2 %; IM – 91.9 %; $P_{Tot.}$– 35.0 %.

The amount of discharged treated sanitary sewage is only indirectly limited. **A maximum of 501.0 l/s and yearly 9342×10^3 m^3/year is allowed to be discharged from the total amount of sewage**, i.e. sanitary sewage together with service water sewage. The share of sanitary sewage from the point of view of fulfilling quantitative limits is insignificant.
Water treatment plant efficiency was tested and verified in the 1998 a 1999 pre-operational period and measured parameters were given in *Documentation EIA 08/2000*.

Conditions for releasing water from control tanks are established by the *Decision about permission to discharge sewage*, issued by the *District office Ceské Budejovice*, in this way: *„Control tanks can be discharged into the 500 m^3 sewage water collection tank only on the case that the **activity of tritium in it is not greater than 2.5×10^{11} Bq** and other radionuclides emitting gamma radiation do not cause a higher load in individuals from the population than one twentieth of the limit $H_{50,L}$ and outflow from the collection tank is greater than 150 l/s".*

The final sewage receiving stream is the river Vltava above the junction with Lužnice.

The sewage treatment technology system and conditions for discharging to the receiving stream were the subject of a more detailed investigation and a water-legal discussion by the relevant authority in 1993.

2.2.1.3.4. Characteristics of receiving streams (water used for technological purposes, supply and distribution; contamination category at the discharge point)

The quality of surface water in the area around the power plant is ascertained, monitored and has been evaluated yearly since 1994. Samples for hydro-chemical analysis are taken with a frequency 1x month from Vltava river profiles - Hluboká n.Vlt., Hnevkovice, Korensko right and left bank; Lužnice – Kolodeje river.

The quality of water at the off-take point has been regularly monitored and evaluated within pre-operational monitoring of the power plant since 1992. The average yearly values for profiles Vltava-Hluboká and Vltava-Hnevkovice for the period 1996-1999 are given in Table 30.

Table 30: Quantitative and qualitative selected surface water indicators at the off-take point

Indicator	Unit	Hluboká				Hnevkovice			
		1996	1997	1998	1999	1996	1997	1998	1999
Q	m^3/s	42.5	32.0	19.53	21.4	43.4	32.6	19.94	21.9
PH	-	7.5	7.4	6.8-7.7	7.3-7.5	7.4	7.2	7.3-8.3	7.0-7.6
COD_{Cr}	mg/l	29.2	24.6	23.3	20.0	20.6	24.3	25.6	21.3
COD_{Mn}	mg/l	8.4	8.9	7.89	7.9	7.5	8.3	8.33	7.5
BOD_5	mg/l	5.2	4.5	4.5	4.0	3.4	4.4	5.1	4.1
Diss. O_2	mg/l	10.3	10.3	10.0	10.1	9.3	9.0	9.8	9.6
DM	mg/l	140	133	126	120	154	134	130	119
IM	mg/l	17.8	14.9	6.2	8.2	6.0	7.4	6.7	6.0
Temperature	°C	9.4	9.9	11.5	11.0	9.3	10.8	11.2	11.1
Ptot.	mg/l	0.18	0.15	0.14	0.12	0.11	0.15	0.14	0.11
PO_4^{3-}	mg/l	0.13	0.17	0.21	0.17	0.16	0.18	0.15	0.12

From radioactive material in the Vltava Hnevkovice profile in 1999 the overall beta volume activity with an average yearly value was 0,243 Bq/l, the overall beta volume activity after subtracting the allowance from ^{40}K was 0.108 Bq/l (in 1998 the overall beta volume activity was 0,171 Bq/l, the overall beta volume activity after subtracting the allowance from ^{40}K was 0.078 Bq/l), the yearly average volume activity of tritium in surface water around the power plant was 1.7 Bq/l (in 1998 the yearly average value of volume activity of tritium was 1.3 Bq/l) and the volume activity of ^{137}Cs was 0.002 Bq/l.

In the **profile of sewage discharge** from the power plant to the Vltava in Korensko and in the Lužnice Kolodeje tributary the yearly average values are given Table 31.

Table 31: Yearly average values of selected indicators monitored by Temelín NPP for profiles Vltava- Korensko and Lužnice- Kolodeje from 1996 to 1999

Indicator	Unit	Korensko				Kolodeje			
		1996	1997	1998	1999	1996	1997	1998	1999
Q	m^3/s	77.2	56.3	32.3	36.2	38.0	24.6	11.7	14.2
pH	-	7.3-7.8	7.4-8.1	7.5-9.4	7.3-8.0	7.4-7.9	7.5-8.3	7.4-9.3	7.7-9.3
COD_{Cr}	mg/l	26.7	27.6	29.7	23.8	34.5	38.0	35.4	33.4

COD_{Mn}	Mg/l	8.6	8.8	9.7	7.7	10.9	9.9	10.6	9.3
BOD_5	Mg/l	4.6	5.0	6.5	4.9	6.5	6.1	6.6	7.2
diss. O_2	Mg/l	10.3	10.0	9.6	9.6	10.0	10.3	9.8	9.3
DM	Mg/l	167	152	153	143	201	187	180	193
IM	Mg/l	10.5	10.2	8.3	7.6	27.3	29.1	14.2	17.3
Temperature	°C	9.7	10.9	12.1	11.4	11.4	12.5	11.6	11.1
Ptot.	mg/l	0.16	0.19	0.16	0.15	0.28	0.32	0.25	0.25
PO43-	mg/l	0.19	0.18	0.12	0.10	0.32	0.28	0.25	0.30

From guide results it follows that in all monitored indicators from 1996 changes in yearly average concentrations were relatively small, thus water quality from the point of view of monitored parameters was stable in the monitored profiles.
Besides this ascertained characteristic values of quality of monitored indicators c_{90} (90 % probability according to *CSN 75 7221*) from 1999 in comparison with emission limits according to *government decree No.82/1999 Coll. (appendix No.3),* in profiles Vltava-Hnevkovice and Vltava-Korensko do not exceed limits for so-called other surface streams. In summary it is possible to state that yearly average concentrations of individual indicators were level in the period from 1993 to 1999 and confirm a steady state in sources of contamination in the monitored catchment areas (profiles) on the Vltava and Lužnice rivers.
From basic indicators of **content of radioactive material** it was ascertained that since 1997 in the Vltava-Korensko profile the overall alpha volume activity with yearly average values was at intervals less than 0.050-0.076 Bq/l and the overall beta volume activity at intervals less than 0.128-0.139 Bq/l. Potassium was found in the range 3.9-5.2 mg/l, which corresponds to a beta volume activity of potassium 40 in the range 1.10-1.47 Bq/l. The overall beta volume activity after subtracting ^{40}K activity is 0.050 Bq/l under the detection limit. This means that the decisive contribution to the overall beta volume activity in the pre-operational period of the Temelín power plant represents and beta activity of natural potassium, or rather potassium 40. From man-made radionuclides the yearly average value of volume activity in 1999 for caesium 137 was the same as in the Vltava-Hnevkovice profile 0.002 Bq/l. The average tritium volume activity in 1999 in surface water around the Temelín power plant was 1.7 Bq/l (in 1998 it was 1.3 Bq/l). The average value for tritium over the period 1998-1999 taken for the calculation of the impact of liquid waste effluents from Temelín power plant in this profile was 1.5 Bq/l.

For the reason of better assessment of future potential loading of the receiving stream from radioactive material the reference level of existing caesium 137 volume activity was monitored in the pre-operational period (using gamma spectrometry in large volume samples of water thickened by evaporation) and for tritium (using liquid scintillation spectrometry). The problem became the subject of more detailed collection of data and serious theoretical research (VÚV TGM Prague). The results of monitoring caesium 137 (^{137}Cs) for 4 control profiles over the period from 1990 to 1999 demonstrated a significant trend of a drop in concentration by this man-made radionuclide. Volume activities at the 1999 level were in units of mBq/l, which during balance assessment means that approximately 3 GBq/year flowed into the Orlík reservoir (in 1990 approx. 25 GBq/year) and an activity at the level of 1.5 GBq/year (in 1990 approx. 9 GBq/year) flowed from the reservoir). These values are much higher than the limit for radioactive material effluents from the power plant to surface water (during operation of one power plant unit 0.7 GBq/year and during operation of two units 1 GBq/year).
Similarly in the case of **tritium ^3H** an analogical trend in the drop of volume activity from 3.1 to 1.7 Bq/l over the period 1990 – 1999 was ascertained. From this a significant part is created by the natural element tritium in surface water at a level of 0.38 Bq/l; a further part is

attributed to nuclear installation emissions. Established development is confirmed by an independent similar investigation of rainwater at stations around the power plant over the period 1991 to 1999 (a drop from 2.2 to 1.7 Bq/l). Similar establishment about gradual changes concerns analyses of river sedimentation and fish. From the above it is possible to assume that **there will be further drops in the monitored volume activity of tritium** in surface and rainwater unaffected by power plant operation.
In summary it is possible to state about the problem of mass activity of man-made radionuclides in river sedimentation that **mass activity of certain radionuclides (e.g. caesium 137, or strontium) will persist in sedimentation and other environmental compounds for a very long time and will interfere with the impact of Temelín power plant operation.**

2.2.1.3.5. Volume of discharged contamination [t/r,; mg/l], average limits of BOD, COD phosphorous, nitrogen, tritium, radionuclides [Bq/l; Bq/year], biological and microbiological parameters, temperature etc.

By the Decision of the Environmental Office of the District office Ceské Budejovice ref.No. Vod.6804/93/Si from 15.12.1993 discharge of a max. of 501.0 l/s and yearly $9342x10^3$ m^3/year of sewage (together with sanitary sewage) during operation of two power plant units is permitted. The average and max. permitted values during operation of 2 power plant units are given in Table 32.

Table 32: Limit values for discharged contamination in sewage according to the decision of the district office Ceské Budejovice EO ref.no. Vod.6804/93/Si from 5.12.1993

Indicator	Unit	Average	Maximum
BOD_5	mg/l	6.0	7.0
COD_{Mn}	mg/l	29.0	32.0
COD_{Cr}	mg/l	40.0	56.0
Cl^-	mg/l	111.0	203.0
SO_4^{2-}	mg/l	420.0	608.0
NO_3^-	mg/l	28.0	42.0
PO_4^{3-}	mg/l	2.0	2.5
Ca^{2+}	mg/l	160.0	210.0
Mg^{2+}	mg/l	24.0	34.0
Na^+	mg/l	115.0	200.0
NH_4^+	mg/l	4.0	13.0
DM	mg/l	938.0	1420.0
IM	mg/l	21.0	25.0
Oil products	mg/l	0.2	0.25
Tensides	mg/l	1.0	1.3
PH		6.5-9	6.5-9
Temperature	°C	32.3	32.3

As a significant part of sewage is formed by **surface blowdown** from cooling towers even the composition of sewage from the power plant will depend on the quality of drawn-off raw water, the degree of concentration in cooling circuits and the efficiency of flocculation (input water or surface blowdown). Earlier water quality in the sample profile Hnevkovice was less suitable and was considered with its treatment. Favourable development of changes to water quality however indicates that water treatment will probably not be necessary. Thus further substances are not introduced into drawn-off water (especially calcium and sulphates).

From the point of view of radioactive material it is calculated that limits of discharge in yearly balance for tritium ^{3}H are $40x10^{12}$ Bq/year and $1x10^{9}$ Bq/year for discharges of other man-made radionuclides when expressing as overall beta activity.

The generally valid regulation of the Czech government decree No. 171/1992 Coll., which sets indicators of the admissible level of water contamination was replaced in 1992 by the government decree No. 82/1999 Coll., which sets indicators and values of the admissible level of water contamination. Hence a **special independent assessment** was undertaken of the validity of conditions of the water-legal document according to the current valid regulation. Assessment was undertaken by **AQUAFIN-ing.F.Šedivý-watermanagement calculation and analyses**, see *„Documentation for cumulative assessment of the impact of Temelín Nuclear power plant on the environment „ (03/2001)*. In the new regulation binding admissible values of the following contamination indicators were established for discharging sewage for contaminators "heating stations and power plants": pH, insoluble matter (IM), non-polar extractable compound (NEC) and dissolved mineral salt (DMS). The result of comparing binding admissible values of contamination indicators (emission limits) set by the government decree No.82/1999 Coll. and values permitted by the District office Ceské Budejovice are given in the following table:

Table No. 33

Contamination indicator	Unit	Permitted value	Binding admissible value	Note
PH	-	6.5-9	6-10	Complies
IM	mg/l	max 25	40	Complies
NEC	mg/l	max 0.25*)	1	Complies
DMS	mg/l	max 1420**)	1500	Complies

*) oil products, NEC values and oil products can be compared
**) dried DM, values of dried DM are higher than DMS

From the table it is obvious that water treatment permitted in the *Decision of the Environmental Office of the District office Ceské Budejovice ref.No. Vod.6804/93/Si from 15.12.1993* **fully complies with binding admissible values of indicators in 2001 pursuant to the government decree No. 82/1999 Coll. A similar conclusion was made for the expected temperature of sewage and volume activity of radionuclides and tritium.**
An expert conclusion confirms the prediction of effects on the environment in section 2.2.3.2. and data in tables 15 and 16.

It is explicitly necessary to differentiate between the categories of liquid waste and liquid effluent. **Liquid radioactive waste** arises especially in the evaporator during treatment of contaminated water, from regeneration of filters and ion exchangers. **Liquid waste is not discharged from the nuclear power plant**, but is treated and the concentrated liquid waste is stored in special tanks and after fixing (bitumenation) is stored together with other solid waste in radioactive waste repositories.

Liquid radioactive effluent arises from processing liquid waste from systems and rooms in the restricted area of the power plant. It contains treated over-balance service water. **The volume activity of this treated service water is caused mainly by the radionuclide ^{3}H (tritium – of the order 10^{4} Bq/l), which cannot be caught by the treatment system.** Overall activity of catches is maximally 21 Bq/l.

Water is discharged through the sewage sump via the discharge channel to the river Vltava.

In the discharge channel the design ensures diluting to an average value of 0.1 Bq/litre.

The amount of liquid effluent before dilution is as follows:

- over-balance water 3 000 m^3/year
- chemical sewerage 200 m^3/year
- conditionally active sewerage 1 100 m^3/year
- regeneration water from steam generator surface blowdown treatment station (SVO 5) 1 100 m^3/year
- wash room water 5 500 m^3/year
- leakages from the secondary circuit 140 000 m^3/year

The decision by the relevant authority about **permitted limits of liquid radioactive effluents** comes from the conversion of effluent activity to a 50 yearly load of effective dose ($H_{50,L}$) for adult individuals from the population (Note: $H_{50,L}$ represents the overall inner irradiation of individuals from the time of taking in radionuclides to over a 50 year period). This limitation of effluents in variables characterising irradiation of humans allows direct comparison of irradiation of individuals from critical groups of the population from liquid effluents from the power plant with irradiation from other sources of irradiation (natural sources, medical exposure, etc.).

For constructing the limit the individual from the critical group of the population was defined as a person whose yearly consumption of drinking water 0.7 m^3 is from the water course under the sewage outlet point from Temelín Nuclear power plant in the Korensko profile, where the average yearly flow rate is envisaged as 50 m^3/s (river km 200.405 in the cadastre territory of Neznašov). The assumption of such a defined critical group is strongly conservative, because in reality nobody from the population ingests untreated river water.

The numerical calculation of effluent activity for a 50 year effective dose load of individual from the critical group is given on page 8 of the *Decision to permit water treatment*, issued by the *District office Ceské Budejovice (1993) pursuant to §8 of Act No. 138/1973 Coll.*, and by means of the factor $H_{50,j}$ [Sv/Bq] (j – radionuclide index) given for individual radionuclides in *APPENDIX No.* 1 of the cited *Decision.*

The yearly discharge of tritium cannot cause a higher 50 year load $H_{50,L}$ than 0.16 µSv in individuals of the population during operation of 1 unit and 0,32 µSv during operation of 2 power plant units. Yearly releases of other man-made radionuclides (activation and fission products) cannot cause a higher 50 year load $H_{50,L}$ than 0.004 µSv during operation of 1 unit and 0.006 µSv during operation of 2 power plant units.

Note: According to Limits of the State Office for Nuclear Safety ref. No. 10139/2000 a max. $H_{50,L}$ = 0.2 µSv is set for Temelín Nuclear power plant during operation of 1 unit and a max. of 0.4 µSv during operation of 2 units.

From comparing permitted effluent values it follows that the **general limit for irradiation from liquid effluent from the power plant, 50 µSv, given by the State Office for Nuclear Safety regulation No.184/97 Coll., will be pumped by less than one percent.**

For discharging sewage during Temelín Nuclear power plant operation an overall beta volume activity (without tritium) of 21 Bq/litre (max. $1x10^9$ Bq/year) and a volume activity of tritium of $3.48x10^4$ Bq/litre (max. $4x10^{13}$ Bq/year) is acceptable.
The influence of river flow will be directly dependent on the actual flow rate in the discharge point profile.
Design values of the content of radionuclides in refined service water (with the exception of tritium), which represent the highest source of radioactivity are given in Table 34. Other sources are less significant and imitate the radioisotropic composition of service water.

Table 34: Radioisotopic composition of effluents to the watercourse during routine operation assumed by the design

Radionuclide	Half-life	Activity in [Bq/l]	Radionuclide	Half-life	Activity in [Bq/l]
^{89}Sr	54 days	2.5E-04	^{58}Co	72 days	3.9E-01
^{132}Te	75 hrs	3.2E-02	^{59}Fe	45 days	5.4E-02
^{131}I	8.0 days	4.0E+00	^{55}Fe	2.9 yrs	4.6E+00
^{133}I	21 hrs	1.8E-01	^{54}Mn	292 days	3.9E-01
^{134}Cs	2.1 yrs	8.0E-01	^{51}Cr	28 days	1.9E+00
^{137}Cs	30 yrs	2.0E+00	^{32}P	14 days	1.5E-01
^{95}Zr	65 days	1.1E-01	^{42}K	12 hrs	4.1E-02
^{95}Nb	35 days	7.0E-02	^{14}C	5570 yrs	2.6E-01
^{63}Ni	120 yrs	4.1E-01	^{24}Na	15 hrs	-
^{60}Co	5.2 yrs	3.0E-01	Total		1.6E+01

The Decision to permit water treatment, issued by the *District office Ceské Budejovice (1993)* contains a condition that **control tanks can only be discharged to sewage water collection tanks in the case that tritium ^{3}H activity in it is not greater than $2.5x10^{11}$ Bq and other radionuclides emitting gamma radiation do not cause a higher load than one twentieth of the $H_{50,L}$ limit in individuals of the population as set by the above-mentioned procedure, and the flow from the collection tanks is greater than 150 l/s.**

On the basis of findings about the effect of the impact of radioactive material on water biocoenosis, see *J.Justýn (1992)*, when not exceeding limit values for overall alpha volume activity 0.5 Bq/l, overall beta volume activity 2.0 Bq/l, overall beta volume activity after subtracting the contribution from ^{40}K 1.0 Bq/l and ^{3}H 5000 Bq/l, according to *appendix No. 3 of government decree No. 82/1999 Coll*., no harmful effects of radionuclides arise on water biocoenosis pursuant to *appendix No. 2, paragraph 8 of government decree No. 82/1999 Coll*.
After running 2 units of the Temelín power plant volume activity of radioactive material in the Vltava below the liquid waste outlet in mentioned indicators will be much less than given limit values and requirements according to appendix No. 3 of government decree No. 82/1999 Coll., will not be exceeded, and will neither lead to harmful effects of these radionuclides on water biocoenosis.
Effluent limits correspond to experience from the operation of Dukovany Nuclear power plant and the forecast of the impact of tritium effluent on the water media corresponds to values measured on the territory over more than 10 years of operation of the mentioned power plant at the liquid waste outlet point in the Jihlava-Mohelno profile. Results of monitoring in the area around Temelín nuclear power plant in the pre-operational period and the forecast of its impact were presented at a special conference and accepted as important groundwork for examination of the reference level.

The assessment and prediction of waste temperature in to the hydrosphere form an unforgettable problem. Original objections since the start of research work for the Temelín Nuclear power plant project have mainly concerned the consequences of thermal contamination **with the subsequent increase in tritium concentration in epilimnion. See *M.Rudiš (1984)* for further details. Subsequent investigation however proved, see *E.Hanslík et al. (1995)* for more details, that epilimnion never reaches the Korensko waterworks, and that water dynamics in the receiving stream enables mixing of liquid waste with cooler water. Consequently thermal contamination practically does not develop and inflowing water in the area of the mouth of the Otava joins the hypolimnion. Contamination is carried over to further parts of the Vltava cascade according to the retention period.**
The potential risk of spread of warmed water can cause significant biological growths in the vicinity of the outlet. It was ascertained that warming, growths and in consequence of this increased overall biological activity attracts a large amount of fish, which as a link in the food chain can transmit contamination, sorbed on biological growth, directly to humans. Even though thermal contamination in the case of Temelín Nuclear power plant is negligible it would be advisable to monitor this problem.

An unforgettable problem is formed by the assessment and prediction of waste heat to the hydrosphere. Original objections from the start of research work for the Temelín Nuclear power plant design mainly concerned the consequences of thermal contamination with subsequent increases of the concentration of tritium in epilimnion, for more details see *M. Rudiš (1984)*. However, subsequent investigation, for more details see *E. Hanslík et al. (1995)*, demonstrated that water dynamics in the receiving stream enable mixing of liquid waste with cooler water. In consequence thermal contamination is practically not exhibited.
The calculation comes from the admissible limit temperature 32.3 °C and the maximum amount of discharged sewage from the power plant 501 l/s according to the *Decision of the District office (1993)***.** Calculation of the characteristic temperature T_{90} is done in the same way as for characteristic concentrations of c_{90} substances with the application of CSN 75 7221. For the two years 1994 and 1995 T_{90} in the Vltava in the Korensko profile was 22.25 °C, for the two years 1996 to 1997 18.22 °C and for the two years 1998 and 1999 22.23 °C. Upon application of T_{90} over the period 1998 to 1999, the above mentioned limit temperatures and the maximum amount of discharged sewage from the power plant according to the Decision of the District office (1993) and conditions of minimum guaranteed flow rate in the Vltava in the Korensko profile 9.45 m^3/s the temperature increase after mixing with sewage with the probability of not exceeding 90 % according to *appendix No. 3 to the government decree No. 82/1999 Coll.*, is calculated altogether at 22.7°C, i.e.. an increase of +0.5 °C. for the average water flow rate in the Vltava 50 m^3/s it will be an average increase of only +0.1 °C to a value of 22.3 °C.
In the study for forecasting Vltava warming from 1988 temperatures of water discharged from the power plant were calculated as average monthly figures, and further as temperatures which will be exceeded for a period of 1 day in the month and temperatures exceeded for a period of 1 hour in the month. The maximum value of temperature exceeded over the period of 1 hour is forecast for the month of August, at the level of 30.0 °C, i.e. less than set by the *Decision of the District office (1993)*.
For obtaining quantitative data about the forecast of increasing the water temperature in the Vltava-Korensko profile below the sewage outlet from the power plant, monthly average water temperatures in this profile (measured on the left and right bank), the monthly average temperatures of sewage from the power plant according to data in the authorised study *Lellák, J., Korínek, V., Straškraba, M. (1988)*, and the volume of sewage and water flows in the

Vltava pursuant to government decree No. 82/1999 Coll., found over the period from 1994 to 1999, were used. Calculated (forecast) values of water temperature in the Vltava after mixing with sewage from the power plant are given in Table 35. Calculated values of water temperature in the Vltava after mixing with sewage from the power plant under conditions of minimum guaranteed water flow rate Q_{min} and average water flow rate Q_{prum} in the Vltava are given in the last column.

Table 35: Forecast of water temperatures in the Vltava after mixing with sewage from the power plant using values of monthly average temperatures of discharged sewage for the Vltava-Korensko profile and Q_{min} and Q_{prum}.

	Monthly average temperature	Maximum measured temperature	Minimum measured temperature	Range of measured temperatures [°C]	Standard deviation of average temperatures	Temperature of sewage from the power plant according to Lellák, J., et al. (1988)	Forecast of water warming in the Vltava	
							Q_{min}	Q_{prum}
	[°C]							
January	1.29	2.5	0.6	1.9	0.63	17.1	2.08	1.45
February	2.18	4.2	0.1	4.1	1.93	17.1	2.92	2.32
March	5.60	7.5	1.2	6.3	2.18	17.7	6.21	5.72
April	9.25	12.5	6.0	6.5	2.38	19.0	9.74	9.35
May	14.46	17.0	10.9	6.1	2.25	21.2	14.80	14.53
June	19.83	27.9	17.3	10.6	3.72	23.3	20.01	19.87
July	20.63	22.7	17.0	5.7	2.48	24.0	20.79	20.66
August	19.75	23.6	15.3	8.3	2.47	23.8	19.95	19.79
September	16.65	19.1	14.7	4.4	1.86	22.0	16.92	16.70
October	11.51	13.2	9.5	3.7	1.42	19.5	11.91	11.59
November	5.85	8.6	1.5	7.1	2.11	17.7	6.45	5.97
December	3.59	5.5	1.5	4.0	1.42	17.2	4.27	3.73
Average	10.88					19.97	11.34	10.97

From the calculations of temperature increase due to the influence of warmed sewage from the power plant it is obvious that **relatively the highest increase is in the winter months, specifically in January when there is the minimum guaranteed flow rate in the river** Q_{min} **, i.e. +0.79 °C, and during average flow rate** Q_{prum}, i.e. **+0.16 °C. The forecast changes are in the interval of monitored minimum and maximum values**. In other months relative warming is lower. The prediction illustrates that changes due to the impact of power plant operation will interfere with natural changes.

If the mentioned impact can be treated as negligible within the framework of interannual variability of meteorological conditions, then it does not have to occur, from the point of view of short term impact on the tank, especially in hot and dry years. In such a situation acceleration of the process of eutrophication and subsequent negative ecological impact can be expected. This scenario is formed by J. Justýn et al. (1992)*, who warn of the potential consequences of the synergetic effect of increased temperature of the table level and* *increased load on epilimnion by phosphor. For this reason it is necessary to monitor, besides temperature, the movement of phosphor in waste to the Vltava.*

2.2.2. Description of affected environment

2.2.2.1. Hydrological and hydrogeological situation

Affected groundwater

Geological conditions predetermine **hydrogeological condition**. Circulation of groundwater occurs in fissure networks of crystalline complex and in superficial deposits. Groundwater is refilled purely by infiltration of atmospheric precipitation. Infiltration territories are practically identical with individual hydrogeological catchment areas. The piezometric level of groundwater does not generally exceed a depth of 10 m under the ground; in certain cut valleys it has a positive discharge level (Brezí, Temelínec).

There are two types of groundwater circulation declared at the site of the power plant, *see Z.Anton et al. (1993).*

(a) altogether monotone development of the crystalline complex, where rock forms moldanubic metamorphites – paragneiss with intersections of rock quartz, create a complicated network of partially mutually connected systems of fissures, clearly exceeding depths of 150 m. Fissure systems are oriented in all directions, dominated by those in SW-NE direction, partly N-S, or NW-SE. In these prevailing directions circulation intensifies, or saturation by the influence of tectonic predisposition. This concerns a small permeable complex with relatively better permeability of partly weathered and weathered surface zones of the rock massif and tectonically disturbed lining of harder rock. Natural circulation does not appear here. Isolated instances of saturated fissure sections with source yield to 0.001 l/s.

(b) Quaternary cover, weathered surface of the crystalline complex and fissured zone of the rock massif create uniform saturation of the shallow system with porous-fissure permeability, which with increasing depth verges into fissure permeability. Shallow circulation shows itself to a depth of 25-30 m, the yield of hydrogeological entities runs to 0.1 l/s. This subterranean groundwater body is significantly affected by climatic factors (precipitation infiltration in the territorial area).

Vertical zonation of natural circulation and coincident zonation of the radiocarbon age, and partly the chemical status is documented by an examination. From the depth interval of approx. 25-30 m natural flow stops and radiocarbon age increases. The distinct absence of tritium in groundwater of deeper levels documents that natural mixing of shallow and deep level water does not occur.

The groundwater level in the power plant area is approximately at a level of 500 m a.s.l. and is predetermined by the morphology of the terrain. According to the measured levels the water level more or less traces the terrain. As the power plant site is on a plateau and groundwater is aided only by precipitation it runs from site to all sides. The size of the current and speed of flow is proportionate to the permeability of the media and slope of the groundwater level. The coefficient of filtration moves in the interval $40x10^{-7}$ to $0.2x10^{-7}$ m/s and the slope (gradient) is in the interval i=0.036 to 0.009. The smallest slope is in the direction of the Budejovická basin and the greatest in the direction of the Vltava. In north and south directions movement of groundwater is restricted by both a lower slant and the clayey character of superficial deposits, see *E.Hanslík et al. (1999).* For balance and migration

calculations two alternative speeds of flow of groundwater are used, namely 2.68×10^{-7} and 2.68×10^{-6} m/s.
The groundwater level was ascertained in most holes to be at a depth of 5 to 7 m under the surface with the spread of level variation 1.0 to 2.0 m. Certain holes are exceptions (e.g. monitoring holes of the Temelínec dump), where the groundwater level moves (in dependence on the morphology of the terrain) 0.5 to 3.0 m under the terrain level. **On the contrary certain holes in the power plant area show an overpressure** 0.5 to 2.0 m above the terrain. The amplitude of groundwater level variation in all holes moves in the interval 1.0 to 2.5 m.
At the present time **regular monitoring** takes place within the power plant and in its immediate vicinity**;** holes are located on the basis of hydrogeological research so that they represent basic directions of flow and water-bearing strata.
Although groundwater has common infiltration regions its quality in individual entities varies. Cumulative effects of standard parameters uncontrollably appear, e.g. composition and state of rock media (intensity of cracking, mutually connected fissures); water retention period in the rock (concentration increase in the winter period owning to longer retention in the rock); impact of slower flow through the rock media; quality of atmospheric precipitation; land maintenance; impact of anthropogenic actions.

The results of analyses (1993 to 1998) are strongly individual; generalisation is not possible. E.g. in summer periods more intensive seepage of water from the surface takes place, COD concentration increases, indicating a greater amount of organic contamination.
Part of pre-operational monitoring is **measuring the content of radionuclides** in groundwater. The content of tritium ^{3}H, summary activity of alpha and beta are monitored, and gamma-radionuclides are monitored using gammaspectrometry. From the evaluation it follows that only natural radioactivity caused by natural radionuclides so far logically shows itself in samples. Volume activity of ^{137}Cs and tritium ^{3}H largely moves under the detection limit.

In the **area of the power plant there are currently 45 drainage holes in operation** that are 25 m deep. At a level of 20 m under the terrain there are submersible pumps in the holes. The water level in individual holes or groups of holes is controlled in automatic mode by probe pairs. The spacing of both probes (switching and tripping) is determined individually (yield of holes, depth of building foundations etc.). The set water level is approx. at a depth of 20 m under the terrain. Most drainage holes are led to rainwater sewer, some discharge into the sanitary sewer.
Indicators, whose scope was set on the basis of a requirement of the water management authority, KHS and Povodí Vltavy are monitored in the samples of pumped groundwater. They are: pH, conductivity, COD_{Mn}, NH_4^+,NO_3^-, NO_2^-, NEC, dissolved material. The amount of pumped water is continuously monitored.

2.2.2.2. Affected surface water

*In the following section the **hydrology of surface water** is briefly described. The power plant site is located on a water divide of both local and water management significant water courses. It lies on the watershed divide of four small catchment area streams: Paleckuv stream, Strouha, Temelínecký stream and Malešický stream. These small streams have their headstreams in the area of the power plant and its surroundings. The power plant is located in the Vltava catchment area in the northern region of the Budejovická basin. The actual area of the power plant lies, according to hydrological division of the Czech Republic on the watershed divide of partial catchment areas 1-06-03 (Vltava from Malše to Lužnice) and 1-*

08-03 (Blanice and Otava from Blanice to Lomnice), specifically on the divide of small catchment areas 1-06-03-077 (drained by Paleckuv stream), 1-06-03-073 (drained by Strouha), 1-08-03-079/2 (drained by Temelínecký stream) and 1-08-03-079/3 (drained by Malešický stream).

Most of the landscaped power plant area is drained through safety and retention tanks via the Strouha stream joining the Vltava at river km 214.118. Site equipment buildings located northeast of the site are drained through retention tanks to the Paleckuv stream, which after approx. 9 km joins the Vltavy (river km 208.151). The western edges of the site are drained to the Temelínecký stream (northwest part) and the Malešický stream (southwest part), which join the Bílý stream (Blanice catchment area) which joins the Radomilický stream. Connection of catchment areas of the rivers Vltava and Blanice is in the system of ponds by Dívcice, i.e. water from the Radomilický stream can drain into the Vltava, or Blanice.

Out of larger water courses the river Vltava has some meaning with regard to the power plant. The power plant takes service water from the Hnevkovice profile of the Vltava, and discharges service water sewage at Korensko and rainwater to the Hnevkovice tanks. The river Lužnice contributes to increasing Vltava flow rates at the Korensko profile.

The river Vltava in the vicinity of the power plant features sizeable water content during considerable instability of flow rate with marked minimum flows. Hydrological data for Lužnice is significant in that this water course contributes to attaining safe flow in the sewage discharge profile from the Temelín power plant to the Vltava at Korensko (below the junction of the Vltava with Lužnice), see Table 36.

Table 36: Hydrological data, basic features

River	Profile	Catchment area [km^2]	Average yearly values				
			precipitation [mm]	Discharge [mm]	Discharge coefficient	spec.disch. [l/s.km^2]	Flow rate [m^3/s]
Vltava	Hluboká nad Vltavou	3450.87	739	276	0.37	8.73	30.1
Lužnice	ústí	4226.17	667	181	0.27	5.75	24.3
Vltava	pod Lužnicí	7871.26	698	221	0.32	7.01	55.2

For the same profiles M-daily water is given in Table 37, expressing that stated flow rates after the stated average period of days in the year are exceeded.

Table 37: Hydrological data, M-daily water [m^3/s]

River	Profile	30	90	180	270	330	355	364
Vltava	Hluboká nad Vltavou	66.5	36.3	20.9	13.0	8.56	6.2	4.2
Lužnice	ústí	54.2	29.1	16.5	9.55	5.26	2.95	1.81
Vltava	pod Lužnicí	123	66.5	39.1	24.0	14.8	9.42	6.21

In Table 38 N-year water is given for the same profile, expressing that flow rates are reached or exceeded on average once for the given number of years.

Table 38: Hydrological data, N-year water [m^3/s]

River	Profile	1	2	5	10	20	50	100

Vltava	Hluboká nad Vltavou	184	291	437	553	679	844	970
Lužnice	ústí	107	158	249	316	390	480	565
Vltava	pod Lužnicí	300	440	660	825	1020	1300	1460

With its operation the power plant will quantitatively affect above all the section of the Vltava between Hnevkovice waterworks (off-take) and Korensko waterworks (discharge of sewage). These profiles are affected by treatment at higher situated waterworks of Lipno and Rímov. ***The improvement of small flow rates by up to 100 % is substantial, whereby the impact of power plant operation in comparison with the "natural" (unaffected) state.***
Comparison of "natural" flow rates and those affected by treatment at Lipno waterworks after 1958 and Rímov waterworks after 1978 to the present day and subsequently by the operation of the power plant is given in Table 39.

Table 39: Comparison of „natural" flow rates and those affected by treatment at the Lipno and Rímov waterworks

Profile	M-daily flow rates												
	Q_{Md} [m^3/s]												
	30	60	90	120	150	180	210	240	270	300	330	355	364
Hnevkovice WW Unaffected	64.9	46.6	37.2	31.0	26.4	22.7	19.6	16.8	14.3	11.9	9.32	6.43	4.10
Hnevkovice WW Affected Lipno WW, Rímov WW	55.0	40.7	33.5	29.2	26.0	23.1	20.9	18.8	16.8	14.9	12.9	10.4	8.16
Hnevkovice Affected Lipno WW, Rímov WW and Temelín NPP	53.4	39.1	31.9	27.6	24.4	21.5	19.3	17.2	15.2	13.3	11.2	8.78	6.53
Korensko WW Unaffected	119	84.9	67.2	55.5	46.9	40.0	34.2	291	24.5	20.0	15.3	10.1	6.04
Korensko WW Affected Lipno WW, Rímov WW	105	75.9	60.7	51.4	44.6	39.7	35.4	31.6	27.9	24.2	20.2	15.5	12.5
Korensko Affected Lipno WW, Rímov WW and Temelín NPP	104	74.8	59.6	50.3	43.5	38.6	34.3	30.5	26.8	23.1	19.1	14.4	11.4

By comparing data with previous tables it is clear that the improving effect of Lipno waterworks and Rímov waterworks is significant. E.g. for the power plant max. discharge 1.875 m^3/s corresponds to 23 % of affected flow of Q_{364} . Other affected water courses are less significant.

In the vicinity of Temelín power plant there are **several tens of small ponds** (fish breeding). More significant ones are on the Radomilický (Bílý) stream. In a thirteen kilometre strip from the power plant the largest pond areas are Blatec (96.8 ha, 416 thousand m^3), Belehurecký (53.6 ha, 983 thousand m^3) and Strpský (40 ha, 480 thousand m^3).
In conjunction with the construction and operation of the power plant **three retention tanks** were built in its vicinity. North from the site there is a retention tank with overflow into the Palecký stream, which serves for catching and accumulating increased outflow from the northern part of the installation. East of the site there is a small retention tank on a nameless

tributary for catching water from the east part of the installation and adjacent roads. The most significant retention tank is Býšov, located southeast from the site on the Strouha river, below safety tanks. The Býšov retention tank is for collecting possible increased outflow of rainwater, which is led from the power plant via rainwater sewerage.

In conjunction with the power plant the **Hnevkovice a Korensko waterworks** are of main importance. The Hnevkovice waterworks was built as the main part of the system solving supply of service water to Temelín power plant. The concrete gravitation dam is located at river km 210.39 and forms a water reservoir with overall capacity of 27.65 million m^3. At constant storage with the water level at an elevation of 365.0 m a.s.l. and a size of 9.4 million m^3 the storage space of the reservoir is 18.25 million m^3. At the level of the bottom of the reservoir in front of the body of the dam at an elevation of 354.0 m a.s.l. the depth of water at the off-take point for the power plant is 18.0 m. The main purpose of the reservoir is the creation of space for compensation increased flow rate from the **Lipno dam**, located 120 km upstream. The storage capacity of Lipno is 252.0 million m^3.
According to operating regulations the **Hnevkovice waterworks** ensures the following functions according to importance:

- provision of the supply of surface water for Temelín NPP,
- provision of the manipulation average daily flow rate in the Vltava under the tank at 6.5 m^3/s and ensuring an average daily flow rate of 9.5 m^3/s in the Vltava below the junction with Lužnice.

A drop in the level in the Hnevkovice reservoir under the so-called dispatcher level will be an impulse for starting discharge of increased outflow from the Lipno waterworks so that required off-takes for the power plant during all operating states are maintained.
The Hnevkovice reservoir has another significant function from the point of view of the sediment and winter mode, when, owing to the depth of water, it creates safe water off-take conditions for the power plant during any operational or climatic conditions. An additional function of the Hnevkovice waterworks is energy utilisation in the water power plant, which is at semi-peak-load operation with daily equilibrium of natural flow rates after pumping station off-take for the power plant. Actual water off-take for the power plant is implemented from the waterworks reservoir in the direct vicinity of the dam body on the left bank.
The main function of the weir stage of the **Korensko waterworks** at river km 200.405 is to maintain the level in the end parts of the Orlík waterworks slackwater pool at an elevation level of 353.0 m a.s.l., i.e. near the minimum level of the Orlík reservoir, and irregardless of the level dropping in this reservoir (ecological function – minimisation of muddy zones at the end of the backwater). When the level is at the normal backwater level, i.e. 353.0 m a.s.l. the capacity of the slackwater pool is 2.8 million m^3. Similarly as in the Hnevkovice waterworks water energy is used in the Korensko waterworks in a small water power plant, working in tandem with the Hnevkovice water power plant. One of the main functions of the Korensko waterworks is to create conditions for safe homogenisation of discharged sewage from the power plant.

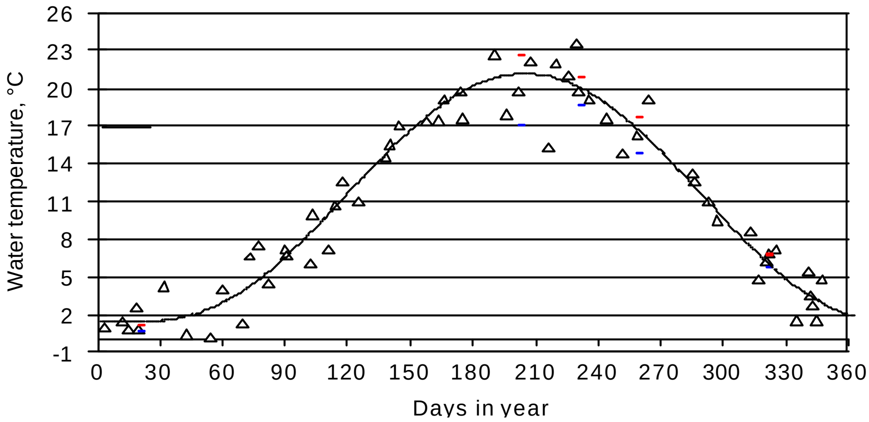
2.2.2.3. Water for technological purposes, supply and distribution

The characteristics of parameters of water for technological purposes, supply and distribution of drinking water does not vary and is the same as data in the introductory section 2.2.1.2. („Description of water resources and supply „).

During evaluation of monitored quality indicators according to *CSN 75 7221 Classification of the quality of surface water* the quality of the water in the Vltava-Korensko profile is classified into III. classes owing to relatively high values of oxygen indicators, COD_{Mn}, COD_{Cr} and BOD_5. From the point of view of classification according to the content of natural radioactive material (which will not be produced by Temelín power plant operation, but will be contained in drawn-off service water and discharged with cooling tower surface blowdown and other sewage) profiles on the Vltava and tributaries around the power plant are classified as class I.

From the point of view of the cooling mode **seasonal dependence on water temperature** in the Vltava is significant; see the statistical evaluation in Graph No. 12 (6^{th} order polynomial). The lowest values of temperature of surface water were in the longterm ascertained in January with an average 1.29 ± 0.63 ° and the highest in July with an average of 20.64 ± 2.48 °C. The range of ascertained values is relatively wide, for example in the month of January it was 0.6 to 2.5 °C and in July 17.0 to 22.7 °C.

Graph No. 12: Seasonal dependence on water temperature in the Vltava Korensko profile between 1994 and 1999; see *EIA documentation (03/2001).*



2.2.3. Potential effects on the environment

At the present time there is no criterion available, which would define the boundaries of seriousness of the impact of Temelín NPP on the hydrosphere. The problem is examined from a number of isolated points of view with awareness of the fact that the impact of Temelín NPP on the hydrosphere is many-sided.

The viewpoint of testing the impact of radioactive irradiation to humans and ecological systems acting directly or through the medium of the hydrosphere has priority. The second in line is the viewpoint of testing the impact of thermal contamination on the environment. An unforgettable parameter is the establishment of quantitative claims on available sources of water, i.e. pre-defined off-take.

Other **anthropogenic impacts on circulation of water in nature, the quality of surface water and groundwater and the hydrosphere are studied systematically like at other industrial buildings.**

From the point of view of geographical localisation the power plant is situated on the water divide of significant watercourses. The actual power plant site is elevated above surrounding terrain with roof-like slant on all sides. From comparison of height data it is obvious that the power plant site is located approx. 135 m above the maximum water levels in main streams, and even on evaluation of historically extreme water flows. No water course can endanger the power plant when high water is flowing**. Flooding cannot even occur from blocking the water flow with ice.**

2.2.3.1. Potential impact on hydrogeological and hydrological conditions (groundwater level, flow rate, available sources of water, changes in sub-hydrological catchment areas, water separation, floods, drainage)

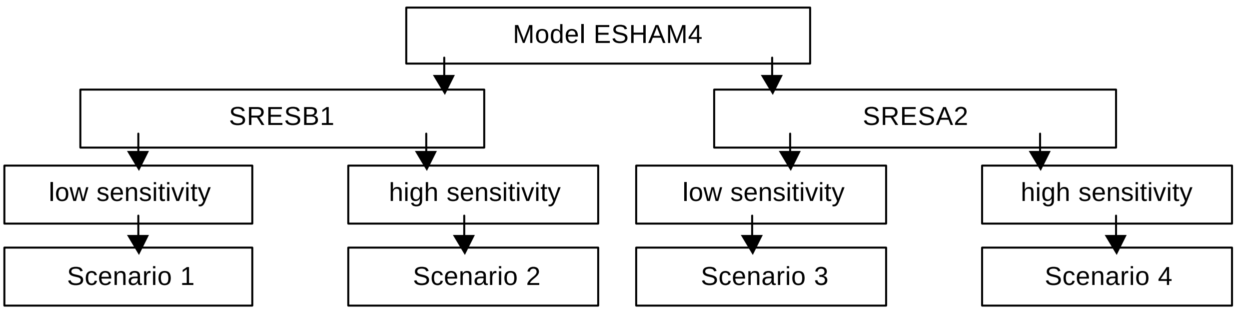
The construction of the Temelín Nuclear power plant strongly affected the natural hydrological conditions of this site. Free areas were solidified and drained. The fundamental difference is the catching and central drainage of most of the precipitation falling on the Temelín Nuclear power plant site to retaining tanks and discharge to the Strouha river and. In consequence of this the **allocation of surface water and groundwater was reduced.** This led to **acceleration of surface run-off**. Drainage of groundwater from the drainage system contributes to this allocation (on average 0.001 m^3/s). From the point of view influencing flow rate in the Vltava it is an increase of approx. +0.03 %.
Transfer of part of the precipitation and groundwater from the territory of the power plant (approx. 0.01 m^3/s) to catchment area 1-06-03-073 (Strouha – unaffected average run-off 0.043 m^3/s) means an increase in average run-off from this catchment area by about 20 %. Peak run-off during rainstorms is caught in retention tanks. Reducing run-off should theoretically show itself in the characteristics of flows in upper parts of small catchment areas 1-06-03-077 (Paleckuv stream), 1-08-03-079/2 (Temelínecký stream), 1-08-03-079/3 (Malešický stream). With regard to the relatively small change and natural fluctuation of water **allocation to these catchment areas there is insignificant impact** (units of percent), objectively difficult to ascertain.
For a yearly average total of precipitation of 0.599 m, a drained area of 133 ha and with a run-off coefficient k = 0.415 approx. $330.6x10^3$ m^3/year is drained off, i.e. on average 0.01 m^3/s.

Off-take of service water from the Vltava-Hnevkovice profile (average 1.625 m^3/s) leads to a reduction of the yearly average flow rate by approx. 5 %, see Table 35 (Vltava-Hluboká profile, average flow rate 30.1 m^3/s). Part of the drawn-off water, approximately 30 %, forms back flow to the Vltava-Korensko profile (average flow rate 55.2 m^3/s). More pronounced impact of hydrological characteristics of the Vltava river can only be recorded in the Hnevkovice – Korensko waterworks section, where a tributary of the Lužnice river and sewage from the power plant come out. The impact of M-daily flow rates of Hnevkovice and Korensko waterworks caused by operation of the power plant on the assumption of constant off-take Q = 1.625 m^3/s and a constant discharged amount of 0.501 m^3/s is not significant out of the area of small flow rates (low-water periods). In this period the off-take of water for power plant operation can reduce flow rate by up to 20%. However, small flow rates in the Vltava will always be improved by waterworks above the Hnevkovice waterworks to eliminate the impact of power plant operation in comparison with the "natural" state. Cooperation between the Lipno and Hnevkovice reservoirs will ensure the minimum required flow rate below the Hnevkovice waterworks (6.5 m^3/s) and even in the Vltava under the junction with Lužnice (9.5 m^3/s). Similarly assessment of max. take-off 1.875 m^3/s amounts to about 23 % of reservoir affected flow rate Q_{364}. For higher M-daily flow rates this percentage drops.
From the point of view of the **cumulative effect** from **other off-take of service water** in the Vltava river section between the Korensko waterworks and the end backwater of the Hnevkovice waterworks the following are significant:

- Jihoceská energetika, Teplárna Mydlovary works (off-take of surface water by pumping from the Vltava in amounts of 44 000 m^3/year, estimated at 50 000 m^3/year, max. 2 l/s),
- Rudné doly Netolice, Týn nad Vltavou works (off-take of surface water from the Vltava in amounts of 45 000 m^3/year, max. 3.3 l/s).

From the above it follows that the impact on flow rate by the above mentioned subjects even in low-water periods (6.5 m^3/s) under Hnevkovice waterworks is max. 0.8 % and their impact on flow rates in the given section are minimal. Temelín power plant will be a significant consumer of service water in the given section.
Waterworks reservoirs on the actual flow of the Vltava are not with the exception of tributaries, see Švihov reservoir Želivka river and Rímov reservoir on Malše river. For the **off-take of drinking water** only two profiles on the Vltava are used, namely Solenice (r. km 144) for the Príbramska area and in Prague - Podolí (r. km 56.2) with a capacity up to 2600 l for Prague.

With regard to the acknowledged and confirmed existence of climatic changes for the 21st Century, see „Third IPCC report„ (International panel for climatic changes; conference in Shanghai in January 2001), a **special independent assessment** of the security of available sources of service water for the power plant was carried out. A study was elaborated *„Elaboration of risk analyses of security of water resources for Temelín Nuclear power plant for the current state and for the scenario against the background of development of climatic changes after 2015„*, which was authorised by Z.Kos et al. (2001). The security of water sources for the first and second unit of Temelín Nuclear power plant over the whole duration of its lifetime was assessed in this study independent of designers. The method used was a series of mutually connected models – emission, climatic, hydrological, water-management and probabilistic, which lead to the estimate of expected risks when ensuring required flow rates in the Hnevkovice profile. For perspective a time horizon of 2050 was used, for which data about climate changes and their impact on water resources are processed. On the strength of NKP (National Climatic Program) data and the IPCC forecast (in the form of climatic scenarios), the regional change in climate for the upper Vltava area was estimated. This is where the Temelín Nuclear power plant and the Lipno-Hnevkovice water management system, which ensures the water source for the power plant, lie.
Scenarios of climate change were calculated for the selected combination: "Climatic model + time horizon + emission scenario + temperature sensitivity„ on the basis of top interdisciplinary knowledge. For this study the year 2050 was selected and these climatic elements were evaluated: daily amplitude of air temperature, average, maximum and minimum daily air temperature, atmospheric precipitation, global irradiation, air humidity and wind speed. For each model four options of climatic groundwork were drawn up and on the basis of them four options of hydrological rows were drawn up by the BILAN model according to the following diagram:



The ESHAM4 model is a global circulatory model of the atmosphere, which was elaborated by the German Climate Research Centre Hamburg, Model #4. This model was selected as a representative of global circulatory models of the atmosphere for the Czech Republic by the working team, which processed the design VaV/740/1/00 „Research of the impact of climatic changes brought about by enhancing the greenhouse effect in the Czech Republic „ (MoE

2000). The model showed, together with the HadCM2 model (UK Hadley Centre for Climate Prediction and Research Coupled Model #2), the greatest conformity for the territory of the Czech Republic. For the emission scenario SRESA2 was used as a pessimistic option and SRESB1 as an optimistic option of the development of the concentration of CO_2.
In the study of security of water resources for Temelín Nuclear power plant the ESHAM4 model was used, which is more suitable for modelling run-off in hydrological conditions of Czech Modelling and prediction of the climate using GCM
From hydrological and watermanagement analysis of the impact of climate changes on the security of improved flow rates in the Hnevkovice off-take profile (i.e. flow rates controlled by Lipno and Hnevkovice reservoirs) carried out in this study the conclusions that follows is that Vltava flow will be sufficiently aqueous, even with climatic changes, so that even in dry years it guarantees the required off-take of water for the power plant and so that operational problems do not arise in consequence on reduced water off-take from the water resource. **Nevertheless it will be necessary to reassess and reduce the minimum residual flow rate (MZP) in the Hnevkovice off-take profile, either permanently or for the period necessary according to the decision of the water management authority.**

From the above analysis a partial conclusion was made: **Off-take for the Temelín nuclear power plant (first and second unit) is guaranteed for the whole duration of its lifetime in accordance with requirements of the valid Water Act No.138/1973 Coll., as amended by updated regulations. Therefore it is not necessary to fear negative impact of Temelín nuclear power plant on the environment from the point of view of the security of the water resource.**

Quantitative impact on **groundwater** can be continuously evaluated by measuring the level of groundwater by existing buildings before and during construction of the power plant (these buildings changed according to the level of territorial investigation). Measurement of the level of groundwater has been carried out almost regularly from the start of the construction of the power plant. By alignment of the terrain at an elevation of 507.1 m a.s.l. the max. level of the groundwater level reduced from an elevation of 512.62 m a.s.l. (hole JV 379 in 1982) to an elevation of 503.8 m a.s.l. (hole RK 7 in approximately the same place in 1992), thus by more than 8.5 m. Evaluation of regime measurement of the level of groundwater was carried out in several stages. To the end of 1996 a drop of the level of groundwater by objects inside the power plant is documented, caused by operation of the drainage system (documented by hydrograms of individual buildings and pumping schedules). The range of level oscillation constantly moves approximately around the same levels.
Owing to shallow circulation of groundwater approx. to 30 m and low yield of the water-bearing section **present findings eliminate the risk of groundwater off-take with such a high intensity that the direction of flow change could change and seriously affect the groundwater regime**.

2.2.3.2. Effects on the ecology of surface water and groundwater owing to contamination, arisen changes to run-off and drainage, water pumping etc.

Findings aimed at **risk analysis** of potential threat to water circulation in the catchment area from the point of view of amount and quality are summarised in the following section.

The territory to about 30 km around the power plant is supplied from both surface and underground resources. The main off-takes of surface water are from the reservoir

Rímov (Plav), Lužnice (Veselí n.L., Tábor, Bechyne), Otava (Písek, Šteken), reservoir Blanice (Husinec). Generally it was estimated that demand from main underground resources amounts to approx. one third of the size of surface water demand**. Higher yield resources are concentrated in basin structures or fluvial quaternary deposits (e.g. D.Bukovsko demand to 90 l/s). In the crystalline complex area the yields of resources are very low. The investigation undertaken within the pre-operational period of the power plant was directed at assessing the possible threat to main groundwater body and water supply resources and local consequence in the area approx. 30 km from the power plant.**

From the undertaken risk analysis, see J. Novák and B. Jedlicka (1992), Threat to groundwater **general or linear release of radioactive material above the scope of admissible values in the case of a design basis accident represents the greatest danger. In this case the probability increases the effect of natural (shear zone, tectonic line, fissures) or man-made (utility networks) preferential routes, whose detailed course is not known in the first case.**

For the case of a maximum design basis accident design data converted to individual dose equivalents is available $\$$ 1 m SV/year and $\$$ 5 m SV/year, for which spaces are delimited in the area surrounding the Temelín power plant to 20 km or to 8.5 km and further radionuclide fallout expressed in kg/m^2.

Increased danger is represented by release in places with shallowly dropped groundwater levels and in places of higher level drop. The risk for the shallow groundwater body and deep groundwater body differs, mutual connection between both is (almost) excluded.

Contamination of shallow groundwater and subsequently surface water courses**, which discharge water wither directly to the Vltava (Paleckuv stream, Strouha) or to the Blanice catchment area (Temelínský stream, Malešický stream), including possible connection with Vltava catchment areas** is considered as the greatest threat to the hydrosphere in the area around the Temelín Nuclear power plant**).**

Theoretically on the basis of research work flow over preferential routes in a NE direction to the Vltava, to the S and SW to the Budejovická basin falls into consideration. The possibility of direct contamination of groundwater in the Trebonská basin can be excluded.

The radionuclide carrier component is flowing liquid. In the surface layer it is either a permanent source of liquid contamination, or the infiltration share of atmospheric precipitation. In the water-bearing layer it is flowing groundwater. Groundwater flows to the surroundings from the power plant site under average slope I = 0.016.

The speed of propagation of contamination in the upper zone of eluvium is dependent on the type of contamination, thickness of the aeration zone, retardation properties of the environment and speed of groundwater movement. Risk analysis results from the least favourable assumptions: direct release of tritium is envisaged to groundwater, which flows at the highest speed found in the Temelín NPP site at a maximum surface slope from the point of release to the outflow point is considered. Thus speed v = 1.4×10^{-4} m/s for slope I = 0.05. Under these conditions transport of contamination to a distance of 100 m took approx. 8 days.

For porous environments with the highest value of coefficient of filtration ascertained from pumping tests, i.e. k = 3.4×10^{-6} m/s for slope I = 0.05 and effective porosity n_e = 1×10^{-2}. For such selected inputs the speed of flow of groundwater v = 1.7×10^{-5} m/s for tritium and v = 3.2×10^{-7} m/s for Sr^{90} with a retardation factor R = 52, see Hanslík E.,

Mansfeld A., Zajícek V. (1983). In this case tritium would get to a distance of 100 m in 68 days and Sr^{90} in 9.8 years.

Aeration zone impacts were not considered during calculations and thus they are on the side of increased safety.

Newer investigation results from the period 1992-1993, see Z. Anton et al. (1993), quantify average hydraulic parameters by means of pumping tests, i.e. filtration coefficient k_f, filtration speed v_f and actual speed v_s differentiated for both assessed zones, see Table 40.

Table 40. Coefficients of filtration and speed [m/s]; according to Z. Anton et al. (1993).

Zone	K_f	v_f	v_s
to 30 m	4.02×10^{-6}	6.44×10^{-8}	(➲) 2.68×10^{-7}
above 30 m	4.33×10^{-7}	6.93×10^{-9}	2.89×10^{-8}

For the stated average value v_s the head of tritium contamination would reach a distance of 100 m in approximately 1.5 years and Sr^{90} in 16 years, cit. E. Hanslík et al. (1995).

Uncertainty **relates to difficult determination of preferential paths for groundwater circulation and the most marked fault lines. This matter is resolved by permanent continuing geophysical exploration.**

According to E. Hanslík et al. (1995) there is marked variance in filtration coefficient values and unspecifiable uncertainty in the estimate of effective porosity**, with respect to the geological structure of the territory.**

Risk analysis does not envisage fuel meltdown from the release of radioactive material from the reactor directly to the rock media even in the case of a serious accident from a pressurised water reactor. Similarly contamination from atmospheric fallout was assessed only for orientation for the case of a maximum design basis accident and for 47 more significant sources to a distance of 30 km. Sources are classified by the point method according to the degree of protection into three categories.

The power plant can influence the **quality of surface water** in the receiving stream by controlled discharge of tritium water to the sewage water tank (500m^3), from where it is discharged with other sewage directly to the Korensko profile of the Vltava. This matter was already envisaged in the Decision of the District office C. Budejovice (1993), where only one balance limit 40 TBq/year is mentioned for discharge of tritium activity.

It can also influence the quality and quantity of **discharged rainwater** (river Strouha opening – subsequently the river Vltava) and **service water** (river Vltava opening - Korensko profile). The quality of rainwater is monitored in safety tanks in 14-day cycles (before the junction with the local water course) and at the outlet from the Býšov retention tank.

A forecast of the impact of liquid effluents from the power plant to the receiving steam **under routine operation** was the subject of systematic research, especially within VÚV TGM Prague from 1993 to the present time. It was demonstrated that water quality in the Vltava is stable and yearly average values of individual quality indicators are in a narrow interval of their concentration.

Inactive material:

On the basis of updated forecasts of changes of water quality in the Vltava Korensko profile, see INVESTprojekt (2001) documentation under planned discharge of sewage from the power plant for guaranteed Q_{min} it is confirmed that no such increase, which could attain limit values according to government decree No. 82/1999 Coll., occurs in monitored and evaluated indicators, with the exception of BOD_5 .

In order to reduce the measure of uncertainty a **balance of material in raw water** taken from by power plant was carried out in the pre-operational monitoring period (1997 to 1999) and compared with balance limits for discharged inactive material in sewage according to the Decision of the District office (1993). Above all it is obvious that the amount of material pumped by the power plant in individual years will not be constant. It is also demonstrated that when adhering to limits for sewage the quality of discharged water will be better in many indicators that natural raw water in the take-off profile (especially oxygen regime indicators). Part of the monitored material is removed by water treatment and mechanical-biological processes in cooling circuits.

Nevertheless it is highlighted that reduction of certain pollutants in the power plant water balance will be accompanied by an increase of anions of chemicals used for flocculation of discharged or drawn-off water and by the creation of sludge (in the case of using e.g. ferric sulphate it will be an increase of the concentration of SO_4^{2-} in discharged water and an increase in the content of Fe in sludge).

The greatest impact is expected for indicators of anionic tensides, PAL-A and SO_4^{2-} .

Radioactive material:

A similarly elaborated forecast of the **impact of releases of radioactive material** demonstrated that in the Vltava-Korensko profile only negligible changes to their volume activity occur, **with the exception of tritium.**

In indicators of overall beta volume activity definite impact will occur in consequence on the **off-take of water** in the Vltava-Hnevkovice profile (similarly as for non-radioactive material), when drawn-off beta activity per year using average values of overall beta volume activity over the period 1998 and 1999, 0.207 Bq/l, and the limit amount of drawn-off water according to the Decision of the District office C. Budejovice (1993) during operation of two units, 38.019×10^6 m^3/year, will be 7.87 GBq/year.

An increase of the value of the overall beta volume activity in the **sewage discharge** profile in the Vltava-Korensko profile, when considering the yearly limit for discharged sewage during operation of two units according to the cited Decision of the District office, 9.342×10^6 m^3/year will be an increase in overall beta volume activity by 0.005 Bq/l for Q_a and by 0.026 Bq/l for guaranteed Q_{min}.

When considering the contribution from discharged radionuclides owing to operation of the actual power plant (with the exception of tritium) according to the Decision of the District office limit, which is 1 GBq for two units, the increase of overall beta volume activity for Q_a and the yearly limit of discharged water will be less than 0.001 Bq/l (calculated value 0.0006 Bq/l) and for guaranteed Q_{min} an increase of 0.003 Bq/l (e.g. yearly average volume activity of caesium 137 in 1999 in the Vltava-Korensko profile was 0.002 Bq/l).

From the mentioned analysis it follows that impacts of discharge of radionuclides from the power plant with sewage will be in the interval of monitored natural changes of volume activity of radioactive materials, but even of the monitored interval of balance of flowing radioactive material in the Vltava-Korensko, or Vltava-Hnevkovice profile.

*For **tritium ^3H**, when considering the contribution from discharged radionuclides owing to operation of the actual power plant according to the District office Decision limit, which is 20 TBq for one unit of Temelín NPP, there will be an increase of tritium volume activity for Q_a and the yearly limit of discharged sewage from the power plant of 13 Bq/l and for the* *guaranteed Q_{min} an increase of 66 Bq/l. (e.g. the average tritium volume activity in the period 1998 and 1999 in surface water surrounding the Temelín power plant was 1.5 Bq/l, which means that the resulting forecast of tritium volume activity for the two above-mentioned regimes would be 14 Bq/l and 67 Bq/l). A similar calculation for two units with the limit of discharge of tritium 40 TBq gives an increase of tritium volume activity for Q_a and yearly limit of discharged sewage of 25 Bq/l and for guaranteed Q_{min} an increase of 132 Bq/l. Generally in the case of tritium a measurable increase of its volume activity under the outlet of liquid waste from the power plant occurs.*

Besides calculated average **values maximum tritium volume activity in discharged water according to planned regimes of power plant operation can be reached for short periods for guaranteed Q_{min} to a value 550 Bq/l,** as stated in the *Preliminary safety report*, see *EGP (1996).*

From the point of view of the amount of **discharged non-radioactive materials** from routine operation of the power plant surface blowdown from the cooling system, at which approximately four times the concentration of materials contained in drawn-off water is counted, is the decider. Improving quality of drawn-off water shows itself in a drop in the amount of this material in discharged water. where necessary discharged surface blowdown will be treated by flocculation.
The forecast of the impact was updated by using characteristic values of c_{90} quality indicators and average values of quality indictors for the period 1998 and 1999, conditions of average flow rate and minimum guaranteed water flow rate in the Vltava-Korensko profile (*Operating regulations, 1994*) and using average and maximum concentrations of discharged material with sewage according to the *Decision of the District office C. Budejovice (1993).* Results were compared with indicators of *Appendix No. 3 of the government decree No. 82/1999 Coll.*, and further with earlier forecast values on the basis of knowledge about the quality of water in the Vltava at the time of processing this forecast.
The forecast of water quality in the Vltava-Korensko profile under conditions of **minimum guaranteed water flow rate, 9.45 m^3/s**, maximum volume of discharged sewage during operation of 2 power plant units, 501 l/s, and the average and maximum concentrations of material in discharged sewage, for optionally envisaged average and characteristic water quality in the same indicators in the profile in question over the period 1998 - 1999 is given in Table 41:

Table 41: Forecast of water quality in the Vltava in the Korensko profile under the sewage outlet from operation of 2 power plant units at minimum guaranteed water flow rate; truncated file according to *EIA Documentation 08/2000*.

Indicator		Vltava, Korensko 1998-1999	Vltava, Korensko during operation of 2 Temelín NPP units Q_{min} guaranteed 9.45 m^3/s		Czech G D No. 82/1999 Coll., appendix No. 3
			Average values of sewage composition	Maximum values of sewage composition	
		c_{aver}	c_{aver}	c_{aver}	
BOD_5	mg/l	5.7	5.7	5.8	8
COD_{Mn}	mg/l	8.7	9.7	9.9	20
COD_{Cr}	mg/l	26.8	27.5	28.3	50

DM	mg/l	148	188	212	1000
Temperature	°C	22.2	22.7	22.7	26.0
$P\text{-}PO_4^{3-}$	mg/l	0.04	0.14	0.16	0.4

From the calculated values it is obvious that relatively small increases in the values of indicators of quality take place owing to discharge of sewage from the power plant.
Similarly a forecast of water quality in the Vltava-Korensko profile under conditions of yearly average water flow rate in the Vltava, Q_a = 50.0 m^3/s, for the above same conditions, is in Table 42.

Table 42: Forecast of water quality in the Vltava in the Korensko profile under the sewage outlet form operation of 2 power plant units during yearly average water flow rate; truncated file according to *EIA Documentation 08/2000*.

Indicator		Vltava, Korensko 1998-1999	Vltava, Korensko during operation of 2 Temelín NPP units Q_a = 50.0 m^3/s		Czech G D No. 82/1999 Coll., appendix No. 3
			Average values of sewage composition	Maximum values of sewage composition	
		c_{aver}	c_{aver}	c_{aver}	
BOD_5	mg/l	5.7	5.7	5.7	8
COD_{Mn}	mg/l	8.7	8.9	8.9	20
COD_{Cr}	mg/l	26.8	26.9	27.1	50
DM	mg/l	148	156	161	1000
Temperature	°C	22.2	22.3	22.3	26.0
$P\text{-}PO_4^{3-}$	mg/l	0.04	0.06	0.06	0.4

From the calculated values and from comparison with the given assessment for the previous table above it follows that under conditions Q_a in the Vltava the logical impact to quality from discharge of sewage is lower.

Assessment of the impact of the power plant and the **risk to surface water**, i.e. sewage receiving stream **taking account of the origination of extraordinary events** creates a separate problem.
This concerns a complex problem of the potential impact on the Vltava cascade**, where results of field measurement define (by its thermal and dynamic behaviour) three different basic sections between the profiles of Korensko-Prague Podolí, i.e. (a) Orlík dam, (b) the system of reservoirs Kamýk-Slapy and (c) the section of the Štechovice reservoir after the Praha-Podolí-waterworks profile. Research documented in detail the** periods of retention and peculiarities for the stratification period **and** the isothermal period. **In the isothermal period density currents can influence passage of contamination through the reservoirs; in the period of stratification they are less probable. For the operational situation and controlled discharge of radioactive material contamination immediately mixes in the profile and proceeds in it at a speed corresponding to flow rate conditions. Further progression of contamination depends on the temperature regime.**

Ad (a): Orlík dam is the inlet reservoir of the system and receiving stream. Its dynamics of temperature conditions are influenced by three significant tributaries – Vltava, Lužnice, Otava, and their flow rate and temperature variability.

Ad (b): Kamýk-Slapy reservoir system, whose tributary is given by peak loading the Orlík power station and the equalising function of Kamýka; it thermally acts in a way that the temperature of entering water is equalised, in the summer significantly lower than epilimnion, in winter higher than the isothermal capacity of the reservoir.

Ad (c): the section Štechovice reservoir - Prague Podolí waterworks profile contains two smaller reservoirs, i.e. Štechovice and Vrané, Modrany lock and about 10 km of free river. The Sázava and Berounka flow into it, which contribute to dilution. Tributaries act thermally opposite to the Vltava flow, in summer they heat it and in winter cool it. As the flow in both tributaries is generally low icy effects occur only rarely in the Vltava river basin.

For risk analysis the following are significant

- contamination travel times **for individual sections up to the waterworks off-take in Prague Podolí during isothermal and thermal stratification;**
- dilution of radioactive contamination **taking account of the thermal situation and the inflow effect.**

From the point of view of safety the situation is less favourable in stratification conditions **(April to September). For reference water flow rates in the Orlík-dam profile 39, 83, 113 and 310 [m^3/s] corresponds to the overall retention time in the Korensko-Prague Podolí section 138, 65, 47 and 24 days. During isothermy times are generally longer. The existence of density current shortens the retention period during isothermy to approximately 1/3.**

Similarly in stratification conditions and for generally set volume activity of radioactive material with increasing flow rate in the reference profile values of the conversion coefficient fall from 0.037 to 0.002. calculations undertaken do not include the interaction between radionuclides in water, undissolved material, bed-load sediments and biomass.

For reduction of the content of radioactive materials their separation between water, undissolved materials and bed-load sediments will cooperate in addition to the processes of dilution caused by flow rate conditions. Dilution during isothermy is liable to other rules of law than during stratification. The assumption of piston flow is fulfilled only in small reservoirs and in the Vrané-Podolí section. The large dams Orlík and Slapy are intensively mixed during isothermy therefore their whole capacity is available for dilution.

Definite risk is attributed to the potential possibilities that sediments at the beginning of the backwater can accumulate radioactivity**. Upon stirring sediments by the passage of high-flood-water waves, when they reach buoyancy, this can subsequently lead to permitted levels of volume activities being exceeded. Therefore it is necessary to monitor the activity of sediments in the slackwater pools.**

Results of research carried out so far are even applicable for the hypothetical case of direct accident leakage of contamination of liquid waste into the receiving stream**.**

Potential effects of the operation of Temelín Nuclear power plant from the point of view of **international obligations of the Czech Republic to the section of the water system** were the subject of a ***special independent assessment*** by the company EKOAQUA-Ing. Václav

Plechác, CSc., see *Documentation for Assessing the Impact of Temelín Nuclear power plant on the Water System (03/2001).* Unforgettable documents are the Contract between the Czech Republic and Germany about cooperation on boundary waters from 12.12.1995 and the Agreement about the International Commission for protection of the Labe (Elbe) from 8.10.1990, which affects conditions of the amount and especially quality of water in the boundary profile Labe Hrensko-Schmilka, which can be affected in consequence on putting Temelín Nuclear power plant into operation. However according to studies processed so far this impact is not at all detectable, or (for tritium) it is deeply under permitted international standards. Another contract between CSSR and Austria about the treatment of water management issues on boundary waters from 7.12.1967 is not affected, because sewage from Temelín Nuclear power plant does not flow to Austria, but to Germany (see above). Documents about EIA (European Community from 1985, EHK OSN from 1991) do not affect the Czech Republic for the time being and were not ratified yet.
Monitored indicators of contamination **to the Labe border profile** can hardly affect Temelín Nuclear power plant at all and amongst others to the minimum amount and scope of contamination of discharged water max. 0.5 m^3s^{-1} and their dilution in about one hundred times the flow rate of reservoirs of the Vltava cascade and almost one thousand times the dilution in Labe flow rates to the Hrensko border profile. According to processed studies it will only be possible to trace the occurrence of tritium to Hrensko; other radionuclides will not be detectable in the measurable amount already in the Vltava under the Vltava cascade.

Potential effects on the hydrosphere and environment owing to operation of Temelín Nuclear power plant were the subject of a ***special independent assessment*** on the strength of **comparative analysis with actual impacts of Dukovany Nuclear power plant.** Analysis was carried out by **AQUAFIN-ing.F.Šedivý-watermanagement calculations and analyses**, see the study *„Documentation for cumulative assessment of the impact of Temelín NPP on the environment„ (03/2001).*

Both power plants are mutually comparable – Temelín Nuclear power plant will have an output of 2000 MW, Dukovany Nuclear power plant was commissioned in 1985 and has an output of 1760 MW (a difference of 14 %). As the technology of the production of electrical energy in both power plants is virtually the same and the efficiency of the conversion of thermal energy to electrical energy will be approximately the same it is possible to compare the impact of Temelín Nuclear power plant on water in many parameters with the impact at Dukovany Nuclear power plant. Differences are outside both power plants, in the capacity of water resources and sewage receiving streams. Generally it is possible to state that conditions for Dukovany Nuclear power plant are considerably worse.
Comparative analysis was carried out along the lines of

- hydrological data;
- off-take of surface water;
- quality of drawn-off water;
- surface water requirement;
- off-take of drinking water;
- amount of sewage;
- composition of sewage;
- difference between the amount of contamination contained in drawn-off water and the amount of contamination in sewage;
- admissible values of sewage contamination;
- permitted limits of contamination and their pumping at Dukovany Nuclear power plant;
- radioactivity of sewage;

- impact of water quality in sewage receiving streams;
- classical contamination (chemical, organic, macronutrients);
- radioactive contamination.

Closely monitored radioactive contamination is possible to suitably assess by means of permitted and actual pumped limits in 1999, as given in the following table.

Table No. 43

Radioactive material	Limits in Bq/r		Actual Dukovany NPP values in 1999	
	Temelín Nuclear power plant	Dukovany Nuclear power plant	Bq/r	Pumping of limit in %
Tritium	$4x10^{13}$	$2.2x10^{13}$	$1.8134x10^{13}$	82.9
Other radionuclides (beta activity)	$1x10^{9}$	$2.0x10^{9}$	$4.596x10^{7}$	2.3

These limits concern only radioactivity occurring in the power plant (contribution from the power plant). The table shows that **limits are feasibly set for Temelín Nuclear power plant**. Besides this, e.g. from comparison of tritium volume activity with volume activity measured in the Jihlava river under the Mohelno reservoir it follows that the impact of Temelín Nuclear power plant on the quality of surface water in indicators of tritium will be significantly less that the impact of Dukovany Nuclear power plant. Average tritium volume activity in the Vltava affected by Temelín Nuclear power plant should be about 1/3 of the level in Jihlava under Dukovany Nuclear power plant. The same assumption is valid for expected maximum tritium volume activity.

Results of independent comparative analysis and the analogy method enable an expert conclusion to be drawn, i.e.

- **the impact of discharge of sewage on water quality in the Vltava will be less than valid legislation in the Czech Republic allows. This applies to both indicators of classic contamination and indicators of radioactivity. The expected relatively small volume load of water in the Vltava by pollutants is a result of the proposed rational treatment of water in the power plant and improvement of flow rate conditions in the Vltava by treatment of water in reservoirs;**
- **besides radioactive material mainly chemical materials used in the treatment of water will be introduced into sewage in Temelín Nuclear power plant. The amount of organic material contained in discharged sewage will on the contrary be lower than the amount contained in drawn-off water. The expected amount of chemical materials introduced into sewage will probably be further reduced if it is shown that water added to cooling circuits will not need to be flocculated; the production of sludge would also drop.**

2.2.3.3. Effects on existing water utilisation

The impact of the power plant on the hydrosphere (surface water and groundwater) shows itself in the off-take of drinking water from the public water supply for the town Týn nad Vltavou, off-take of service water from the Vltava in the Hnevkovice profile and discharge of sewage to the Strouha water course, the Vltava tributary in the backwater of the Hnevkovice reservoir in the bight of the village of Jeznice and further treated sanitary sewage from the sewage treatment plant directly to the Vltava at Korensko.

The system of drinking water supply is gravitational with maintenance of hydrostatic overpressure from the Zdoba reservoir. No pumping stations are in the system and operational reliability has no relation to possible power failure. The quality of drawn-off water is monitored in half-yearly intervals.

Parts of the service water system are the waterworks of Hnevkovice (concrete gravitation dam) and Korensko (weir structure). The raw water system is constructionally and technologically built for a power plant output of 4x1000 MW. According to operating regulations for the waterworks of Hnevkovice and Korensko and in consequence on cooperation with the huge Lipno dam, the capacity of the water resource is several times greater than the additional water requirement in the power plant for an output of 2x1000 MW. Before use raw water is treated chemically by flocculation and filtration.

Sewage is treated in the biological sewage treatment plant with the exception of rainwater. Liquid radioactive waste originates especially in the evaporators during treatment of contaminated water, from regeneration of filters and ion-exchangers. Liquid waste is not discharged from the power plant, but is treated and when concentrated is stored and after solidification (bitumenation) is stored together with other sold waste in the radioactive waste repository. Over-balance treated activated service water (mainly tritium) forms liquid radioactive effluent, which cannot be caught in the treatment system. Water is discharged in a controlled manner through the sewage tank via the discharge channel to the Vltava. Sewage parameters and admissible limits doe discharge of individual materials and radionuclides is established by the decision of the relevant watermanagement authority. Adherence to permitted values is controlled by an indication (monitoring) system.

The potential impact of water off-take on existing practice in water utilisation in the Vltava catchment area is determined by permitted off-take of service water from the Vltava at an average of 1.625 m^3/s and a maximum of $38.019 x 10^6$ m^3/year. Due to its operation the power plant will quantitatively influence especially the section of the Vltava between the waterworks of Hnevkovice (off-take) and Korensko (discharge of sewage). This section is significantly affected by controlled outlet from the higher positioned waterworks of Lipno and Rímov. The bulk of improvement of small flow rates is up to 100 %, whereby the impact of power plant operation is eliminated in comparison with natural (unaffected) conditions.

The impact of liquid effluents on existing Vltava river water utilisation is given by permission to discharge a maximum of 501.0 l/s and yearly $9342 x 10^3$ m^3/year of the overall amount of sewage (sanitary and service water together).

The planned activity of tritium in treated and discharged water is approx. 10^9 Bq/m^3; the overall amount of discharged radioactive water will be approx. 3000 m^3/year, i.e. a load of $30 x 10^{12}$ Bq/year; the permitted harmless amount is $40 x 10^{12}$ Bq/year. From the point of view of tritium at a power of 2000 MW for more distant profiles it is ascertained that in the Prague-Podolí waterworks off-take profile the average tritium activity will be approx. 12 Bq/l, which means less than 2 % of the limit for public water supply watercourse according to valid regulations; in the Labe-Hrensko border profile about 5 Bq/l including so-called background.

The impact on the quality of groundwater can be evaluated partly from the point of view of the impact on chemical and physical properties, and partly from the point of view of hypothetical release of radioactive material to groundwater. Discharge of liquid waste (active and inactive) from operation of the power plant to groundwater is not admissible. From the mentioned reasons it is possible to qualify the impact of the construction and operation of the Temelín power plant on the quality of groundwater as not very significant, locally restricted.

Cumulative evaluation of the impact of the power plant on the hydrosphere does not exceed the scale established by relevant legal regulations. Neither quantitative impacts nor qualitative changes to parameters of surface water and groundwater are classified as significant. According to expert consensus it is possible to evaluate them as very low, deep in the band of natural background variation. Similarly discharge of warmed sewage to the Vltava river does not cause such changes in its temperature, which would exceed the natural state and its interannual changes.
For the assumed combination of biotic factors (fish) and abiotic factors (temperature) significant changes in the specific composition and biomass of zooplankton and phytoplankton are not expected. By regulation of fish store-ponds in the Orlík dam it is possible to influence the development of phytoplankton, zooplankton, benthic consumers and the chemical properties of water.
International obligations of the Czech Republic to the section of water system by the impact of Temelín NPP in the Labe Hrensko-Schmilka boundary profile are not affected.
The overall impact of the power plant on hydrological changes, circulation of surface water and groundwater can be evaluated as acceptable.

2.2.4. Monitoring effluents

As part of the protection of surface water and groundwater the indication (monitoring) system was specialised in the surroundings of potential or actual sources of contamination. The monitoring system in the sphere of the hydrosphere is complex and is not restricted only to discharge!
The system covers monitoring of quantity and quality of:
- surface water;
- drawn-off surface water;
- drawn-off drinking water;
- service and sanitary;
- rainwater.

2.2.4.1. Sampling, measurement and analysis of effluents, undertaken by operator or supervisory body

A special independent assessment of the monitoring system in the area of the hydrosphere was carried out by **AQUAFIN-ing.F.Šedivý-water management calculations and analyses**, see the study *„Documentation for cumulative assessment of the impact of Temelín Nuclear power plant on the environment „ (03/2001).*

Monitoring surface water
- In quantitative portions standard hydrological data derived from Czech Hydrometeorological Institute water meter stations is monitored. The state company Povodí Vltavy also measures flow rates, namely at the outflow from the waterworks of Hnevkovice and Korensko. Measurement of flow rates on the river Strouha is

recommended. The quality of water is monitored in state water quality monitoring networks (Czech Hydrometeorological Institute), in Povodí Vltavy purpose-built networks and within pre-operational monitoring of Temelín Nuclear power plant.

- Monitored profiles and indicators with a frequency of 12x per year:
- Vltava-Hluboká, the Czech Hydrometeorological Institute monitors, amongst other things, these indicators: water temperature, air temperature, icy effects, colour-visually, cloudiness, small, pH, conductivity, oxygen saturation, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, CO_3^{2-}, HCO_3^{2-}, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, Cl^-, SO_4^{2-}, NEC, tensides, total organic carbon, NEC, chlorophyll
- Vltava-Hluboká, Temelín NPP monitors in these indicators: pH, conductivity, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+},K^+, $ANC_{4,5}$, $BNC_{8,3}$, Cl^-, SO_4^{2-}, NEC, tensides, temperature
- Vltava-Hnevkovice, Temelín NPP monitors in these indicators: flow rate, pH, conductivity, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+},K^+, $ANC_{4,5}$, $BNC_{8,3}$, Cl^-, SO_4^{2-}, NEC, tensides, temperature, chromatographic profile, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples
- Vltava-Korensko – above weir, monitored by state company Povodí Vltavy,
- Vltava-Korensko – under weir, monitored by state company Povodí Vltavy,
- Vltava-Korensko - under weir (right and left bank), Temelín NPP monitors in these indicators: pH, conductivity, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+},K^+, $ANC_{4,5}$, $BNC_{8,3}$, Cl^-, SO_4^{2-}, NEC, tensides, temperature, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples
- Lužnice-Kolodeje, the Czech Hydrometeorological Institute monitors, amongst other things, in these indicators: water temperature, air temperature, icy effects, colour-visually, cloudiness, small, pH, conductivity, oxygen saturation, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, Cl^-, SO_4^{2-}, NEC, tensides, chlorophyll,
- Lužnice-Kolodeje, Temelín NPP monitors in these indicators: flow rate, pH, conductivity, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, $BNC_{8,3}$, Cl^-, SO_4^{2-}, NEC, tensides, temperature, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples
- Vltava-Hladná, the Czech Hydrometeorological Institute monitors, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples
- Vltava-Zvíkov, the Czech Hydrometeorological Institute monitors, amongst other things, in these indicators: water temperature, air temperature, icy effects, colour-visually, cloudiness, small, pH, conductivity, oxygen saturation, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, HCO_3^{2-}, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, Cl^-, SO_4^{2-}, NEC, tensides, chlorophyll, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples
- Vltava-Solenice, the Czech Hydrometeorological Institute monitors, amongst other things, in these indicators: water temperature, air temperature, icy effects, colour-visually, cloudiness, small, pH, conductivity, oxygen saturation, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, HCO_3^{2-}, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, Cl^-, SO_4^{2-}, NEC, tensides, chlorophyll, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples

- Otava-Písek (Topelec), the Czech Hydrometeorological Institute monitors, amongst other things, in these indicators: water temperature, air temperature, icy effects, colour-visually, cloudiness, small, pH, conductivity, oxygen saturation, COD_{Cr}, COD_{Mn}, BOD_5, diss. O_2, HCO_3^{2-}, DM, IM, P_{tot}, PO_4^{3-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, $ANC_{4,5}$, Cl^-, SO_4^{2-}, NEC, tensides, chlorophyll, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples.

When monitoring radioactive material in surface water it is possible to mention for information the recommendation of the EC commission from the 8h June 2000, C(2000) 1299, which with reference to EURATOM (2000/473) states in its appendix for monitoring of surface water caesium 137 as the indicator of content of radioactive material and tritium, stroncium 90 a caesium 137 for overall volume activity after subtracting the contribution of potassium 40 and for drinking water. They are the same indicators as are monitored in conjunction with control of the impact of Temelín power plant.

Monitoring drawn-off surface water

Indicators enabling control of adherence to the Decision of the District office C. Budejovice are monitored from the quantitative group of indicators, i.e. flow rate in m^3/s and off-take balance data. From qualitative data indicators important from the point of view of water treatment or from the point of view of utilisation of water without treatment are monitored. This concerns special-purpose measurement in the interests of Temelín Nuclear power plant.

Monitoring the off-take of drinking water

This concerns off-take from the public water supply. The purpose of measurement is the control of adherence to the quality of drinking water determined by the regulation of the MoH No. 376/2000 Coll. and the overall alpha volume activity, overall beta volume activity, H3.

Besides measuring the amount and quality of drinking water at the inlet to the Temelín Nuclear power plant site measurement of the quality of this water at the inlet to individual monitored buildings is also carried out.

Monitoring of groundwater

At selected drainage holes the height of the level and quality of water is monitored in these indicators:

Quality of groundwater in indicators:

- conductivity, pH, $COD_{Mn,}$ m($ANC_{4,5}$), chlorides, ammonia ions, nitrites, nitrates, sulphates, NEC, heavy metals: Ba, Pb, Cd, Cr (tot.), Co, Ni, Hg, Zn, tensides, phenols, cyanides (tot.), fluorides, cations: Ca, Na, Mg, K, phosphates, overall alpha volume activity, overall beta volume activity, H3, Cs137

  Quantitative factors:
- height of groundwater level

  Current monitoring:

  At the present time these holes are part of the monitoring system:

  Dump holes S1, S2, H1, H2, H3, H4.
- frequency of off-take 2x per year, implemented chemical analysis: pH, COD_{Mn}, NEC, DM, NH_4^+

  Dump holes HV 1001, HV 1003, HV 1005:
- frequency of off-take 4x per year, implemented chemical analysis: pH, COD_{Mn}, hardness, conductivity, m($ANC_{4,5}$), DM, NEC, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, Mg^{2+}, Cl^-, Ca^{2+}, tensides, Fe (tot.)
- frequency of off-take 1x per year, implemented chemical analysis: metals (Cr, Cd, Hg, Pb, CO, Ni, Cu)

Holes for control of central oil and diesel system PV 50, PV 51:

- frequency of off-take 2x per year, implemented chemical analysis: pH, COD_{Mn}, NEC

Holes in the power plant area RK 2, RK 25, HV 615:

- frequency of off-take 4x per year, implemented chemical analysis: pH, COD_{Mn}, hardness, conductivity, m($ANC_{4,5}$), DM, NEC, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, Mg^{2+}, Cl^-, Ca^{2+}, tensides, Fe (tot.), CO_3^-, HCO_3^-, $BNC_{8,3}$, overall alpha volume activity, overall beta volume activity, H3, Cs137

Holes around the power plant for shallow and deep circulation HV 1A, HV 2B, HV 3A, HV 3B, HV 3C, HV 4C, HV 5A, HV 5C, HV 6C:

- frequency of off-take 4x per year, implemented chemical analysis: pH, COD_{Mn}, hardness, conductivity, m($ANC_{4,5}$), DM, NEC, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, Mg^{2+}, Cl^-, Ca^{2+}, tensides, Fe (tot.), overall alpha volume activity, overall beta volume activity, H3, Cs137

system of drainage holes OV:

- frequency of off-take 1x per year (at holes pumped to rainwater sewerage), implemented chemical analysis: pH, COD_{Mn}, conductivity, DM, NEC, NH_4^+, NO_2^-, NO_3^-, H_3

Monitoring discharged sewage

The amount and quality of sewage discharged into the Vltava in the Korensko profile is measured. The scope of measurement of determined by the Decision of the District office C. Budejovice. Water samples for establishing the quality of discharged water are drawn at the outlet from the collection tank of all service and sanitary sewage. Certain indicators are measured continuously. The following indicators are the subject of monitoring:

- **radioactivity – H3, overall alpha volume activity, overall beta volume activity gammaspectrometric analysis affecting 22 radioactive materials, including Cs137**
- conventional contamination – BOD_5, COD_{Mn}, COD_{Cr}, Cl^-, SO_4^{2-}, NO_2^-, NO_3^-, PO_4^{3-}, Ca^{2+}, Mg^{2+}, Na^+, DM, IM, NEC, NH_4^+, tensides, pH, temperature, conductivity, total carbon.

The quantity and quality of treated sanitary sewage is measured separately (specific point – outlet from the sewage treatment plant). The following contamination indicators are monitored: BOD_5, COD_{Cr}, NEC, NH_4^{+-}, IM, NO^-, NO_3^-, pH, PO_4^{3-}, DM.

24 to 48 measurements per year.

The activity of radionuclides is also measured in control tanks from which over balance of the amount of active water is discharged into the collection tank of all sewage from the power plant.

On the basis of results of measuring radioactive material the amount of discharge of this water to the collection tank for all sewage from the power plant is decided. The limit value of volume activity for tritium is 3.57×10^6 Bq/l and for other radionuclides emitting beta radiation it is 714 Bq/l. If the limit level is not adhered to water is returned for further treatment.

Monitoring rainwater

- the quality of rainwater is monitored at the specific point „Safety tanks „. The following are measured: COD_{Cr}, NEC, NH_4^+, NO_3^-, Pc, pH, DM, tensides and conductivity, overall alpha volume activity, overall beta volume activity, H3, Sr90, gammaspectrometric analysis of evaporation residue of large volume samples.

Number of samples taken: 24 per year.

In fourteen day cycles the quality of water at the outlet from retention tanks is also monitored. These indicators are measured: COD_{Cr}, NEC, IM, pH, DM, tensides, conductivity.

2.2.4.2. Basic characteristics of monitoring equipment

Monitoring of liquid effluents forms part of the complex project of radiation control (RK) and the Centralised monitoring and information system (RRMS). During operation of Temelín Nuclear power plant discharges of sewage to the water course are monitored. Conditions for discharge are precisely set by a legal document and adherence to them is controlled. Around the power plant it is monitored by a special workplace and in the Temelín Nuclear power plant by an independent workplace, where the following are analysed:

- dose equivalents measured around Temelín Nuclear power plant,
- the level of volume activity of radioactive gases, aerosols and iodine in the atmosphere,
- the level of volume activities, specific and general activities of environmental samples,
- radioactive fallout from the atmosphere,
- volume activity of groundwater in the Temelín Nuclear power plant site.

The system of Temelín Nuclear power plant radiation control ensures that no radioactive material occurs in inadmissible concentrations in control tanks of treated water. It ensures that in the case that set limits are exceeded discharge of these tanks to the waste channel and from there to the environment does not take place. The system also ensures that monitoring and sampling took place in the collection tank of service and sanitary water, which is located at the water outlet from the nuclear power plant site. Thereby the efficiency and adherence to previous safety measures is verified, and the overall balance of material, which is discharged into the water course, is monitored. The results of measuring are the main basis for evaluation of the impact of the nuclear power plant on the environment.

Monitoring of sewage at the outlet from the Temelín Nuclear power plant site:

- has built in signalling, which is started when permitted levels of activity of discharged water are exceeded and has equipment which restricts the release of radioactive material to the environment;
- ensures further additional information for balancing discharged activity. Continuous sampling of sewage takes place for complex laboratory analysis, whereas the sample amount is proportional to immediate flow rate in the waste channel.

Within the RK document continuous taking and measuring of samples is ensured with detailed specification of the title of measuring, location of measuring, labelling of measuring, detector type, analyses carried out, measuring scale and measured isotope. A beta scintillation detector, a gamma scintillation detector, NaI(Tl) gamma scintillation detector, CdTE, GM tube, ionisation chamber are used for detection.

2.2.4.3. Alarm and intervention level (manual and automatic)

As far as radioactive discharge is concerned the activity of radionuclides originating in the nuclear power plant and discharged during one calendar year cannot cause a 50 year load in individuals of the population H50,L greater than 40 Sv during operation of two units, whereas the conversion of activity to this load must be carried out in a manner authorised by the State Office for Nuclear Safety. If it would lead to such limit values being attained the reactor must be shut down in one hour and further operation can be started after the next permit has been issued by the State Office for Nuclear Safety. This of course is an intervention level given by legal measures. An extensive system of internal monitoring exists in the power plant, which monitors the radiation situation in individual technological systems and areas of the restricted zone of the nuclear power plant. Upon exceeding general values in these places signalling of exceeding these operational levels occurs which is a signal for operator action. These limits are not given by law, they are proposed by the plant operator and approved by the State Office for Nuclear Safety within the internal monitoring plan. At the present time commissioned equipment is set very conservatively. They will (again with the agreement of the State Office for Nuclear Safety) be gradually specified to reflect the real situation in operation and in a timely manner upon origination of any anomaly directly at the source signal the situation elusive to a common level. The endeavour of the power plant is to not react at the last moment when the situation reaches the outlet to the environment, but to intercept unusual states directly at their point of origination, i.e. as soon as possible and with the greatest sensitivity. This concerns not only the monitoring of air gases, but also liquid media, which is monitored in technological operation, where it can occur or where it can be transported to.

Key problems of the sphere of assessment:
(A) drinking water security and quality
(B) service water security and quality
(C) risk of radioactive contamination of the receiving stream owing to the discharge of tritium water

According to the existing investigation it is possible to state that the:

Impact of Temelín nuclear power plant on the hydrosphere is negligible and acceptable.

Recommendation:

For verification of conclusions from the survey, especially in the area of the impact of Temelín NPP on the hydrosphere, it has been shown as effective to provide independent and continuous control of the impacts of operation of the Temelín power plant from the period of starting unit 1 to a period of 3 years after starting unit 2. Impacts would be controlled in key problem circuits:

- **security of the supply and quantity of drinking water from the point of view of the power plant and the impact of the power plant on water resources around Temelín power plant;**
- **security of the supply and quantity of service water from the point of view of the power plant;**
- **impacts of emissions on the water media and the risk of radioactive contamination of the receiving stream owing to discharge of tritium water and other water, including evaluation of thermal effects, accumulation and synergetic action of harmful material (including eutrofisation) in the Orlík waterworks;**
- **impacts of emissions to the atmosphere, verification of thermal contamination and evaporation of water on cooling towers;**
- **impacts on agricultural activity and forest management.**

For ensuring independent perception of above-standard control of the impact of power plant operation (besides standard monitoring by the Temelín Laboratory of radiation control, standard monitoring in the Czech Hydrometeorological Institute state networks, or others) proposal of a research task with mentioned focus, financed from purpose made funds for science and research in the government council program is shown to be optimal. On the basis of experience with investigating the reference level (zero point) of the environment around the Temelín power plant and with the forecast of the impact of Temelín on the environment it is shown to be effective to ensure a solution of the proposed complex task in sponsorship from the Ministry of the Environment of the Czech Republic and coordination with e.g. the T.G. Masaryk Water Research Institute, which has a Reference laboratory for measuring the radioactivity of water and other compounds of the environment.

2.3 Soil and Rock Environment

2.3.1 Uses of Natural Resources

2.3.1.1 Used Land and Soil - General

The Temelín Power Plant occupies an area of 143.1382 hectares, comprising land estates which have been bought out on a permanent basis and are now owned by CEZ a.s. The area reflects the original intention to build a power plant with four power generating blocks. The boundary of the area matches the fence of the power plant´s premises. The fenced area occupied by the two existing power generating blocks is now 123.3370 hectares.

The land comprising the nuclear power plant´s premises is not used for agricultural purposes. All the land within a radius of 3 kilometers from the power plant are owned by CZE-ETE; consequently, it is extremely unlikely it would be used for other than intended purposes.

The power plant is located within its own zone of protection declared in 1985. To handle potential radiation incidents/accidents, a contingency planning zone and an inner contingency planning zone were declared in 1997 as areas within a radius of 13 kilometers and 5 kilometers, respectively, from the center of the containment of the first power generating block.

2.3.1.2 Temporary Uses of Land

As a rule, temporarily occupied areas and areas of villages and municipalities which had to give way to the construction of the power have mostly been or will be rehabilitated as the construction draws to its end. The rehabilitation of the temporarily occupied areas is expected to result in arable land constituting just a third of its initial area; the remaining two thirds will be left to their own devices, with just a basic planting of natural (original) tree and hedge species.

The investor holds ownership rights to permanently and temporarily occupied areas.

2.3.1.3 Permanently Used Land: Agricultural Land, Forests, Areas Protected by Law, Areas Used for Special Purposes

The zone of protection of the power plant occupies whole or parts of the cadastral areas of the municipalities of Temelín, Sedlec, Malešice, Temelínec, Kocín, Brezí u Týna nad Vltavou, Zverkovice, Krtenov and Bohunice. Some of the above villages have been torn down and their population resettled.

The regimen of the declared zone of protection of the power plant rules out any permanent settlement and construction of any new buildings not connected with the operation of the power plant. Any use of soil and water within the zone is subject to checks which constitute a part of the plant´s operation monitoring program.

The Temelín Nuclear Power Plant falls into Class III Catchment Area of the Praha-Podolí surface source of drinking water. It does not fall into any groundwater catchment area or protected area of natural accumulation of water.

There are no areas of particular protection (as defined in Section 14 of Act No. 114/1992 Coll., on protection of nature and landscape) or their zones of protection in the area in question. According to Section 37 of Act No. 114/1992 Coll., the width of zones of protection of both existing and planned small areas of particular protection in the vicinity of the power plant is 50 meters around their entire perimeter, except for the Karvanice Nature Reserve the zone of protection of which is subject to an exemption.

The Temelín Nuclear Power Plant does not fall into any zone of protection of any elements of the ecological stability system. Each supra-regional bio-corridor in its vicinity is characterized by its axis and zone of protection (buffer zone). The maximum width of the buffer zone is derived from the maximum distance between local bio-centers - i.e. 2 kilometers to either side of the supra-regional bio-corridor centerline.

There are the following zones of protection falling outside the premises of the plant:

Zones of protection of highways and roads:

- Class I highways - 50 meters from the highway/inside lane centerline
- Class II and III roads and highways - 15 meters from the highway/inside lane centerline

Zones of protection of electrical facilities and equipment:

Overhead power lines:

• 1 kV to 35 kV	7 meters to either side of the outside conductor
• 35 kV to 110 kV	12 meters to either side of the outside conductor
• 110 kV to 220 kV	15 meters to either side of the outside conductor
• 220 kV to 400 kV	20 meters to either side of the outside conductor
• above 400 kV	30 meters to either side of the outside conductor

Underground power lines:

• up to 110 kV	1 meter to either side of the outside cable
• above 110 kV	3 meters to either side of the outside cable
Power stations and power generators:	20 meters from the fence or wall of the facility

Zones of protection of gas facilities and equipment:

Gas pipelines and connections:

• up to 200 mm in diameter	4 meters to either side of its plan view contour
• 200 to 500 mm in diameter	8 meters to either side of its plan view contour
• above 500 mm in diameter	12 meters to either side of its plan view contour

Low- and medium-pressure gas pipelines and connections:

- within built-up areas of municipalities   1 meter to either side of its plan view contour
- technological facilities   4 meters to either side of its plan view contour

Zones of protection of heat facilities and equipment:

- heat generation/distribution facilities   2.5 meters from the facility
- exchanger stations   2.5 meters from the facility

2.3.2 Description of the Environment Affected by the Power Plant

2.3.2.1 Geology and Morphology

Geological Setting

In terms of regional geology, the area in question falls into the northwestern part of the South Bohemian Moldanubicum represented by rocks of the monotonous series on the plant´s premises. The formation of the Moldanubian crystalline rocks occurred in several phases taking place until the end of the Paleozoic period, with older structures being repeatedly activated and reshaped.

The most frequently occurring rocks are represented by biotitic, biotitic-sillimanitic to biotitic-cordieritic paragneiss and migmatite, sometimes intercalated by quartzite, amphibolite, granulite and orthogneiss. The metamorphic rocks are products of a complex, nappe-like metamorphic and deformation cycle. Quaternary deposits are mostly represented by slope loam, deluvio-fluvial deposits and fluvial sandy gravel. The thickness of layers depends on geomorphology.

The classification system employed with respect to rocks found on the power plant´s site is based on genetic (rock type), technical (degree of weathering, strength, fracturing/fissuring) and petrological (mineralogical composition, grain size, texture) criteria. The bedrock is composed of rocks of the so-called monotonous series, consisting of a complex of sillimanitic-biotitic paragneiss, gneiss and migmatite, intercalated by several types of granitoids. The metamorphic rocks identified on the site are represented by sillimanitic-biotitic paragneiss (fine- to medium-grained, dark brown-gray to black-gray, medium to heavily migmatitized, displaying a variable degree of silicification), sillimanitic-biotitic greywacky paragneiss (fine- to small-grained, light-gray and light-gray, fine-striped, showing a low degree of migmatitization, highly silicified, strong, heavily fractured), quartzitic gneiss (very fine- to fine-grained, light-gray to white-gray, showing a low degree of migmatitization, highly silicified, extremely strong, heavily fractured), and migmatite with a prevalence of the para component over the ortho one (fine- to medium-grained, dark-gray, light- to dark-schliered, heavily to very heavily migmatitized, showing a weak degree of silification, with a high to very high content of mica, medium-strong to soft, medium-fractured).

Granitoids constitute intercalations within the Moldanubian metamorphic rocks. Those identified on the site are as follows: vein (aplitic) granite - fine- to medium-grained, strong to extremely strong, heavily fractured; pegmatitic granite - medium- to coarse-grained, with a granitic texture, strong to very strong, medium- to heavily fractured; pegmatite - coarse- to large-grained, with a pegmatitic texture, strong, heavily to very heavily fractured; and vein (secretion) quartz - massive to very fine-grained, extremely strong, heavily fractured.

Geological survey revealed slightly weathered to sound rocks from the depth of 20 meters downward. Contour lines of the weathering base indicate an irregular and variable nature of weathering processes. The process of weathering was also affected by the degree of fracturing and silicification. The depth of the weathering base, confirmed by detailed survey, ranges from 5 to 15 meters below the surface, and even up to 25 meters along fault zones.

The layer of heavily weathered rocks gradually passes into a zone of fossil weathering, representing by decomposed paragneiss, migmatitized or granitic-pegmatitic rocks. In terms of their physico-mechanical properties, they are similar to Quaternary soils. Depending on the nature of the parent rock, the zone of fossil weathering (eluvium) shows a high degree of variability with respect to mineralogical composition and/or grain size. Products of weathered/decomposed gneiss are represented by fine-grained, loamy-sandy soils containing mica, dark rusty-gray, compacted, occasionally cohesive, low- to medium-plastic, tough to strong. Those of weathered/decomposed greywacky gneiss contain more sand and less mica, are medium-grained and ochrish in color. Granitic rocks produce medium- to coarse-grained, loamy, compacted sand. The entire eluvium zone is of a variable strength, with physico-mechanical properties varying over a broad range of values.

Overlying the zone of fossil weathering of the Moldanubian rocks are Quaternary deposits whose average thickness on the site was found to be up to 1.5 m. In genetic terms, they are represented by deluvial Pleistocene deposits, with only the topsoil being of the Pleistocene-Holocene age. Five basic types of Quaternary deposits were distinguished on the basis of their grain-size distribution, namely: topsoil; removed gneiss eluvium, loamy sand, clayey loam, and materials filling in rill depressions. **With respect to the foundations of the nuclear power plant, the Quaternary deposits are irrelevant, as they were stripped and removed during site leveling.**

Results of detailed engineering-geological survey indicate that all sites where principal buildings and facilities of the nuclear power plant are located on a single **tectonic (geological block)** comprising just local discontinuities which do not constitute major faults, and thus do not disturb the continuity of the Moldanubian block of the site. The term "single tectonic block" as used above is consistent with the terminology of IAEA safety instructions.

An analysis of hydrogeological survey drillholes, which focused on the reactor sites, confirmed the existence **of a significant tectonic line running NE-SW**, identified by the following drillholes: ventilation stack - BAPP Bldg - area between Reactors 2 and 3 (see J. Novák and B. Jedlicka, 1992). According to O. Pazderník (1982) and results of a previous basic geological survey, these are *"relatively significant tectonic faults of the main site, represented mainly by two N-S fault lines running obliquely across the reactor sites and partly also affecting the site earmarked for cooling towers, off the village of Brezí. With a width of up to several meters, they comprise heavily to very heavily fractured, heavily to very heavily weathered rocks, with frequent manifestations of secondary metamorphism, but without any continuous or thicker younger hydrothermal filling (dislocation clay etc.)... Their depth also seems limited, generally not exceeding 20 to 30 meters. The deeper they go, the lower the intensity of fracturing and weathering. Consequently, it may be assumed they do not constitute regional lineaments disturbing the continuity of the Moldanubian block of the site.*

Geomorphology

The Temelín Nuclear Power Plant site is situated in South Bohemia, in the district of Ceské Budejovice, off the village of Temelín. Orographically, it belongs to the Tábor Downs, a subsystem of the Central Bohemian Downs. Typically, the morphology of the Tábor Downs is that of a peneplain, segmented into flat-shaped ridges and denudation plateaus by erosion, the only morphologically significant elements being the deep cuts of the Vltava and Lužnice rivers. The Temelín Nuclear Power Plant site is situated on one of such plateaus, at an altitude of approximately 507 meters a.s.l.

Prior to the commencement of construction work, the site was leveled, including a removal of a 5 to 10 meters thick layer of soil. The buildings were founded at depths ranging between 7 and 8 meters, i.e. approximately 10 to 15 meters below the original terrain surface level.

2.3.2.1 Soil Structure and Soil Types

Description of Soils Currently Found on the Site

Initially, there was a layer of Quaternary deposits overlying the heavily weathered crystalline bedrock, its thickness averaging 1 meter, occasionally 2 meters and exceptionally even 3 meters. **As a rule, the Quaternary deposits show medium load-bearing capacities and medium to high compressibility values. With respect to the foundations of the nuclear power plant, the Quaternary deposits are irrelevant, as they were stripped and removed during site leveling.**

The original in situ soil types were disturbed by stripping and follow-up filling operations during the plant construction. The soils on the site can thus be labeled as affected by anthropic activities. In the morphogenetic soil classification system, they are classified as anthropogeneous forms of original soil types, with a varying intensity of anthropic effects, ranging from affected to transformed to man-made soils. As far as soils containing an anthropic, man-made Horizon A over a man-made underlying layer are concerned, they are represented by the degradation anthro-soil (built-up areas) and typical anthro-soil (soils initially developing on man-made substrates enabling plant growth) types.

Soil Types

Basic information with respect to the soils originally found on the power plant site and its vicinity and broader surroundings is provided by a graphic annex in the documentation, which also uses the earlier genetic classification of soils in addition to numerical indexes.

As a rule, the underlying soil-forming substrate is represented by weathered products of paragneiss and migmatite, less frequently by acidic poly-genetic loam. There are also isolated islets of loess loam in the vicinity.

Prevailing soil types on the site were (and in its vicinity still are) acidic cambi-soils (KMm/a - acidic brown soil Ha) and temporarily wetted, gleyfied acidic cambi-soils, subtype - pseudo-gleyfied cambi-soil, acidic variety Kmg/a (acidic gleyfied brown soil Hag). In places where effects of the temporary wetting were more pronounced, pseudo-gleyfied soils (Pgm - pseudo-gleyfied soils O) have developed. In the broader vicinity of the power plant, namely on the islets of loess loam mentioned above, the soil formation process has resulted in lluvi-soils (LMm - illimerized soil I). The acidic cambi-soils rank among medium-quality soils.

Soil Quality

Most of the soils initially found on the site (80%) were assigned the **qualitative soil/environmental unit code** equal to 5.29.04, the remaining part of the site falls into Classes 5.73.11 and 550.11. The above code characterizes the unit in question in terms of its climatic region, main soil unit, slope and exposure, and depth and structure of the soil. The first digit (5) indicates a moderately warm and moderately humid region with an average yearly temperature between 7 and 8 degrees Centigrade and an average yearly rainfall of 550 to 650 mm.

Characteristics of principal soil units:

5.29.04 Brown soils, brown acidic soils and their slightly gleyfied forms, mainly found on gneiss substrate; medium-heavy to lighter, with some gravel, mostly with good humidity;

5.73.11 Gleyfied boggy soils and gleyfied slope soils, medium- to very heavy, wetted, with spring areas on slopes; if drained, they can be used as meadows;

5.50.11 Gleyfied brown soils and gleyfied soils on various substrates (mainly gneiss), generally medium-heavy, with a low to medium content of gravel and rock fragments, temporarily wetted.

2.3.2.3 Soil Conditions

Principal characteristics of the soils are presented in the previous section. Available documentation failed to provide any special data, such as on proneness to erosion, degree of compaction etc.

2.3.2.4 Uses of Land

Available documentation failed to provide any information on the ownership structure or current uses of the land in question.

2.3.3 Potential Environmental Effects

2.3.3.1 Uses of Land

By way of opening, it must be emphasized that the power plant construction has resulted in completely changing the nature of the land and topsoil.

The operation of the power plant and emissions of all types do not constitute a permanent source of contamination of soils and underlying rocks. These are represented by remnants of inert construction materials and drippings of fuels powering means of transport and building machinery, which are biodegradable. Soils on the site are not used for agricultural production. There is a minimum possibility of any contamination by surface water or atmospheric imissions.

Potential single-point leakage of contaminants from their sources (diesel fuel and oil storage and handling facilities, dump sites etc.) are checked by the monitoring system.

2.3.3.2 Soil Changes Resulting from Use and Contamination

A special independent assessment *of potential changes of soils and land was performed by GEOSCI-RNDr. Dana Procházková DrSc., see* "An Assessment of Changes in the Categorization of Soils and Land Resulting from the Construction of the Power Plant" (03/2001).

When assessing potential impacts of the Temelín Nuclear Power Plant on rocks and soils in its vicinity**, it is necessary to take into account basic parameters of the bedrock and soils, which are as follows:**

- bedrock quality (stability, load-bearing capacity, erosion)
- soil quality (stability, load-bearing capacity, erosion)
- content of radionuclides in bedrock
- content of radionuclides in soils

A risk typically involved in a nuclear facility is that of rocks and soils being contaminated with radioactive substances. The Temelín Nuclear Power Plant can have such impacts only through gaseous, liquid or solid substances produced by abnormal operation or incidents/accidents, or through normally operating outlets releasing radionuclides into the atmosphere or surface streams. Contamination of rocks and soils with radioactive substances can also result from nuclear waste handling accidents.

Secondary (or delayed) impacts of the Temelín Nuclear Power Plant on rocks and soils can include:

- transfer of heat from heated buildings or warm discharge water into the atmosphere and soils;
- increased evaporation from the surface of warm discharge water;
- reduced evaporation resulting from changes of the original soil surface on the premises of the plant (vegetation replaced by man-made surfaces, such as macadam or concrete);
- changes in the nature of the surface and terrain relief on the premises of the plant (changed reflective capacity, thermal capacity, thermal conductivity, moisture content of soils, changed terrain relief with respect to flow conditions);

The factors listed above affect the thermal and moisture balance of soils. Based on results of the bedrock and soil monitoring obtained so far, these effects range within limits of the measurement error, i.e. do not attain critical values.

The fuel cycle of the Temelín Nuclear Power Plant comprises two processes which produce radionuclides, namely fission and activation. When the reactor is operating under normal conditions, the U_{235}-containing fuel generates products of fission and transurans. Most of the fission products and transurans remain in the fuel and are removed from the reactor together with the spent fuel. However, some of the fission products pass through microscopic cracks or imperfect seals of the outer shell of fuel rods into the active zone coolant. These fission products activate corrosion products of structural materials of the primary circuit and reactor coolants or resulting from impurities and chemical additives in the coolant.

For technological and particularly safety reasons, radionuclides in the coolant and technological systems of the nuclear power plant must be continuously or periodically removed (special water treatment plants). The use of various technological, recuperation or decontamination processes employed to clean contaminated objects produces radioactive wastes.

Soil Contamination

A detailed assessment of the current state of bedrock contamination in places and areas where changes have been made during the pre-operation period of the plant has not been undertaken. Potential soil contamination in the course of construction work might occur as a result of a spillage or escape of hazardous substances into the bedrock. The latter are represented mainly by oil hydrocarbons and building waste and debris. Laboratory analyses of groundwater did not identify any contamination by oil hydrocarbons; it can therefore be assumed there was not any substantial contamination of the rock environment due to the substances referred to above. According to available data, there was not any substantial soil contamination with hazardous substances identified during the plant construction. An inspection of the plant site and its surroundings did not reveal any atypical occurrences or growths of plants which might be indicative of either natural or anthropogeneous soil contamination.

Given the current and anticipated atmospheric pollution levels around Temelín and the level of dynamics of compounds of nitrogen, fluorine, heavy metals and radioactive substances, high concentrations of these substances in soil are not expected. The assumption is corroborated by findings of a recent monitoring of agricultural and forest soils in the area.

The light to medium-heavy cambi-soils found around the power plant can be classified as highly prone to anthropogeneous pollution.

Data on contents of radionuclides in soils is presented in relevant parts of documentation.

2.3.3.3 Changes in Local Topography, Impacts on Soil Stability and Erosion

The construction of the power plant has resulted in dramatic changes of local topography (earthworks, the plant proper).

The operation of the power plant and the design of drainage systems are not expected to have a substantial impact on the stability of soils, including erosion phenomena. The proposed method of reclamation/regeneration of temporarily occupied areas will ensure land stability and render them erosion-resistant.

The area occupied by the Temelín Nuclear Power Plant contains a non-continuous water-bearing layer directly communicating with the shallow circulation of groundwater. Its existence is attributable to fracture-related permeability due to which subsurface water slowly communicates with underlying horizons. The groundwater flow deceleration is also attributable to local barriers represented by some buildings of the power plant complex, whose foundations are sunk at different depths. In these zones, local accumulations of subsurface water under the foundations were identified (although the related buildings had been supposed to have their foundations situated above the groundwater table in the project documentation). In some places, there were even local overflows. The water is dealt with by the drainage drillholes referred to above, whose very existence disturbs the hydrodynamic filtration field. The drillhole poses no obstacle to the groundwater flow, which results in different groundwater flow speeds (the drillhole allows through more water than the matching volume of rocks). If the water is retained by the leveled surface of paragneiss layers (which show just fracture-related permeability) or building foundations, it accumulates in drillholes. The flow is also affected by drillhole design and equipment, namely its diameter, casing, perforation density and packing. These drillholes thus locally regulate the groundwater table on the site and its communication with horizons situated at greater depths. As indicated above, the effects are local, limited to the plant site and its immediate surroundings. It can be concluded that the nuclear power plant *per se* is not a factor resulting in any major disturbance of hydrogeological characteristics.

The impacts resulting from the construction work necessitated by changes on the quantity and communication of groundwater is insignificant and utterly overshadowed by natural short- or long-term groundwater table fluctuations. The construction of the system of drainage drillholes at selected buildings (cable conduits in the central part of the site, CHÚV, engine rooms, ops building, office building), under the foundations of which a non-continuous aquifer was identified, seems to have a measurable, but insignificant impact on the groundwater table on the site. It can be attributed to fracture-related permeability of rocks owing to which subsurface water does not seep down to deeper horizons at all, or only at a very slow pace. Reflecting the hydrogeological survey findings, buildings of the Temelín Nuclear Power Plant have not been fitted with pressure insulation against water (they were supposed to have their foundations situated above the groundwater table in the project documentation). Because of the impermeable bedrock, there were difficulties with groundwater seepage into underground parts of these buildings, which required the system of drainage drillholes to be established, their purpose being to draw the groundwater table down. The first phase consisted of 30 drainage drillholes (completed and put into operation in 1994). As the power plant neared completion, their number was increased to 45 (completed and put into operation in 1997). The pumped water is monitored and, having passed the check, is discharged into the rainwater and sewage collection system. Its approximate volume is 35,000 m^3/year, more accurate information is available in the documentation.

The system monitoring the quality of surface water and groundwater is consistent with the geological and hydrogeological setting of the Temelín Nuclear Power Plant site and its vicinity, as well as with groundwater circulation conditions in the above environment. Similarly, it also reflects the anticipated speed and magnitude of migration of radionuclides in groundwater.

In addition to qualitative parameters, the groundwater table level and its fluctuations are monitored as well. Water level measurements are of a dual purpose - to monitor the groundwater flow direction and rate enabling to monitor the migration of radionuclides (especially in contingencies), and to check and monitor the system draining deeper-founded buildings on the plant site.

Groundwater Monitoring

Purpose	Monitored Buildings	Frequency
Hydrogeological and migration	RK, RK25, HV615, HV1A, HV2B, HV3C, HV4C, HV5A, HV5C, HV6C, HV1001, HV1002, HV1003, HV1005	Once a week, since 1999 continuous measurements
Drainage	OTKA 1,4,5,7,8,9,12,17,21,¨22,24, 39,43,46,49,51,51b,53,56,57,58, 63,63a,63b,66,67,68,71, 74-91	Groundwater table drawn down to -22 to -23 meters below the surface, level control based on electrodes

2.3.3.4 Impacts on Geomorphology and Non-Renewable Resources

The site was leveled to two basic altitudes: the buildings housing equipment relevant for nuclear safety have been concentrated in the central part of the site the altitude of which is 507 meters a.s.l. Most of auxiliary buildings are situated at an altitude of 503 meters a.s.l. The bedrock of individual buildings is composed of low-weathered rocks showing a low degree of tectonic disturbance.

The plant technology does not produce any heat which would spread underneath the foundations, and could thus affect the rock environment. At the same time, the plant is not a source of any vibration which could be transmitted into the bedrock and affect or disturb the geological setting of the area and its dynamic stability, or result in a liquefaction of earth berms and fills.

The power plant does not affect registered or potential mineral resources.

Potential leakage or seepage of contaminants from their sources (diesel fuel and oil storage and handling facilities, dump sites etc.) will be identified by the monitoring system before it can spread far enough to cause a major problem; in such cases, measures are in place which will dispose of the leakage and its consequences.

There is not a possibility of any major pollution of land and soil by surface water or atmospheric imissions.

The drainage drillholes have resulted in local disturbances of the rock environment. This intervention is of local importance only, as it affects the groundwater flow. With the plant operating normally, it does not disturb the homogeneity or quality of the rock mass.

It is therefore concluded that:

- The Temelín Nuclear Power Plant has been built on a stable geological bedrock having a sufficient load-bearing capacity and not prone to excessive erosion. In the course of preparations, construction and determination of operating conditions, applicable legal regulations and standards of the Czech Republic were adhered to. This means that occurrences of negative phenomena resulting from the operation of the Temelín Nuclear Power Plant is highly unlikely, and the in-place monitoring system has not indicated any occurrences which might lead to a degradation of the rock environment.
- The plant is not a source of any vibration which could be transmitted into the bedrock and affect or disturb the geological setting, i.e. bedrock and topsoil.
- According to the in-place monitoring system, the Temelín Nuclear Power Plant does not pose any source of soil contamination which would deserve special attention.

2.3.4. Seismology

2.3.4.1. The degree of seismic activity in the region; probable maximum seismic activity and designed seismic resistance of the installation

For the purposes of the construction, the power plant operation, and estimation of earthquake probability, a detailed survey of the faults in the power plant near surroundings was carried out. The following faults were identified (Šimunek et al., 1994 a; Šimunek et al., 1994 b):

The fault of the Blanice breakthrough – the shortest distance from the Temelín power plant is 12 km. The fault of the Blanice breakthrough (N-S direction) runs west of the power plant in the valley of the Blanice river. A microquake epicentre was located in the vicinity of this fault. According to some interpretations, this microquake is related to the activity of the Vodnany mylonisation zone (this quake is discussed also in the following, denoted as T1). Although no neoid movements were proved in the area, the fault must be classified as a fault with an unproved seismic activity, that is conditionally capable of producing a quake. With respect to the knowledge about the seismicity of this region, to the opinion of the experts, and to the seismo-tectonic model of the area, the prevailing opinion is that the quake intensity on this fault may not exceed the threshold of I0=5.5° on the 12-degree macroseismic intensity scale MSK-64.

Vodnany mylonisation zone – the shortest distance from the Temelín power plant is 4 km. This zone of the NE–SW direction runs from Týn nad Vltavou to Vodnany in total length of 16 km. It is about 1 km wide and has a dip of 30–40° towards NW. It separates two lithologically and tecto-genetically different formations of the Moldanubic – the Podolí complex and the monotonous and t he diverse series of the Moldanubic. This zone represents a distinctive morfological phenomenon of the South Bohemian region often discussed in the literature. Some authors (Machart, 1987; Klecka et al., 1988; Kalvoda, 1989; Czudek et al., 1993) suppose neoid tectonic movements in this fault, which were, however, not proved (Šimunek, 1994a). In the vicinity of this zone, four weak local earthquakes were observed with a local magnit ude less than or equal to 0.1 (Švancara, 2000). Same as with the fault of the Blanice breakthrough, this zone can be classified as a fault with an unproved seismic activity. However, no part of this zone extends to the area of the power plant, and it is thus not capable of causing any deformations of the foundation soil. With respect to the knowledge about the seismicity of this region, to the opinion of the experts, and to the seismo-tectonic model of the area, the prevailing opinion is that the quake intensity on this fault may not exceed the threshold of I0=5.5° MSK-64.

Radomilice fault – the shortest distance from the Temelín power plant is 10 km. The Radomilice fault (N-S direction) constitutes the Radomilice trench, filled with middle Miocene deposits; seismo-tectonically, it is unimportant.

Vlhava fault – the shortest distance from the Temelín power plant is 10 km. The Vlhava fault (NNE-SSW direction) delimits the north-western edge of the Budejovice basin. It is 7 km long and appears to belong to the type of a fault band wit h a continuous increase of the amplitude of motion. An insignificant dislocation of the strata of Mydlovary can be expected at this fault. The fault is not important from the seismo-tectonic point of view.

Zbudov fault – the shortest distance from the Temelín power plant is 11 km, Haklodvory fault – the shortest distance from the Temelín power plant 15 km. The Zbudov fault runs in parallel wit h the Hluboká fault, delimits the Píština trench in the north, while the Haklodvory fault delimits this trench in t he south. The age of the latest movements at both of these faults is the same – middle Miocene. From the seismo-tectonic point of view, these faults are not important.

Munice fault – the shortest distance from the Temelín power plant is 10 km. The Munice fault (NNE–SSW direction) played an important role in the tectonic evolution of the Budejovice basin. The most marked effect of this fault was its impact on the deposition of the lower part of the strata of Klikov, whereby the fault divided the basin transversally into the deeper

eastern part and the more shallow western part. Its tectonic activity gradually decreased from the Cretaceous to the Tertiary era, and in the present, the fault appears to be sesmically inactive.

Hrdejovice fault – the shortest distance from the Temelín power plant is 20 km. The Hrdejovice fault runs in parallel wit h the Drahotešice fault. Movements at the fault were proved in the period from the Permian-Carboniferous the Pleistocene era and were of an inversion nature.

Líšnice fault – the shortest distance from the Temelín power plant is 7 km. The Líšnice fault constitutes a system of old faults (in the NNE–SSW direction of the Blanice trench), accompanied by a marked mylonisation, and constituting the Neogene valley of the Porežany stream (the Porežany trench). The latest survey did not prove a markedly tectonic nature of the Porežany trench, the geological evidence indicates a tectonic rest in this band since the middle Miocene (inclusively).

Drahotešice fault – the shortest distance from the Temelín power plant is 13 km. The Drahotešice fault is the most distinct fault of the Blanice dislocation system in the area of interest. It is regarded as an involved tectonic struct ure with a repeated inversion function. The dislocation activity of this fault is dated to the middle Pliocene (inclusively).

Hluboká fault – the shortest distance from the Temelín power plant is 9 km. The Hluboká fault (dislocation band) has the NW–SE direction. Based on an incentive of the IAEA, this fault was surveyed in detail, and based on the results of this detailed survey, the course of the

fault as recorded in the official geological maps was revised. The survey results show that no movement can be proved in the last 0.78 million years. The measurements of the seismic stations confirms that this fault is "burnt out", no earthquake was observed neither in t he vicinity of the fault, nor in its wider surroundings.

All of the above tectonic faults, which could possibly influence the area of the Temelín power plant, are also competently described and assessed in the report of the Academy of Sciences of the Czech Republic (AS CR, 1998), while the comprehensive assessment of the seismic safety of the location and the evaluation of the long-term measurements performed (AS CR, 1999) correspond to the earlier results of tectonic and seismological surveys (Šimunek, 1995). Although all of the described faults are significant features from a seismologist's point of view, it was shown in the cited literature of the AS CR they do not pose any greater seismic risk for the location of the Temelín power plant than the risk considered in the design (Masopust, 2000).

On the basis of the requirements of the IAEA Safety Guide 50-SG-S1 the measurements of S waves were performed at the Temelin site. The results and applied criteria (ASCE 4-86) showed, that background is stable and that it cannot be liquidified due to the earthquake. During the identification of the input seismic parameters for the NPP design, it was not necessary to change parameters for the site. Only with regards to the IAEA Safety Guide 50-SG-S1 the seismic hazard was increased to the value PGA_{SSE} = 0,1 g (treshold minimum value of the top acceleration on the free terrain used generally for all plant, disregarding the fact that they are located on sites, where such acceleration cannot occur) which means in the conditions of Central Europe 7° MSK-64.

Seismic monitoring of the NPP Temelin site has been performed since 1991. Since 2000 the monitoring was supplemented by the monitoring, which is located at the site and which has output directly at the control room of the NPP. On the basis of these results the parameters used in the design of NPP Temelin are step by step verified and supplemented.

From the probability curve of seismic hazard, it can bee seen that at annual frequencies of incidence below 10 -4 , the PGA tends not to increase fut her in any significant way. It is apparent that at the location of the Temelín power plant, an earthquake with PGA exceeding 0.09 g cannot occur, however small its annual frequency of occurence would be (Masopust, 2000).

Using the above, very conservative approach, the values of the design earthquake (according to IAEA SL-1) equal the strongest earthquake observed or in other words, the strongest earthquake that could according to the isoseismal lines of strong earthquakes be observed at the location in the history, i.e. for the given case 6° MSK-64. In agreement with the generally taken approach, the service earthquake is taken equal to the design earthquake.

The studies of the historic seismicity as well as the location of weak quakes observed at the seismic stations in the Czech Republic show that in t he narrower area of the Temelín power plant, no earthquake centres occurred that would have the intensity at the epicentre higher than or equal to 3° MSK-64. The catalogue data suggest that the earthquakes observed in the area of interest and its surroundings are of a swarm nature (Rudajev et al., 1994 – unpublished report ”Evaluation of results of the measurements of the local seismic network of the Temelín power plant”). This means that the geological structure is not capable of a long-term accumulation of a larger quantity of the tectonic deformation energy and of releasing it consequently in a strong earthquake (Šimunek, 1994b). Since 1991 up to the present date, a detailed regional seismological survey is being carried out in the wider space of the Temelín power plant, the main purpose of which is the observation of the local tectonic phenomena. In order to establish the level of seismic danger for the Temelín power plant, the identification of dislocations in the construction area and the evaluation of their seismic potential are important.

At present, the local seismological network consists of five seismological stations, deployed in the distance of about 4 to 15 km from the power plant.

The Temelín power plant at present fulfils all of the current requirements of the IAEA on seismic resistance of both the civil engineering structures and the technological systems and particular components of the equipment in terms of the so called 1st category of seismic resistance includes:

a) safety systems and other systems related to nuclear safety, including the respective civil engineering structures and all partial components, which are necessary to maintain the nuclear

block in a safe state in case of an earthquake and thereafter and which must be seismically resistant up to the magnitute of SSE (7° MSK-64), inclusively, and also in case of a plane crash or an external pressure wave acting on the reactor building and other selected buildings of the nuclear power plant; and

b) systems, structures, and equipment components that must be seismically resistant due to the fact that their damaging or failure could affect other systems, structures, and equipment components, which are important for nuclear safety in case of an earthquake, plane crash or impact of an external pressure wave, or which are necessary for fulfilling other specific safety functions in case of an earthquake and thereafter, and which must be seismically resistant up to the magnitute of operating basis earthquake (6° MSK-64), inclusively.

The following systems belong to the first class of 1st category of seismic resistance:

. civil enginering strucures, technological systems, and the individual components of the equipment, the failure of which could directly or indirectly result into an event of accident,

. civil enginering strucures, technological systems, and the individual components of the equipment, which are necessary for the shutdown of the reactor, monitoring of the critical parameters, maintaining the reactor in the conditions of safe shutdown, and for extraction of the residual heat for a sufficeiently long time,

. civil enginering structures, technological systems, and the individual components of the equipment necessary to prevent spreading of radioactive substances and ionising radiation into the environment, or as the case may be, to maintain any possible radioactive escapes below the limits applicable for the event of accident.

Taking a conservative approach, this category includes also civil enginering strucures, technological systems, and the individual components of the equipment, which serve for the purpose of mitigation of the consequences of the possible design events of accident, postulated for the primary circuit, irrespective of the fact that the primary circuit is designed as seismically resistant up to the level of SSE, inclusively.

The second class of 1 st category of seismic resistance includes secected civil enginering strucures, technological systems, and the individual components of the equipment, which are not included in the class a), but which constitute:

. a part of the structures where manipulation with the fresh fuel cells is performed prior to their introduction in the reactor,

. a part of the structures where manipulation with low and medium radioactive liquid media is performed, irrespective of the prooved fact that possible escapes of radioactive substances in events of accident due to earthquake do not result in exceeding the limits for doses and accumulated bonded doses defined for the given location.

The design of all stuctures, systems, and components of the Temelín power plant was carried out in compliance with the valid standards for strength, reliability and other technical properties, which require that the actual resistance and reliability of these structures, systems and components be proved with a certain safety factor, specifically stipulated for the various types of structures, systems and equipment components and the various types of their failure, but being at least 1.30 - 1.50.

On the basis of design evaluation of structures and components it is possible to state, that the design takes into consideration all event scenarios with probability 10^{-5} per year and a member of the event scenario with even lower probability and that the impact of earthquake up to 0,1 g was taken into account. For the cases of beyond design basis events the on-site and off-site emergency plans has been prepared in compliance with legal requirements of Czech republic and the IAEA recommendations.

Until now recorded earthquakes at NPP Temelin show, that measured acceleration are lower than those coming from the model, according to which the NPP was designed and according to which the seismic resistance has been verified. In another words the model used for the design is conservative one, which means high safety margin.

The above mentioned facts show that all requirements given by the current knowledge and modern „risk management“ technology, are fulfilled. It is possible to state, that the seismic resistance of NPP Temelin is assured adequately and that the impact of strong earthquake will not cause the radiation accident.

The documentation to this topic consists of 14 reports (see arch. EGP 4914-6-970001)

The specific independent evaluation of the seismicity in the region and design seismic resistance, was performed by GEOSCI (Dr. D. Procházková, see Evaluation of NPP Temelin safety during the strong earthquake 03/2001) and study Evaluation of the NPP Temelin safety from the foundation conditions point of view and changed regime of underground water (stochastic fluctuation of the water table and way of drainage, 03/2001).

The presented facts are confirmed by the context of another special evaluation, which was authorized by Dr. Schenk in the study Seismic safety and value of safety hazards (OBE, SSE, 03/2001). One of the important criteria for the NPP siting is knowledge of regional seismicity that allows reliable values of the earthquake hazard to be determined. From the designer view, it is necessary to assess the ***operation basic earthquake*** **OBE** (according to the IAEA standards: SL1; in Czech so called the project earthquake [projektové zemetresení]) and the ***safe shutdown earthquake SSE*** (according to the IAEA standards: SL2; in Czech so called the maximum calculated earthquake [maximální výpoctové zemetresení]). We gathered all earthquake hazard assessments (see Table) that have been calculated in the last two decades by different authors both directly for the NPP Temelín site and for its surrounding areas (e.g. hazard evaluations made by the Austrian and Czech specialists for national building codes and hazard assessments prepared under joint international projects [e.g. DACH, GSHAP, etc.]). To obtain reliable evaluation of two hazard levels, OBE and SSE, for the NPP Temelín site, the earthquake hazard values given in the Table were carefully compared and a reasonable balance among them was found. Due to great number of various approaches applied to the hazard determination, we expect that the resulting values OBE and SSE should be objective ones.

When we compare values close to the first safety level (OBE) expressed both in the macroseismic intensity MSK-64 and in the peak ground acceleration (PGA), we find that most of the hazard assessments correspond to the intensity 5.5º ± 0.5º MSK-64 and/or 0.05 g. This seismic safety level represents an "*everyday standard*" for all NPP operations. It means, when any earthquake affects the NPP Temelín by 6º MSK-64 nothing has to happen, i.e. no disruption of standard NPP working operations as well as no breakage and/or damages of equipment and common buildings. Generally, it is assumed that only the OBE can appear at the NPP within its life time of 50 years. Thus, **the OBE = 6º MSK-64 and/or 0.05 g for the NPP Temelín site are correct.**

The second safety level (SSE) determines the upper limit of all possible seismic vibrations that could appear in future at the site and strike the NPP by the maximum expected earthquake effects. We understand that the SSE value guarantees no the 1st category equipment (e.g. the nuclear reactor) breakage and no structure damages belonging to the 1st category. One can see that all calculated or estimated SSE values given in the Table (except the values of the Pre-Operation Safety Report) are less then or equal to 6º MSK-64 and 0.081 g, respectively. To be on the safe side (see Pre-Operation Safety Report), **the SSE = 6.5º MSK-64 and/or 0.1 g for the NPP Temelín site are not only correct, but also conservative ones.**

If the OBE and SSE values for the NPP Temelin are compared with similar ones obtained **for the Austrian territory close to the South Bohemia** (see in the Table Lenhardt 1995, Grünthal et al. 1995, 1999), the intensity 6º MSK-64 and PGA 0.06 g can be observed. All hazard maps display a pronounce linkage of these hazard values with earthquake activity of individual source regions in the Alps. Since a systematic regional decrease of earthquake effects with increasing distance from the Alps is observed, it is evident that inside of the South Bohemia the seismic vibrations cannot increase. Since one decade monitoring of the micro-earthquakes of the Temelin area have not indicated a distinct seismoactive fault or zone there, nobody can assume that moderate or strong local earthquake could appear within the South Bohemia. This comparison supports the reliability of the OBE and SSE values adopted for the NPP Temelin.

In Masopust (2000) one can read that some specific structures are designed up to 0.12 - 0.15 g to ensure their safety if any strong seismic vibrations appear. Descriptions of structure improvements are in individual Energoprojekt Reports. The Austrian materials mentioned the German KTA criterion recommended to apply the square value of the horizontal particle acceleration in order to include an impact of the vertical particle acceleration into the seismic safety procedures. If one read all values of the SSE given in [g] in the Table, all of them are below 0.07 g, except the one assessment (Rudajev et al.; 0.081 g). Then, if the *KTA squared criterion* is applied to acceleration 0.07 g, we obtain “KTA acceleration” 0.099 g and, similarly, for the acceleration 0.081 g the “KTA acceleration” is 0.114 g. As mentioned above, all SSE accelerations (except one) do not exceed 0.07 g and, thus, **the value 0.1 g fits the KTA criterion**. Moreover, the higher accelerations applied for some structures (Masopust 2000) increase the seismic safety more then the KTA regulations require.

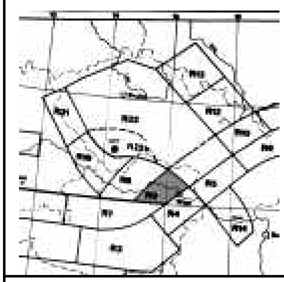
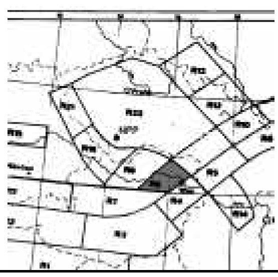
As to **Neulengbach 1590 earthquake** (see source regions schemes in Table) the distance between 30 and 100 km is evident mistake. When one starts to check these values in individual hazard assessments, the distance is in a range between 125 and 140 km. Please, if anywhere a distance 30 km is written, it is an absolute mistake.

A report on an existence of macroseismic effects of **6º MSK-64 near town Sobeslav** can be accepted and explained without great problems. Firstly, the distance to the Neulengbach epicenter is approximately for 10 kilometers shorter then the distance to Temelin. This exceptional intensity in a regional pattern can be also explained by local geological conditions. Part of the town Sobeslav is located on alluvial sediments of the river Lužnice and they could easily increase the seismic vibrations occurred during the Neulengbach earthquake.

As for the probability **seismic hazard curves and their “curvatures” change round annual probability of 10^{-3}** it has a physical nature. All seismologists know that recurrence graphs compiled for individual source zones (expressing the rate of their seismic activity in time) must be terminated in the range of high magnitudes (or epicentre intensities) because of an impossibility to keep more and more energy without releasing. Every geological or tectonic structure has its own potential of an energy cumulation. The cumulation depends on the PT conditions of that region and on other elements. Therefore, the curvature of the probability seismic hazard curves for the NPP Temelin site is caused by a capability of the individual source region to cumulate the energy. If most earthquakes that occur in delineated source regions, even the highest ones, are released within a period of a few thousands years, then they cannot affect the NPP site longer then those several thousand years. From that viewpoint, even many dozen studies done by Sholz cannot be simply compared with the NPP Temelin study if no initial conditions are known (active or non-active regions, shallow or deep earthquakes, rift or intraplate events, etc.).

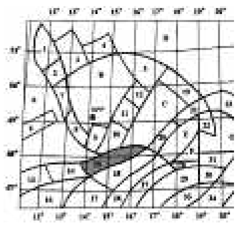
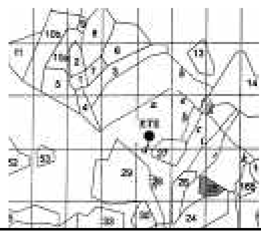
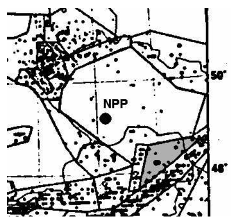
It is evident that a lot of questions can be risen because of plenty observation materials and theoretical calculations. The best way for an exchange of information is direct contacts with the specialists who are responsible for the same professional tasks. They will save their and our time and the goals can be reach easily and quickly.

Table. Earthquake hazard assessment for the Temelín site

S O U R C E S			
Kárník, Schenk and Schenková. 1979 *Report for CEZ*	Schenková, Schenk and Kárník, 1981 ***PAGEOPH*** 119**,** ***1077-1091***	Schenk and Schenková, 1982, *Report for CEZ*	Barták. 1987 *Report for CEZ*
I N P U T S			
EQ Catalogues			
Catalogue for broad Central European area, compiled by authors *Neulengbach 1590,* I_0 *~ 9º*	Catalogue for broad Central European area, compiled by authors; *Neulengbach 1590,* I_0 *~ 9º*	---	---
Source Regions (*the region with EQ 1590 marked*)			
		---	---
Earthquake Activity Rate / Recurrence Graph (*applied methodology*)			
normalised to the annual earthquake occurrence	normalised to the annual earthquake occurrence	---	---
Maximum Expected Earthquake (*applied methodology*)			
maximum observed I, recurrence graphs and expert estimates	max.observed, recurrence graphs, Gumbel III and expert estimates	with respect to OBE / SSE values (Kárník et al., 1979)	with respect to OBE / SSE values (Kárník et al., 1979)
Seismic Vibrations Attenuation (*applied methodology*)			
particular relations for directions from “source region” to NPP Temelín	particular relations for directions from “source region” to NPP Temelín	---	---
METHODOLOGY OF EARTQHUAKE HAZARD CALCULATION			
conditional prob.(Cornell 1968) SERIAL 1978 (Schenk & Schenková)	*conditional prob.(Cornell 1968)* SERIAL 1978 (Schenk & Schenková)	analogous accelerograms	analogous and synthetic accelerograms RESP (Barták 1984)

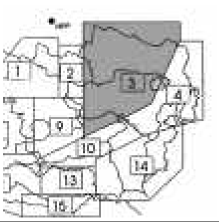
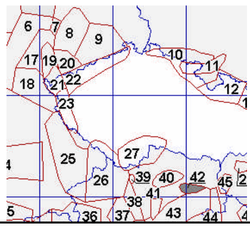
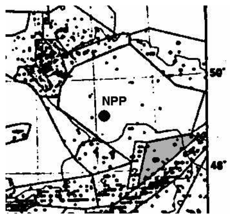
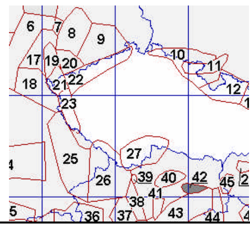
EARTHQUAKE HAZARD ASSESSMENT FOR NPP TEMELIN			
in macroseismic intensity MSK-64 : OBE / SSE			
OBE ~ 5º MSK **SSE = 5.5º MSK**	**SSE = 5.5º MSK**	OBE ~ 5º MSK **SSE = 5.5º MSK**	**SSE = 6º MSK**
in particle ground accelerations [g] : OBE / SSE			
---	---	---	**SSE = 0.06 g**
response spectra : OBE / SSE			
---	---	set of 4 analogous accelerograms	4 analogous and 1 synthetic accelerograms
N o t e s			
results approved by the Czech and Soviet experts and by the ESC community	paper passed an **editorial reviewing of international journal**	**results approved** by the Czech and Soviet experts	

Table. Earthquake hazard assessment for the Temelín site (1st cont.)

S O U R C E S			
Šimunek and Barták, EPP, 1995 ***for the IAEA Site Safety Mission***	ENERGOPROJEKT 1998 ***Pre-Operation Safety Report prepared for the IAEA Vienna***	Rudajev et al., ÚSMH AV CR, 1998 *Report for CEZ*	Grünthal et al., 1995, *Proc.10th ECEE ,57-62*
I N P U T S			
EQ Catalogues			
Catalogue for Central European area (Kárník et al., 1979)	Catalogue for Central European area (Procházková, 1979)	Catalogue compiled by authors from CE earthquake catalogues	Catalogue for the DACH / GSHAP region compiled by DACH partners
Source Regions (*the region with EQ 1590 marked*)			
			
Earthquake Activity Rate / Recurrence Graph (*applied methodology*)			
normalised to the annual earthquake occurrence	standard recurrence graph	standard recurrence graph	
Maximum Expected Earthquake (*applied methodology*)			
maximum observed and recurrence graphs	maximum observed and recurrence graphs	maximum observed and recurrence graphs	maximum observed and Gumbel III
Seismic Vibrations Attenuation (*applied methodology*)			
particular relations for directions from "source region" to NPP Temelín	particular relations for directions from "source region" to NPP Temelín		relations ? *I* (*R*) for Central Europe compiled by the DACH partners
METHODOLOGY OF EARTQHUAKE HAZARD CALCULATION			
conditional prob.(Cornell 1968) SERIAL 1978 (Schenk & Schenková)	*No conditional prob. applied* Kijko (1985), cumulative earthq. effects at NPP site	*No conditional prob. applied*, cumulative earthquake effects at NPP site	*conditional prob.(Cornell 1968)* 50 yrs , 10% exceedance SEISRISK III
EARTHQUAKE HAZARD ASSESSMENT FOR NPP TEMELIN			

in macroseismic intensity MSK-64 : **OBE / SSE**			
OBE ~ 5.5º MSK **SSE = 6º MSK**	**OBE ~ 6º MSK** **SSE = 6.5º MSK**	---	**6º MSK**
in particle ground accelerations [g] : **OBE / SSE**			
OBE $_{horiz}$ ~ 0.05 g **OBE $_{vert}$ ~ 0.03 g** **SSE $_{horiz}$ = 0.07** (0.1) **g** **SSE $_{vert}$ = 0.05** (0.07) **g**	**OBE $_{horiz}$ ~ 0.05 g** **OBE $_{vert}$ ~ 0.035 g** **SSE $_{horiz}$ = 0.1g** **SSE $_{vert}$ = 0.07 g**	**OBE = 0.054 g** **SSE = 0.081 g**	---
response spectra : **OBE / SSE**			
***PGA $_{horiz}$:* 0.1 g** ***PGA $_{vert.}$:* ~ 0.07 g**	***PGA $_{horiz}$:* 0.1 g** ***PGA $_{vert.}$:* ~ 0.07 g**	---	---
N o t e s			
hazard values obtained by Kárník et al. (1979) were increased for 0.5º MSK for Temelín site **results approved** by the Czech & IAEA experts	**response spectra** were adopted from Šimunek and Barták, EPP, 1995	**source regions** applied from Schenk et al., 1989	*I_{max}* values for standard **structures built on the Austrian area close to South Bohemia**

Table. Earthquake hazard assessment for the Temelín site (2nd cont.)

S O U R C E S			
Lenhardt, 1995, *Proc.10th ECEE ,63-68*	Schenk & Schenková 1997 CSN 73 0036, 2ndAmend. CSN NAD EC-8 1998-1-1	Grünthal et al., 1999 *IUGG/ILP GSHAP Project* *Ann.Geoph*. **42**, 999-1011	Schenk et al. 2000, *IUGG Birmingham 1999* ***Natural Hazards* 21**, 331-345.
I N P U T S			
EQ Catalogues			
Drimmel and Fiegweil and other catalogues *Neulengbach 1590, M 6.0* (Gutdeutsch, 1987)	Catalogue for broad Central European area, compiled by authors	Catalogue for the GSHAP Region 3 was compiled by all Project partners	Catalogue for broad Central European area, compiled by authors
Source Regions (*the region with EQ 1590 marked*)			
			
Earthquake Activity Rate / Recurrence Graph (*applied methodology*)			
	normalised to the annual earthquake occurrence	normalised to the annual earthquake occurrence	normalised to the annual earthquake occurrence
Maximum Expected Earthquake (*applied methodology*)			
Gumbel III statistics, MCE applied in the Austrian building code (Drimmel, 1978)	max.observed, recurrence graphs, Gumbel III, M(L) and expert estimates	max.observed, recurrence graphs, Gumbel III and expert estimates	max.observed, recurrence graphs, Gumbel III, M(L) and expert estimates
Seismic Vibrations Attenuation (*applied methodology*)			
	? *I* (*R*) and ? *ACC* (*R*) for Central European area and expert estimates	three weighted relations ? *ACC* (*R*) for Central and Northern Europe	? *I* (*R*) and ? *ACC* (*R*) for Central European area
METHODOLOGY OF EARTQHUAKE HAZARD CALCULATION			
conditional	max. observed	*conditional*	*conditional*

prob.(Cornell 1968) 50 yrs , 10% exceedance EQRISK (McGuire 1976)	intensity *conditional prob.(Cornell 1968)* 50, 100 yrs, 10% exceed. modified EQRISK	*prob.(Cornell 1968)* 50 yrs , 10% exceedance SEISRISK III (Perkins et al.)	*prob.(Cornell 1968)* 50 and 100 yrs, 10% exceed. modified EQRISK
EARTHQUAKE HAZARD ASSESSMENT FOR NPP TEMELIN			
in macroseismic intensity MSK-64 : **OBE / SSE**			
---	[CSN 73 0036] **6º MSK**	none	***I*** $_{475yrs}$ **: ~ 5.5º - 6º MSK** ***I*** $_{1000yrs}$ **: ~ 5.5º - 6º MSK**
in particle ground accelerations [g] : **OBE / SSE**			
effective PGA: 0.02-0.04g *i.e.* ***PGA :*** **0.03 - 0.06 g**	[CSN NAD EC-8] **0.04 g**	***PGA*** $_{475yrs}$ **: ~ 0.03 g** ***PGA*** $_{1000yrs}$ **: ~ 0.04 g**	***PGA*** $_{475yrs}$ **: ~ 0.03 g** ***PGA*** $_{1000yrs}$ **: ~ 0.04 g**
response spectra : **OBE / SSE**			
none	none	none	none
N o t e s			
PGA_{eff} values for standard **structures built on the Austrian area close to South Bohemia**	I_{max} and $ACC_{peak\text{-}eff\ EC\text{-}8}$ for standard **structures Temelín area** **values approved** by the Commission of the Czech experts for building codes	*PGA* values for **standard structures in Temelín area** paper passed an **editorial reviewing of international journal**	*PGA* values for **standard structures in Temelín area** paper passed an **editorial reviewing of international journal**

2.4. Impacts on Population including Analysis and Evaluation of Health Effects of Ionising Radiation and Other Physical (Noise, Vibration, Non-ionising Radiation) and Chemical Factors

2.4.1.1. Structure of Settlements

The structure of settlements in the vicinity of the Temelín NPP corresponds to the average inland structure of settlements in the Czech Republic, with respect to both social and cultural conditions. The near zone defined by direct and relatively detailed visibility of the Temelín NPP includes 5 municipalities; their characteristics are typical for settlements located in a predominantly agricultural region. 25 associated settlements belong to these 5 municipalities; therefore, the total population of this zone is approximately 11,300 persons. Another zone is defined as an annular area. The internal border of this area is the circumference of the internal zone, while the external border is located at a distance of approximately 13km and represents the external border of the emergency-planning zone. This zone comprises 23 municipalities and 48 associated settlements. The total population of this zone is approximately 18,700 persons. The nearest towns are Týn nad Vltavou (approximately 7,800 inhabitants - 6km), Protivín (approximately 5,000 inhabitants - 12km) and Zliv (approximately 3,800 inhabitants – 12km). The district centre is the city of Ceské Budejovice (approximately 160,000 inhabitants, distance from the Temelín NPP approximately 22km). Population density of the Ceské Budejovice district is 109 persons/km^2, which is slightly less than the average population density of the Czech Republic (132).

2.4.1.2. Adjacent structures

Criteria for the classification of a region as an adjacent region are not unambiguous. With respect to the geomorphologic criteria, the adjacent regions include the other parts of the Budejovická basin, Vltava valley, Šumava foothills in the south, and Jihoceská pahorkatina (hills that are the continuation of Písecké hory) in the north. As for the protection of nature and endangered species, the area including the adjacent regions is described in another section (chapter 2.5).

2.4.1.3. Population figures and development

According to the analysis performed in the document named Pre-operational safety report (Predprovozní bezpecnostní zpráva) issued by Škoda Plzen Company in 1999, the number of inhabitants living in the vicinity (below 30km) of the power plant is 256,008, the total number of inhabitants living at a distance below 50km from the power plant is 544,720. The prognosis of demographic development will be stated more precisely according to the census performed in 2001. According to current estimates, neither natural exchange nor migration of inhabitants will cause a marked quantitative alteration of the settlement structure. For example, the estimated number of inhabitants living at a distance below 50km from the power plant in 2020 is 531,204, i.e. by 2-3% less than the current number.

2.4.1.4 Health hazards significant in terms of human health occurring in the surroundings of the nuclear power plant (previous level of air pollution, radioactivity, and sound)

So far, no hazards unrelated to radioactivity that are caused by the Temelín NPP operation and have negative impact on the population health have been known. As for the original „Documentation“ concerning the environmental impact of the Temelín NPP, it is necessary to point out that the presented air pollution limits for dust (Ihr 150 μg/m^3 and Ihd 500μg/m^3) was wrong - the correct values according to the Appendix 4 to the Provision of Federal Environmental Committee (Opatrení FVŽP) as of 1991 are Ihr 60μg/m^3, Ihd 150μg/m^3 and Ihk 500μg/m^3. However, this error does not mean a change in the general evaluation of the Temelín NPP impact from the point of view of public hygiene.

With respect to the ionising radiation effects, the population living in the vicinity of the Temelín NPP is exposed to the ionising radiation caused by natural sources (as all other inhabitants of this planet). However, the exposure to natural radiation varies considerably depending on the geographical coordinates, height above sea level, character of the bedrock, housing conditions (buildings) and also on the dietary habits, because the exposure of humans also depends on internal contamination through inhalation of radioactive substances and ingestion of food.

Natural exposure is caused by two different sources: *cosmic radiation* that reaches the Earth from the space and *natural radionuclides* that naturally occur in the environment. The origin of natural radionuclides is partially cosmogennous, as they may be created through nuclear reactions during the interaction of cosmic radiation with stable elements of the thin atmosphere in the outer layer of the Earth gaseous coating (^{14}C, ^{3}H, ^{7}Be etc.) and can be transported to the Earth surface. Primary radionuclides are especially the starting elements of three natural radioactive transformation series (uranium, thorium, and actinium). The secondary unstable elements are the descendants of the primary radionuclides mentioned above. Among the secondary radionuclides, the most important role with respect to exposure is played by radium ^{226}Ra and its gaseous descendant radon ^{222}Rn. Among the other primary radionuclides, potassium ^{40}K is the most important.

The nuclear weapon trials caused the occurrence of other radioactive substances in the atmosphere. These radionuclides have been introduced into the environment by human activity. The most important among these radionuclides are the nuclear fission products. This source had produced the most significant environmental pollution in the beginning of the 1960s, before the moratorium was imposed on atmospheric nuclear explosion testing. These radionuclides are represented especially by ^{137}Cs and ^{90}Sr. Another contribution to this component is represented by the radioactive substances scattered around the area of many European countries in 1986, after the Chernobyl accident. The increased level of ^{137}Cs caused by this disaster is still measurable in the Czech Republic.

There is enough information about the current external exposure levels in the population living in the vicinity of the Temelín NPP and about the content of radioactive substances in the air, water and food. The Laboratory of Environmental Radiation Control (Laborator radiacní kontroly okolí, LERC) has been measuring the photon dose equivalent using the TLD method in 35 locations in the Temelín NPP surroundings. The quarterly average values in 1999 were 114.5 to 129.9 nSv/h. The Radiation Monitoring Network (RMN, radiacní monitorovací sít) in the Czech Republic has been measuring the photon dose equivalent using the same method in 30 locations in the broader zone of Southern Bohemia. The quarterly average values in 1999 were 147.3 to 161.9 nSv/h. The results have been available starting with 1992. No time trend can be observed.

For example, in Temelín, the LERC obtained the following data concerning the presence of radionuclides in the respective components of the environment:

Surface contamination with ^{137}Cs	1.3E+03 Bq/m^2
Aerosols - ^{137}Cs content	1.2E-06 Bq/m^3
^{137}Cs overall fallout	below the method sensitivity
^{137}Cs soil	5.6E+01 Bq/kg
^{137}Cs surface water	1.3E-03 Bq/kg
^{3}H	2.7E+00 Bq/kg
^{137}Cs drinking water	below the method sensitivity
^{3}H	below the method sensitivity
^{137}Cs milk	9.3E-02 Bq/kg
^{137}Cs cereals	below the method sensitivity
^{137}Cs fish	1.4E+00 Bq/kg
^{137}Cs mushrooms	8.5E+02 Bq/kg
^{137}Cs sediments	3.1E+01 Bq/kg

The values obtained through the water resource research are also important. The data obtained provide characteristics of the radioactive substances content in the Vltava river, Hnevkovice profile, where the water for the Temelín NPP has been taken. In 1999, the total activity per volume was beta 0.243 Bq/l; after the subtraction of the ^{40}K component, the value was 0.108 Bq/l. The average annual activity of tritium (^{3}H) per volume of surface water in the vicinity of the Temelín NPP was 1.7 Bq/l; the value for ^{137}Cs was 0.002 Bq/l. These values agree with the LERC data.

With respect to the data presented above it can be said that the exposure of inhabitants caused by environment in the vicinity of the Temelín NPP does not exceed the range usual in the other regions of the Czech Republic. It should be noted that the exposure of the Czech population exceeds the global average (for the global values, see the document of the United Nations Scientific Commission on the Effects of Atomic Radiation - UNSCEAR of 1993); the effective dose difference is 2.4 mSv per year. This is due to the type of bedrock in the Czech Republic, which increases the exposure caused by radon and its descendants inhalation in buildings. According to the State Institute of Protection against Radiation (Státní ústav radiační ochrany, SIRP) survey in 1999, the average equivalent activity per volume for radon (ekvivalentní objemová aktivita radonu, EOAR) inside buildings for the Czech Republic is 77.5 Bq/m^3. The average value for the Ceské Budejovice district is 75.3 Bq/m^3. As the survey was aimed at detection of buildings unsuitable for use with respect to radon occurrence, the results may show a deviation towards higher values. Thus, the radon-related component of the effective dose in the vicinity of Temelín might be approximately 3 mSv, while the global average is 1.3 mSv. Therefore, the total effective dose produced by natural sources in the vicinity of Temelín may be estimated at approximately 4 mSv.

A document named The Limits and conditions of safe operation for the Temelín NPP, approved by the State Office for Nuclear Safety (reference number 10139/2000), specifies:

A .4.1 Limits for discharge of radioactive substances into water

Activity of tritium and other artificial radionuclides (activation and fission products except tritium) produced by the NPP and discharged through the liquid discharge outlet into running water during one calendar year must not cause in an individual a 50-year $H_{50,L}$ load higher than 0.2 µSv during the operation of one NPP unit and 0.4 µSv during the operation of two NPP units.

A 4.2 Limits for discharge of radioactive substances into air

The activity of radionuclides produced by the NPP and discharged through the ventilation chimneys into the air during one calendar year must not cause in an individual a 50-year $H_{50,L}$ load higher than 40 µSv during the operation of two NPP units. The conversion of activities to the 50-year $H_{50,L}$ load must be performed using a method authorised by the State Office for Nuclear Safety.

Through this process, the supervisory body provides a more detailed specification of the dose limits for a particular case. These more accurate values are related to a population group of interest, which is defined as a population living in the annular area defined by the distances of 3km and 5km from the Temelín NPP (the total exposure resulting from all ways of irradiation is evaluated).

Of course, the average exposure of the population living in wide surroundings of the NPP will be significantly lower. This is due to the optimisation method aimed at the lowest reasonably achievable exposure. A suitable indicator for the purposes of protection optimisation is the collective dose expressed as a product of the average doses and the number of inhabitants that the researcher decides to use for the calculation (in this context, the question of how many inhabitants living in the NPP vicinity should be included in the collective dose calculation, is irrelevant; other methods may be used).

At this point it should be stressed that exposure acceptability means ***parallel*** and ***simultaneous*** meeting of the requirements for both optimisation and not exceeding the limits (in this context, the limits are represented by authorised limit values).

The protection control requires considering all exposure components, i.e. the contribution of all radiation sources. E.g. the determination of the average dose in a population, i.e. the effective dose, involves adding the effects of cosmic radiation, content of radionuclides in food, inhalation of radon etc. The exposure due to medical irradiation is usually specified separately and includes the sum of X-ray diagnostic exposure and exposure to radionuclides used in nuclear medicine. This attitude cannot be regarded as an effort to *calculate a cumulative effect*, but only as a part of the effective dose concept. On the other hand, the respective exposures specified on various exposure control levels (e.g. in the legislation) may define the respective situations (radon in buildings, occupational exposure, exposure due to medical irradiation etc.) in a different manner, irrespective of the cumulative dose obtained by summation of all sources.

The cumulation of exposures may be considered with respect to their distribution in time. While reparation is markedly involved in the deterministic effects, the protection against radiation does not allow us to create a simple model of dose cumulation, as the dose cumulation during time also involves stochastic effects. For stochastic effects, the summation of doses during a specified time is applicable. E.g. a genetically significant exposure includes all exposures beginning from the conception through the mean parental age (30 years by consent). International groups of specialists who recommend the limit values must also take into consideration the consequences of the annual permissible exposure with respect to the lifetime exposure.

The harmful factors of different nature may combine, and thus we can talk about the *synergism* or *antagonism* of harmful factors. The amount of reliable data in this field is very limited, especially with respect to the information that can be used in environmental protection. The experimental animal studies on the ionising radiation showed that e.g. administration of certain chemicals (radiomimetic agents) can increase the exposure effects, while the administration of other substances (radioprotective agents) may reduce the effects of exposure to radiation.

The effects of smoking and inhalation exposure to radon have been studied both in the occupational and general environment. The aim was to evaluate whether the action of these two factors is a simple sum of their harmful effects or whether they potentiate (multiply) the effect of each other. As for radon and smoking, the respective studies have not provided consistent results. In most cases, the effect has been assessed as supra-additive, i.e. slightly higher than an effect represented by a simple sum of the respective effects. There is no reason to assess the effects of radiation and other factors as synergistic. All hypotheses that have been created in this field should be viewed sceptically.

The issues of cumulation and the alleged synergism are related to the objections against MAPE and its sedimentation basin. These issues cannot be connected with the issues of environmental impact of the Temelín NPP. These issues have been assessed independently with respect to their environmental impact. The documentation concerning the environmental impact of the Temelín NPP refers to this facility in a sufficient breadth.

2.4.1.5 **Quality of drinking water**

The previous section said that the presence of ^{137}Cs and ^{3}H in drinking water has not been proven using the method of the given sensitivity. From the radiological point of view, it is also necessary to assess the content of natural radionuclides in drinking water. The quality of water in wells is usually worse than the recommended quality according to Directive No. 184/1997 Coll. of laws, Table 1, Appendix 12 (recommended standard values for drinking water for infants) with respect to the content of radionuclides alpha and beta, however, the concentrations of these radionuclides do not exceed the recommended standard values for natural mineral water.

2.4.1.6 **Description of areas suitable for recreational purposes**

The landscape in the vicinity of the Temelín NPP is varied and attractive and offers good conditions for tourism and recreation. The camps, weekend houses and guesthouses in this region offer the lodging capacity for more than 6,000 persons. The lodging capacity of public camping sites along the Lužice, Otava and Blanice rivers and at some of the artificial lakes or ponds is estimated at another 2,000 to 2,200 persons. In 1991, the hotels in Ceské Budejovice, Písek, Hluboké nad Vltavou and Vodnany offered the lodging capacity for 1,200 persons. There are more than 5,000 objects that serve for individual recreation within 30km from the NPP.

If the recreational capacity of this region has been limited at all, the cause was the positioning of the NPP and the building site. The Temelín NPP operation will not further affect the features of this region that are relevant for its recreational use.

The potential negative effects on the recreational use of this region (although not very probable) might be caused by possible side effects, e.g. by spreading rumours about the lack of NPP operation safety. On the contrary, a positive effect may be produced by creation of a new attractive sight, i.e. the NPP information centre, which has been intensely visited by tourists (usually in connection with sightseeing in both the near and remote surroundings).

2.4.2. Inhabitants

2.4.2.1.1.1 Number of inhabitants to be affected by the effects of the construction, activities, and technologies

To determine the number of inhabitants to be affected by the effects of the Temelín NPP operation, it is necessary to adopt the appropriate criteria related to the usual NPP operation. It is also necessary to take into account the population that might be affected by immediate measures to be taken in the case of a major ("supra-project") accident, i.e. to the emergency planning zone. A suitable method has been used in the Masaryk University (Brno, Czech Republic) study concerning the health status of the population living in the area affected by the Temelín NPP. The study mentioned above proposes to define the region of interest as a set of municipalities and settlements, i.e. neither using geometrical methods (e.g. as a circle of a certain diameter), nor according to geomorphologic criteria. The method mentioned above includes the definition of a near zone of potential exposure given by direct and relatively detailed visibility of the Temelín NPP from the settlements. The inhabitants living in these settlements are permanently aware of the fact that they live in the immediate vicinity of a NPP. This zone comprises 5 municipalities and 25 associated settlements. All of them belong to the Ceské Budejovice district. The population of this zone comprises approximately 11,300 persons. The remote zone is defined as an annular area. The internal border of this zone is the circumference of the near zone, while the external border is identical with the external border of the emergency-planning zone and is located at a distance of approximately 13km. This zone comprises 23 municipalities and 48 associated settlements. The municipalities belong partly to the Ceské Budejovice district (11,900 inhabitants), partly to the districts of Písek (6,200 inhabitants), Tábor (400 inhabitants), and Strakonice (400 inhabitants). The total population of this annular zone is approximately 18,900 persons. For the purposes of environmental impact evaluation, the total number of inhabitants to be affected by the effects of the Temelín NPP operation, including the transport and storage of radioactive waste at the Temelín NPP estate, may be estimated as 30,000 persons. With respect to the currently finished construction phase, a study aimed at the impact of the construction phase on the health status of the population would have a retrospective character and, therefore, would be of limited importance. Similarly, it does not make much sense to analyse the number of inhabitants to be affected by decommissioning and disassembly of the nuclear power plant in the future. It may be estimated that this population will be identical with the inhabitants living in the region used for the evaluation of the NPP operation, however, a detailed analysis will be possible only when the method of solution to this problem is accepted.

2.4.2.2. Effects upon Human Health - Ionising Radiation

Evaluation of possible effects of ionising radiation upon the health of the population living in the vicinity of the Temelín NPP is of key importance in the EIA process. The reason is not only the objective threat to the health of inhabitants, but also their subjective perception of the risk. Analysis of irrational attitudes towards the ionising radiation shown by some members of the public is beyond the scope of this document. However, there are many references to this phenomenon in literature published worldwide; it has been noticed in almost every country all over the world. The causes of this phenomenon cannot be clearly defined, and therefore it is very difficult to find methods that might help to establish an objective and balanced opinion concerning the hazards caused by nuclear power production. The specialists, who are better informed in the field of the radiation exposure risks, must not show lack of understanding, or even criticism or disregard for the members of the public that do not approve of nuclear power production for various reasons. Although experience has taught us that anxiety is an irrational phenomenon and cannot be conquered by rational explanation, the specialists must continue to explain the real nature of the problem with the necessary patience. It is also appropriate to emphasise the description of potential effects of ionising radiation upon the public health in this document.

Biological effects, which may result in harmful health effects, are conditioned by reaching a certain dose of ionising radiation absorbed by biological systems, i.e. by the tissues and organs of the human body. (Nevertheless, psychological and social consequences related to radiation exposure are not dose-dependent. Several cases have been published in which a pronounced psychological reaction occurred in persons or groups that believed they had been exposed to radiation, although it was possible to prove that no exposure had been involved).

If we know the total radiation dose, the distribution of the respective doses in time (single dose, long-term exposure) and the exposed area (local irradiation of a part of the human body, whole-body irradiation), we can estimate the health effects with a high probability. Such estimates are based on numerous observations of exposed humans and also on thorough experimental animal studies. International groups of scientists apply themselves to critical evaluation of data obtained in such a manner and after the necessary generalisation they create quantitative indicators that may serve for prediction of exposure consequences. The superior authority and at the same time the guarantor of independence in this area is the United Nations Scientific Commission on the Effects of Atomic Radiation (UNSCEAR) founded in 1955 by the General Assembly. So far this commission has published 13 extensive summary reports concerning the data concerning exposure and effects in humans.

The health effects of ionising radiation can be divided into two categories depending on the basic type of relationship between the dose and effect. High doses, usually the doses at the level of the gray (Gy) or sievert (Sv) units (these units are interchangeable for the gamma and beta radiation and X-rays, i.e. the conversion factor is 1), cause *deterministic* changes. A *deterministic* change means that the effect occurs after reaching a certain *threshold dose*. These effects include e.g. acute radiation illness or skin changes known as radiation burns. They were observed e.g. in the members of emergency teams working in the first shifts after the Chernobyl accident. As this document is aimed at the evaluation of the normal Temelín NPP operation, this group of health disorders is of little importance in this context. However, these disorders are important when considering the exposure to high doses of radiation following a potential radiation accident – i.e. a major ("supra-project") accident. However, as in Chernobyl, it is probable that in such a case the NPP personnel present in the NPP estate would be affected rather than other persons. Deterministic effects in the inhabitants might occur only under very unlikely circumstances. The basic precautions taken in the case of a major ("supra-project") accident would be aimed at the reduction of doses absorbed by the inhabitants. Such doses would not reach the threshold of deterministic effects and the precautions would include sheltering, prophylactic administration of potassium iodide and, if necessary, evacuation.

Another group of health problems includes late effects, e.g. malignant tumours and hereditary effects. Both these groups of health alteration also occur in a normal population that has not been exposed to any additional radiation. The incidence of such disorders is high; approximately 20-25% of population die from malignant tumours and approximately 10% of live births produce children who have some hereditary handicap. The analyses of data mentioned above have proven that ionising radiation increases the incidence of tumours in the exposed populations. This relationship has not yet been proven for the human populations, however, based on the experimental animal studies, it is regarded as an existing relationship. However, in an individual case it is impossible to determine whether the particular tumour or hereditary feature is an effect of exposure to radiation.

These effects are called the *stochastic effects* due to their random occurrence in a group of exposed persons. Further evaluation of the risk of health impairment requires considering the method of construction of quantitative indicators. The quantitative indicators enable the researcher to estimate the effects of the doses that are the inhabitants exposed to.

The generalisation of the data concerning stochastic effects enabled the researchers to make a conclusion that for low doses, the dose-effect relationship may be described as directly proportional, i.e. the effects are directly proportional to doses. Such a relationship can be documented only for a limited range of doses. For higher doses, the direct proportionality is affected by the occurrence of deterministic phenomena. For lower doses, the analysis would require the researcher to increase the number of persons under observation and finally, the lowest doses might require too large groups (that are impossible to assemble) to achieve statistical significance of results. For practical purposes, it is necessary to extrapolate the effects of lower doses from the effects of higher doses. Such method made the researchers to accept a hypothesis of *linearity and no threshold.* It must be emphasised that this hypothesis cannot be regarded as a radiobiological law. This hypothesis has been created for the purposes of radiation protection and must be regarded as the most convenient generalisation of the data currently available. This hypothesis may overestimate the actual risks related to low doses exposure and the underestimation is unlikely. If the hypothesis of linearity and no threshold is valid, for a respective type of tumour the line slope (gradient) represents a *risk coefficient*. The risk coefficient represents the probability that a particular phenomenon will occur following the exposure to a unit dose.

Whether or not the dose threshold exists for stochastic effects is the subject of a long-lasting theoretical discussion. Certain new radiobiological discoveries suggest that the dose-effect relationship may be non-linear for low doses. The occurrence of stochastic effects (health disorders) is related to the total number of cells exposed to radiation in a tissue and to the lethal effect of radiation, which occurs even at low doses. Such ”hypersensitivity” has been proven for a number of cell types in several scientific laboratories. It means that the lethal effect of relatively low doses (100-500 mSv) of radiation is comparatively higher than the lethal effect of doses of approximately 1 Sv. Under certain conditions, the facts mentioned above might imply that a threshold for the occurrence of tumours exists. Therefore it is obvious that estimating the health risks for doses under 1 mSv does not make much sense, as there are no experimental grounds available and the biological data suggest that there might be a non-linear relationship for the doses of several hundreds of mSv.

The natural background radiation may be regarded as a reference level that might be used for the evaluation of very low dose effects in the area of interest. The natural background radiation for the region of interest is approximately 4 mSv per year. It is obvious that doses representing only several percents of natural background radiation or a fraction of a percent are of no practical importance, as they are concealed by the fluctuation of natural background radiation due to movements of persons, eating habits etc.

The examination of population health status cannot serve as a method of assessment of health risks caused by the ionising radiation produced by the NPP. The levels of such ionising radiation which are the inhabitants exposed to (see later in this document) are so low that they cannot affect the trends in the malignant tumours and genetic disorders incidence. This incidence varies depending on location and time and is also affected by other factors (determinants) the role of which is not fully understood now. From the point of view of the population living in the vicinity of the Temelín NPP and from the point of view of regional authorities, conducting local studies may seem to make sense. However, in the whole-republic context it would be more strategically appropriate to focus on the improvement of registration systems on a scale of the whole republic. Such registration systems would later enable us to evaluate the health status of the population living in the vicinity of the Temelín NPP or to assess other ecological effects in the whole Czech Republic. From the statistical point of view, the potential confounding of the results (bias) cannot be excluded, if the inhabitants living in other regions of the Czech Republic, where the active screening for the phenomena of interest is not being conducted (and therefore the incidence of these phenomena may be underestimated) are used as control groups for local studies based on screening. However, alternative views on this aspect exist. For example, a proposal has been submitted to conduct a retrospective study that would include a five-year period prior to the Temelín NPP commissioning and that might continue during the Temelín NPP operation by a health status follow-up of approximately 30,000 persons living in the NPP vicinity. The scope of this study and methods to be used (both epidemiological and radiobiological- e.g. chromosome analysis) as well as the issues of financing etc. should be discussed by a professional forum including the appropriate critical analysis.

Evaluation of doses for the respective inhabitants or groups of inhabitants might appear to be another method for the risk assessment. However, this method is not suitable for use as the potential additional exposure of the inhabitants to radiation due to the Temelín NPP operation is below the sensitivity of the methods available and is concealed by the fluctuation of natural background radiation, including the global fallout and the consequences of the Chernobyl accident. This applies to the photon dose equivalent, i.e. to external exposure, and to the values of internal contamination with radioactive substances. The potential additional exposure mentioned above can be determined neither by whole-body measurement in persons, nor by the calculation based on the radioactivity detected in the respective components of food, as the values of additional contamination of foods are below the sensitivity of the methods available. Although the monitoring plans include the measurement of various components of the environment and various components of the food chains, this monitoring will only represent another control barrier and its results will not be suitable for use in the operational control of protection.

The only method for the evaluation of the potential NPP contribution to the population exposure is a calculation based on the data concerning volumes of discharged gaseous radioactive substances (and aerosols) through the ventilation chimney and the data concerning liquid discharges through the liquid discharge outlet, followed by the use of mathematical models describing the spreading of these substances in the environment and their transfer to food components. Prior to the NPP commissioning, the project calculations may serve as the input data for the calculation. The project calculations may be regarded as trustworthy as they are based on physical laws and have been validated through the observation of analogous facilities in other countries. During the Temelín NPP operation, the discharges through the ventilation chimney and through the liquid discharge outlet will be monitored, as the concentrations of radionuclides prior to dilution will be sufficient to enable the activity measurement. The aim of the monitoring is to follow the data concerning radioactive discharges, as described in the relevant sections of this document. To check the measurement executed by the nuclear power plant is subject to special interest of the state supervisory bodies, i.e. the State Office for Nuclear Safety.

The evaluation of potential health risks following the radiation exposure was performed using the last attitude – i.e. the model-based approach. For these purposes, two methods have been used. The first method was described in a document named Cancer Risk Coefficients for Environmental Exposure to Radionuclides (Federal Guidance Report No 13, 1999) that was issued by the Environmental Protection Agency – EPA – in the United States. For the 15 most important radionuclides, this document contains data concerning their activity per volume in the atmosphere at the distance of 667 to 10,667m from the ventilation chimney and from the engine hall. This data allow the researcher to calculate the lifetime risks of cancer and death from cancer. Similar methods enable the researcher to calculate the risks related to the drinking water ingestion (as an extreme presumption, drinking of water directly from the Vltava downstream from the discharge outlet has been considered), to the consumption of locally cultivated food and to the external exposure due to the ground deposition of radionuclides. The overall lifetime risk of death from cancer is 10^{-6} to 10^{-7} for all the radiation sources mentioned above. If the overall lifetime risk is decomposed to the respective risks per year, the risk values for an additional death from cancer are approximately 10^{-7} per year.

A parallel estimate of impact was also made based on the attitudes according to the Directive No. 184/1997 Coll. of laws. This attitude was based on the recommendation of the International Commission on Radiological Protection (ICRP). The coefficients in the documents mentioned above make it possible to assess the risk of malignant cancer causing death and also the probability of the “overall health loss”, which includes fatal tumours, health loss in persons in whom the tumours have cured successfully and consequences of hereditary disorders caused by radiation. For the purposes of these calculations both inhalation and ingestion of radionuclides were taken into account. The highest additional lifetime risk of death from cancer related to one particular radiation source and found in these calculations was the probability of 8E-07 for the ^{3}H effect from drinking the Vltava river water and the probability of 1.1E-06 for the overall health loss. However, these values are based on an unrealistic conservative presumption, so the more realistic figures should be at least tenfold lower.

It might be useful to demonstrate what exactly these coefficients of additional risk mean. Of one million of inhabitants, approximately 10,000 – 15,000 die every year. 2,000 to 3,500 of these people die from a malignant tumour. If the value of annual additional risk of fatal cancer is 1. 10^{-6}, it means that the number of deaths will increase by one case per year to the total numbers of 2001 or 3501. Such a case of additional death from tumour cannot be individually identified as a consequence of irradiation and is concealed by the fluctuation of this indicator between the respective years.

To assess the significance of additional exposure caused by internal contamination, it is possible to compare the value of yearly dose equivalent load with the corresponding load caused by natural background radiation. If this procedure is used e.g. for ^{3}H, it is possible to compare the highest dose load (again based on the unrealistic conservative presumption of drinking Vltava river water downstream of Korensko) per year, i.e. 320 nSv, with the average yearly load caused by natural background for a person living in the vicinity of the Temelín NPP, i.e. 4 mSv (4 000 000 nSv). Again, the fluctuation represents a fraction of a per mille of the usual dose and therefore may be regarded as negligible, as it is concealed by other effects which play a decisive role in the total annual cumulative dose per inhabitant.

The analyses suggest that despite the effort to retain all radionuclides produced by the power plant and to neutralise them as radioactive waste, a certain fraction of these radionuclides will escape into the environment. It is difficult to identify theoretically the health effects caused by these releases and discharges. It also cannot be expected that even the long-term indicators of population health will conclusively reflect these consequences. The probability values for long-term effects are based on the presumption that the hypothesis of linearity and no threshold is valid for these effects. As there is no direct evidence that the lowest doses have a harmful effect on health, it is often recommended to present the lifetime risk in the form of a range beginning with zero. Therefore, the estimate of the lifetime risk mentioned above should read 0 -10^{-7}, or 0 - 10^{-6}.

2.4.2.3.1.1 Effects upon other factors affected by the purpose, activity or technology of the building construction

Some comments relevant to this issue were made in Chapter 2.4.1.6. It is obvious that certain members of the public who live both in the vicinity of the Temelín NPP and in the remote regions are concerned about the adverse effects and risks related to the nuclear power plant operation, although with respect to the impact on the mental and physical health of the population, this concern does not necessarily have objective grounds.

2.4.2.4 Effects upon the "well-being" of (permanent or temporary) residents in general

It is necessary to be aware of the fact that both the presence and the operation of the Temelín NPP may affect the population living in its vicinity through the effects on the mental status, i.e. through the induction of worries and anxiety related to the proximity of a nuclear power plant, including the fear of the potential risks and adverse effects.

It is obvious that the preparatory phase, construction and trial operation of the Temelín NPP and the related phenomena have exerted significant psychological effects on the population living in the NPP vicinity for several decades. There are two opposite (and ambivalent) psychosocial attitudes towards the nuclear power plant: a positive attitude related to the economic benefits brought by the NPP to the whole region and, on the other hand, a negative attitude related to the potential negative impact of the NPP operation on the environment.

The positive effects (that are perceived as positive) of the NPP construction include building of traffic systems and other services in this region, increase in the number of job opportunities both in the NPP and in the related services and firms, reduction of public expenditures in Týn nad Vltavou and other municipalities (e.g. through using the waste heat etc.).[1]

Therefore, the positive attitudes may be expected in the vicinity of the Temelín NPP in the locations where the Temelín NPP operator offers job opportunities and support to various municipal programs, including leisure activities (the attractiveness for tourism may be increased by excursions to the Temelín NPP facilities and by various educational programs). There is no evidence that the occurrence of psychological stress and phobias should generalise. We can assume that these phenomena will occur in a minority of population and their incidence will develop through time. The potential emotional stress may be positively affected by suitable educational and cultural events organised by the Temelín NPP operator or local authorities.

[1] The positive effects mentioned in this paragraph and other positive effects are documented in detail in the appropriate chapters.

Negative effects may be divided into two categories: objective effects and subjectively perceived effects. As for the objective effects, they include the overall stress given by the pollution caused by the process of construction, increased traffic, esthetical degradation of the landscape, and also the numerous public negotiations, proceedings, demonstrations etc. The increasing (and marked) publicity in the local, Czech and foreign media related to the Temelín NPP and its impact does not contribute to psychological well being of the inhabitants either.

As for the subjectively perceived effects, they include especially the fear of possible health effects, accidents and emergencies, and fear of other unspecified risks and the resulting stress and anxiety. The decisive role in the social and psychological burden laid on the respective individuals is played not by the objective conclusiveness of the facts, but by their subjective perception. It seems that the education has been insufficient, especially with respect to the relatively insufficient attention paid to this issue by the Czech state and the local authorities, despite the effort of the project investor, i.e. the CEZ. However, as implied by the principles of preventive caution, education cannot produce a final solution to this problem. In any case, these types of load must be added to the other negative impacts.

It seems that the psychosocial impact has been underestimated on a long-term basis and that the necessary systematic sociological and psychological studies have not been conducted. In the last years, the prevailing feelings of the local population (according to randomly obtained subjective data collected among the local inhabitants) fluctuated between a relatively favourable attitude towards the NPP in the periods when the benefits were strongly perceived and the negative attitude in the periods when the local population was negatively affected by some of the negative consequences of the construction (e.g. dissolution of some settlements in the immediate vicinity of the NPP) and in the periods of major demonstrations of the NPP opponents, who exerted influence on the local population through spreading information about the potential hazards and risk factors.

Systematic psychological studies describing and evaluating this situation have not been available. It is a fact that the basic empirical survey into the topic mentioned above could have been completed during the NPP construction or finishing. The current situation – i.e. the commencement of the NPP operation- puts even more emphasis on the systematic follow-up of these effects, especially with respect to the impact of psychogenic factors on the overall health status of the population. In general, it is necessary to prepare a programme of sociological surveys as a method for monitoring of the psychological and socio-economic well being of the population. With respect to the considerable impact of psychogenic factors on the well-being and mental and physical health of the population, it is necessary to conduct a continuous follow-up of the NPP impact on the population, especially during the periods of NPP trial and normal operation (as these periods mean acceleration of the development in this field). Apart from that, it is useful to exert positive influence on the presumed future decline in the positive and especially in the negative impact of the NPP through education, trustworthy and open communication with the public, and also through offering an opportunity to participate in the processes of decision making (within the reasonable limits).

From the socio-economic point of view, the project being evaluated represents a remarkable benefit to the local inhabitants, as it has brought a substantial number of job opportunities, (both in the power plant itself and in the related services and firms) and improved the economic opportunities available to the surrounding settlements. Nevertheless, the negatives of the facility include some common external consequences that are given by the partial degradation of the esthetical and recreational function of the landscape. However, the exact damage assessment for these effects is theoretically and practically difficult and the results would be spurious (e.g. with respect to limited possibility of off-market assessment). However, the almost complete absence of such studies or attempts to develop such studies may be regarded as one of the major imperfections of the whole process of Temelín NPP construction and research into its impact. It may be recommended for the future that a programme of psycho-sociological surveys for the monitoring of psychological and socio-economic well being of the inhabitants should be developed. This requirement should be regarded as urgent.

On the other hand, from a more general (in terms of time and space) point of view it is necessary to take into account the concern about the restriction of other power sources, decline in coal mining production and, consequently, increase in unemployment in the North Bohemia coal-mining district. The significance of this effect is difficult to predict; it will depend on a number of other circumstances of the economic and social development in the Czech Republic. The potential solutions to these remote problems are within the competence of the central authorities and local authorities in the North Bohemia and are beyond the scope of this documentation.

2.4.3 Evaluation of transfer to man from atmospheric discharges

2.4.3.1.1.1 Models and parameter values used to calculate the consequences of the release

See Chapter 2.1.1.3.

2.4.3.1.1. Source term, yearly emission

See Chapters 2.1.1.5.1 and 2.1.1.6 of this document.

2.4.3.1.2. Meteorological data (average and extreme weather conditions)

See Chapter 2.1.2.

2.4.3.1.3 Atmospheric dispersion of the effluents

See Chapter 2.1.2.1.3

2.4.3.1.4. Ground deposition and resuspension

Commented in Chapter 2.3.3.2.

2.4.3.1.5.1. Food chains, external exposure etc.

Ingestion risk from foods is evaluated according to the documentation concerning the intake of radioactivity from locally cultivated foods consumed by local inhabitants (Energoprojekt, April 2000). These data were calculated with the aid of the NORMAL programming system that was developed at the Institute of Information and Automation Theory of the Czech Academy of Sciences, Prague, Czech Republic (P. Pecha, E.Pechová, 1999). This system is used for evaluating radiation load of the environment and population in the surroundings of nuclear power plants. The programme takes the following factors into account and uses them for detailed mathematical processing:

- space distribution of ground-level concentration of radionuclides present in the air and the deposition of radionuclides on the Earth surface (with respect to the orographic characteristics, meteorological data including the effects of precipitations, sedimentation rate and reverse whirling of light particles, influence of local air flow in the vicinity of buildings, etc.),
- penetration of radionuclides into foods and their movement in the food chains (including the deposition of radionuclides on plant leaves and penetration into the plants through the roots calculated with respect to the characteristics and methods used in agricultural production; furthermore, the following aspects are taken into account: vegetation periods, movement and conversion of radionuclides in both the plants and the environment, factors supporting natural decontamination as opposed to nuclide fixation etc.); the calculations are made for vegetable foods, animal foods and animal feed,
- conversion of the data obtained into the intake of radionuclides and radioactivity (using an average "shopping basket" for the Czech Republic).

We have taken the data concerning the yearly integral intake of activity from local food for adults from the documentation mentioned above and converted them into the lifetime risk using the coefficients of carcinogenic risk taken from the US EPA methodology and according to the following formula: $R = A_r \cdot r \cdot 75$ (years of lifetime), where A_r is the yearly intake of activity for an adult in Bq . s, and r is the respective risk coefficient. A strictly conservative approach was used, presuming that the local inhabitants would eat nothing else during the whole of their life (75 years for this purpose) than the food cultivated in the immediate vicinity of their place of residence. The risk calculations were again made for the distances from Temelín NPP mentioned above (667m, 1667m, 5333m and 10667m). As the surface deposition of radionuclides will slightly increase through time, we calculated the risks from food ingestion after the 1st year and after 30 years of Temelín NPP operation.

The external exposure assessment is based on an estimate of a dose for a reference adult man, standing outdoors (outside a building) and unshielded from the activity of external atmosphere and soil. The approach was again very conservative.

a) The risk from external exposure from radionuclide deposition was calculated from the documentation provided by Energoprojekt mentioned above. The values were calculated for the same four distances from Temelín NPP in the north-east direction and for the lifetime exposure according to the following formula: $R = A \cdot r \cdot 2.37.10^9$ (seconds in a 75 year lifetime), where A is the activity of the respective radionuclide on the terrain surface in Bq . m^{-2}, r is a respective risk coefficient (m^2 Bq^{-1} s^{-1}). Furthermore, we evaluated the increase in activity from deposited radionuclides through several years of Temelín NPP operation. The half-life of most of these radionuclides is very short and therefore the equilibrium is established during the first year of operation; the deposited activity does not change through time. The exception to this rule is represented by the following radionuclides with a longer half-life: ^{55}Fe, ^{60}Co, ^{63}Ni, ^{134}Cs, and ^{137}Cs. Based on the documentation supplied by Energoprojekt, we used the values of total deposition of these radionuclides after 30 years of Temelín NPP operation for the calculations. These calculations made it possible to evaluate the overall risk from deposition after 30 years of Temelín NPP operation. We also used the same data for the above-mentioned evaluation of risk from local food after 30 years of Temelín NPP operation.

b) The risk from external exposure from radionuclides present in the atmosphere was calculated according to the same method as the risk from the deposition of radionuclides, i.e. according to the formula $R = A \cdot r \cdot 2.37.10^9$ (seconds in a 75 year lifetime), where A is the activity of the respective radionuclide in the atmosphere in Bq . m^{-3}, r is a respective risk coefficient (m^3 Bq^{-1} s^{-1}). As the discharge into the atmosphere of the radionuclides under question does not change through time, the results are valid for any year of NPP operation.

2.4.3.1.6. Living habits (diet, exposure time etc.)

Living habits and other parameters related to the lifestyle correspond to the conditions in other parts of the Czech Republic. The NORMAL programme, mentioned in the previous section, takes also into account the potential effects of consumption of foods of local origin.

2.4.3.1.7 Other parameter values used in the calculations

See the appropriate chapters for relevant comments.

2.4.4 Evaluation of concentration and exposure levels associated with the discharge limits (an outline of evaluation methods)

The evaluation of exposure levels and radiation exposure risk was performed using the US EPA methodology, which is based on the knowledge of radioactive substance intake expressed in Bq.

a) The evaluation of risk from air inhalation was based on a detailed study concerning the spreading of radionuclides into the surroundings of the Temelín NPP (Energoprojekt, April 2000). This study calculates the discharge of radionuclide emission through the Temelín NPP air outlets, according to detailed mathematical models and with respect to all relevant orographic, meteorological and other factors. The spreading of radionuclides is calculated for 16 directions (pie slices with the angle of 22°) and for the distances of up to 17.3km from the source. For the purposes of this analysis, we have evaluated the north-eastern pie slice, where the greatest emission values are found (the emission values for the other directions are smaller, however, the differences are not very marked). We made the evaluation for the distances of 667 m, 1667m, 5333 m and 10667m from the source. We calculated the carcinogenic risk for people who would inhale the outdoor (outside a building) air continuously for the whole of their life (75 years). This approach is intentionally extremely conservative and markedly overestimates the probable actual exposure. In accordance with the methodology, we used the value of 17.8 m^3 for the average volume of daily-respired air and the value of 2.74×10^4 days (in a 75-year lifetime). The calculation was made according to the following formula: R = A . r . 17,8 . 2.74E+04, where A is the ground concentration of radioactivity of the respective radionuclide in Bq . m-3, and r is the respective coefficient of carcinogenic risk (morbidity or mortality). The coefficients express the mean value for all age groups and both sexes and for the average absorption rate from the lungs into the blood circulation.

Emission of radionuclides is calculated for the equilibrium status, which will develop as a consequence of stable emission from the Temelín NPP and the natural decrease of radionuclides due to the extinction and natural cleaning processes. Therefore, the loading of the atmosphere with radionuclides will not increase through time during the Temelín NPP operation. For that reason, it was not necessary to consider the potential changes in the effects on population in various periods of Temelín NPP operation.

b) Ingestion risk from drinking water

As stated above, the risk of Temelín NPP-produced waste water penetration into the drinking water is minimal. Despite this fact, we decided to verify to which extent the waste water might affect the human health. Therefore we calculated the morbidity and mortality risks for malignant neoplasms under an extremely conservative presumption of a lifetime of drinking water directly from the Vltava downstream from the Temelín NPP discharge outlet (Korensko profile). Our calculations were based on the documents published in the Safety Report (bezpecnostní zpráva) issued by the Temelín Nuclear Power Plant and on the supplements concerning the nuclide content in the technological liquid discharges provided by Energoproject. Liquid discharges are the component that carries the major radioactive load. We chose the conservative approach and used the radioactivity values for liquid discharges for the whole waste water volume (10,000 m^3 per year), although this component mixes with other components of much lower activity. As the average water passage in the Vltava for the profile mentioned above is 1.6 10^9 m^3 per year, the waste water will be diluted by 1.6 . 10^5. We calculated the average activity concentrations for the respective radionuclides in the Vltava water (Bq . l^{-1}) at the profile being evaluated using the ratio mentioned above.

The methodology we used defines water consumption as water that is directly drunk or added into meals and drinks when preparing food. Water consumption does not include water naturally present in foodstuffs. According to the methodology, the average daily water consumption is 1.11 l (the age structure and ratio of sexes for the given population must be taken into account).

Another calculation used the following formula (in accordance with the methodology): R = A . r . 1.11 (litres of water daily) . $2.75x10^4$ (days in a 75 year lifetime), where A is the activity of the respective radionuclide in Bq . l^{-1} and r is the respective risk coefficient (expressed as a unit of activity intake in Bq . l-1).

a) Ingestion risk from foods was evaluated according to the documentation concerning the intake of radioactivity from locally produced food consumed by local inhabitants (Energoprojekt, April 2000). These data were calculated with the aid of the NORMAL programming system that was developed at the Institute of Information and Automation Theory of the Czech Academy of Sciences, Prague, Czech Republic (P. Pecha, E.Pechová, 1999). This system is used for evaluating the radiation load of the environment and population in the surroundings of nuclear power plants. The programme takes the following factors into account and uses them for detailed mathematical processing:

- space distribution of ground-level concentration of radionuclides present in the air and the deposition of these radionuclides on the Earth surface (with respect to the orographic characteristics, meteorological data including the effects of precipitations, sedimentation rate and reverse whirling of light particles, influence of local air flow in the vicinity of buildings, etc.)
- penetration of radionuclides into foods and their movement in the food chains (including the deposition of radionuclides on plant leaves and penetration into the plants through the roots calculated with respect to the characteristics and methods used in agricultural production; furthermore, the following aspects are taken into account: vegetation periods, movement and conversion of radionuclides in both the plants and the environment, factors supporting natural decontamination as opposed to nuclide fixation etc.); the calculations are made for vegetable foods, animal foods and animal feed.

- conversion of the data obtained into the intake of radionuclides and radioactivity (using an average "shopping basket” for the Czech Republic).

We have taken the data concerning the yearly integral intake of activity from local food for adults from the documentation mentioned above and converted them into the lifetime risk using the coefficients of carcinogenic risk taken from the US EPA methodology and according to the following formula: $R = A_r \cdot r \cdot 75$ (years of lifetime), where A_r is the yearly intake of activity for an adult in Bq x s, and r is the respective risk coefficient. A strictly conservative approach was used, presuming that the local inhabitants would eat nothing else during the whole of their life (75 years for this purpose) than the food cultivated in the immediate vicinity of their place of residence. The risk calculations were again made for the distances from Temelín NPP mentioned above (667m, 1667m, 5333m and 10667m). As the surface deposition of radionuclides will slightly increase through time, we calculated the risks from food ingestion after the 1st year and after 30 years of Temelín NPP operation.

2.4.4.1. Annual average concentrations or short term exposures in the atmosphere near the ground and surface contamination levels, in the vicinity of the installation and in adjacent Member States.

See the appropriate chapters for relevant comments.

2.4.5 Evaluation of transfer to man from liquid discharges

2.4.5.1 Models and parameter values used to calculate the consequences of the releases

See Chapter 2.2.1.3.

2.4.5.1.1 Aquatic dispersion of the effluents

See Chapters 2.2.2.1 and 2.2.2.2.

2.4.5.1.2 Their transfer by sedimentation and ion exchange

See Chapter 2.2.1.3.1.

2.4.5.1.3. Food chains, external exposure etc.

Ingestion risk from foods is evaluated according to the documentation concerning the intake of radioactivity from locally cultivated foods consumed by local inhabitants (Energoprojekt, April 2000). These data were calculated with the aid of the NORMAL programming system that was developed at the Institute of Information and Automation Theory of the Czech

Academy of Sciences, Prague, Czech Republic (P. Pecha, E.Pechová, 1999). This system is used for evaluating the radiation load of the environment and population in the surroundings of nuclear power plants.

The risk coefficients for external exposure are based on an estimate of a dose for a reference adult man, standing outdoors (outside a building) and unshielded from the activity of external atmosphere and soil. The approach was again very conservative.

a) The risk from external exposure from radionuclide deposition was calculated from the documentation provided by Energoprojekt mentioned above. The values were calculated for the same four distances from Temelín NPP in the north-east direction and for the lifetime exposure according to the following formula: $R = A \cdot r \cdot 2.37.10^9$ (seconds in a 75 year lifetime), where A is the activity of the respective radionuclide on the terrain surface in $Bq \cdot m^{-2}$, r is a respective risk coefficient ($m^2\ Bq^{-1}\ s^{-1}$). Furthermore, we evaluated the increase in activity from deposited radionuclides through several years of Temelín NPP operation. The half-life of most of these radionuclides is very short and therefore the equilibrium is established during the first year of operation; the deposited activity does not change through time. The exception to this rule is represented by the following radionuclides with a longer half-life: ^{55}Fe, ^{60}Co, ^{63}Ni, ^{134}Cs, and ^{137}Cs. Based on the documentation supplied by Energoprojekt, we used the values of total deposition of these radionuclides after 30 years of Temelín NPP operation for the calculations. These calculations made it possible to evaluate the overall risk from deposition after 30 years of Temelín NPP operation. We also used the same data for the above-mentioned evaluation of risk from local food after 30 years of Temelín NPP operation.

b) The risk from external exposure from radionuclides present in the atmosphere was calculated according to the same method as the risk from the deposition of radionuclides, i.e. according to the formula $R = A \cdot r \cdot 2.37.10^9$ (seconds in a 75 year lifetime), where A is the activity of the respective radionuclide in the atmosphere in $Bq \cdot m^{-3}$, r is a respective risk coefficient ($m^3\ Bq^{-1}\ s^{-1}$). As the discharge into the atmosphere of the radionuclides under question does not change through time, the results are valid for any year of NPP operation.

2.4.5.1.4. Living habits (diet, exposure time)

Living habits and other parameters related to the lifestyle correspond to the conditions in other parts of the Czech Republic. The NORMAL program, mentioned in the previous section, takes also into account the potential effects of consumption of foods of local origin.

2.4.5.1.4. Other parameter values used in the calculations

See the appropriate chapters for relevant comments.

2.4.6. Evaluation of concentration and exposure levels associated with the discharge limits (attitude towards the exposure control and usage of limits)

Firstly we should mention the basic approaches to the control of radioactive substances content in the effluents in compliance with Regulation No. 18/1997 Coll. of Laws ("atomic law") and the Directive of the State Office for Nuclear Safety No. 184/1997 Coll. of Laws about the requirements for ensuring radiation protection. The main principle is presented in Paragraph (4), Article 4 of the regulation No. 18/1997 Coll. of Laws. According to this provision, every person or organisation that uses nuclear energy or performs an activity that may result in exposure to radiation is obliged to adhere to such a level of nuclear safety and radiation protection that the risk of endangering the human life, health and environment is As Low As Reasonably Achievable with respect to economic and social aspects. The implementary regulation determines technical and organisational requirements and recommended standard values of exposure that are considered sufficient to prove the reasonably achievable level of protection (see especially Article 7 of the Directive No. 184/1997 Coll. of Laws), so that it is not necessary to document meeting of the requirements for *protection optimisation* (the ALARA principle, maintaining the exposures As Low As Reasonably Achievable) by complex quantitative and semi-quantitative methods (cost-benefit analysis, multicriterial approach, aggregation methods).

Apart from the documentation related to meeting the requirements for protection optimisation (which is mostly related to the collective dose received by a wide group of inhabitants), it is necessary to prove that the dose distribution ensures that no individual is exposed to an unacceptably high dose of radiation. This is the purpose of the determination and respecting of the *basic limit of effective dose*, determined by Article 9 of the Directive No. 184/1997 Coll. of laws as 1 Sv per calendar year (or 5 mSv during the period of five subsequent calendar years). The validation of this requirement related to an individual is performed in a model case for a small group of persons called the *critical group of inhabitants.* This group should be reasonably homogeneous with respect to exposure to radiation from a given source and through a given way of exposure and should characterise the individuals in the population who receive the highest effective or equivalent dose through the given way of exposure and from the given source. Up to the limit of 1 mSv per year, doses resulting from exposure to various sources created by planned activity (i.e. the natural background exposure is not controlled through this limit and is not included into the limited dose). Therefore, it is reasonable for the regulatory body to determine (e.g. through a binding regulation) a certain fraction of this limit as binding for a particular activity (in this case for the Temelín Nuclear Power Plant). Directive No. 184/1997 Coll. of laws determines in Article 5, Paragraph (1), Letter b for approved discharge of radioactive substances into the environment from one source (e.g. from Temelín NPP), that the average effective dose received by the critical group of inhabitants may not exceed 250µSv in any calendar year. This limitation has the character of a *critical value of the limit* determined according to Article 4, paragraph (6) of the Regulation No. 184/1997 Coll. of laws Article 32 of the Directive No. 184/1997 Coll. of laws specifies that this total limit dose is divided into a partial dose of 200µSv determined for discharge of radioactive substances into air and a partial dose of 50µSv determined for discharge of radioactive substances into running water. For the purpose of permit issuance and decision making in the issues of discharge of radioactive substances into the environment, the State Office for Nuclear Safety determines (apart from other values) specific values for the limit exposures - i.e. the *authorised limits* for a particular facility, according to Letter h, Paragraph (1), Article 9 of the Regulation No. 184/1997 Coll. of laws. The document named "Limits and conditions of safe operation for the Temelín Nuclear Power Plant" (Limity a podmínky bezpecného provozu Jaderné elektrárny Temelín), which was approved by the State Office for Nuclear Safety under the reference number of 10139/2000, determines the value of 40µSv for discharge of radioactive substances into air during the operation of two NPP units and the value of 0.2 µSv or 0.4 µSv for discharge of radioactive substances into running water during the operation of one or two NPP units, respectively. These values represent the yearly load caused by the effective dose equivalent for the critical group of inhabitants living in the vicinity of the Temelín NPP. The critical group of inhabitants living in the vicinity of the Temelín NPP includes the inhabitants who live in the annular area defined by the distances of 3km (external border of safety zone) and 5km from the Temelín NPP. The assessment of radiation load must take into account all ways of potential exposure.

There was a reference to the recommended standard values earlier in this document. If the recommended standard values have not been exceeded, it may be regarded as an evidence that the optimisation requirements have been met. As for the discharges subject to the approval of the State Office for Nuclear Safety, the recommended standard value for the total yearly effective dose (defined as a sum of all discharges) is 50 µSv (Article 7, Paragraph 3, Directive No. 184/1997 Coll. of laws). The reasonably achievable level of radiation protection is regarded as sufficiently proven if this recommended standard value cannot be exceeded in any individual even under a predictable deviation from normal operation.

The materials, substances and objects containing radionuclides or contaminated with radionuclides can be introduced into the environment without permission under the following condition (Article 5, Paragraph 1, Letter a, Item 1): the release from the regulatory system is appropriate, if the average effective dose in the critical group of inhabitants does not exceed 10 µSv in any calendar year and at the same time the collective effective dose not exceed 1 mSv.

2.4.6.1 Annual average concentrations of activity in surface waters, at the points where such concentrations are highest, in the vicinity of the installation and in the adjacent Member States

A more precise analysis of the radioactive substances discharge showed that there will be minor changes in their activity per volume in the Vltava river, Korensko profile (except tritium).

The indicator of *total beta activity per volume* will be slightly altered due to the intake of water for technological purposes at the Hnevkovice profile (similarly as in non-radioactive substances). The yearly beta activity taken in during one NPP unit operation and under the condition of the limit water intake of 19,110.106 m^3/year (according to the appropriate Decision of the District Authority in Ceské Budejovice as of 1993) will be 3.96 GBq/year (the average value of the total beta activity per volume in 1998-1999 was used for the calculation). During two NPP units operation and under the condition of the limit water intake of 38,019.106 m^3/year, the yearly beta activity taken in will be 7.87 GBq/year. The increase in the total beta activity per volume in the profile where the waste water outlet is located, i.e. in the Vltava Korensko profile, will be 0.003 Bq/l, if the yearly limit for the discharged waste water volume during one NPP unit operation is considered, i.e. 4,775.106 m3/year (based on the above-cited Decision of the District Authority in Ceské Budejovice), and under the condition of average water passage in the Vltava; under the condition of minimal water passage in the Vltava, the increase will be 0.013 Bq/l. Analogously, if the yearly limit for the discharged waste water volume during two NPP units operation is considered, i.e. 9,342.106 m3/year (based on the above-cited Decision of the District Authority in Ceské Budejovice), the increase in the total beta activity per volume will be 0.005 Bq/l under the condition of average water passage in the Vltava and 0.026 Bq/l under the condition of minimal water passage in the Vltava.

For *tritium*, if the contribution of the discharged radionuclides produced by the operation of the power plant itself is considered, i.e. 20 TBq per Temelín NPP operation unit (based on the limit according to the appropriate Decision of the District Authority in Ceské Budejovice), the increase in tritium activity per volume will be 13 Bq/l under the condition of average water passage in the Vltava and the yearly limit for the waste water discharged from Temelín NPP, or 66 Bq/l under the condition of minimal water passage in the Vltava. In 1998-1999, the average activity per volume for tritium in surface water in the Temelín surroundings was 1.5 Bq/l. That means that the resulting predicted activity per volume for tritium under the two operating modes specified above will be 14 Bq/l and 67 Bq/l, respectively.

Analogous calculation can be performed for two Temelín NPP operation units with the discharge limit of 40 TBq. The resulting increase in tritium activity per volume will be 25 Bq/l under the condition of average water passage in the Vltava and the yearly limit for the waste water discharged from Temelín NPP. Under the condition of minimal water passage in the Vltava, the increase will be 132 Bq/l. If the tritium background is included in the calculation (as above), the resulting predicted activity per volume for tritium under the two operating modes specified above will be 27 Bq/l and 133 Bq/l, respectively (all tritium activities per volume were rounded to integer values, except the background activities). Apart from the average values calculated above, the short-term maximum tritium activities per volume can occur in waste water under the planned NPP operating modes and the minimum water passage in the Vltava; such peak activities may reach 550 Bq/l (EGP, 1996a).

The analysis performed above implies, that the effects of radionuclide discharges from the power plant through the waste water will occur within the range of natural fluctuation of the radioactive substances activity per volume and within the range of the balance of radioactive substances running through the Vltava Korensko profile or the Vltava Hnevkovice profile, respectively, except tritium. As for tritium, a measurable increase in its activity per volume will occur downstream from the NPP liquid discharge outlet.

2.4.6.2 <u>For the reference group(s) in other Member States: effective dose to adults, children and infants</u>

The estimation of effective doses at the frontiers between the Czech Republic and Germany and Austria, respectively, was made in an additional document elaborated by Investprojekt s.r.o. in March 2001. This document examines the impact of two types of potential accidents and the potential resulting exposure at 7 locations at the frontier, evenly distributed over the respective segments of wind direction. In the case of DBA LOCA connected with a leakage from the containment 1 per mille/24 hours and wind intensity of F category, the highest effective doses will be observable in infants at the age of 0-1 year. For the B and F locations, the estimate is 1.E-5 Sv 1 year after the accident. The highest thyroid gland exposures can be observed in the same age category at the F location and are estimated at 2.E-5 Sv 1 year after the accident. In the case of an accident of the second type (i.e. rupture of the TK pipe of fuel discharge), the estimate of effective doses in infants aged 0-1 is slightly higher, i.e. 1-2.E-5 Sv 1 year after the accident in all directions being followed. For this type of accident, the effective doses for adults are analogous. The thyroid gland exposures in the case of an accident of the second type are lower.

2.4.7 Environmental monitoring

Chapter 2.4.2.2. explains the importance of the monitoring of the respective environmental components. However, in the operational protection control the key role is played by the ventilation chimney and the liquid discharge outlet, where the activities per volume of the radioactive substances are sufficiently high for measurement and evaluation. Such measurement can determine the fluctuation of the indicators being followed, enable the comparison with the discharge values in the project documentation and allow timely signalling of non-standard situations and emergencies. Monitoring of the photon dose equivalent input and activities per volume in the atmosphere at the estate of Temelín NPP, organised by the NPP operator, represents an important supplement to the measurements specified above and may be important in case of radioactive substance leakage through other ways than through the chimney (e.g. leakage in the engine hall).

Monitoring of environmental components outside the estate of Temelín NPP represents another control barrier. The plan of monitoring is based on the analysis of potential ways of exposure to the inhabitants living in the NPP vicinity. Under normal operation, photon and neutron radiation emitted directly from the objects located at the estate of Temelín NPP may be excluded. The potential local population exposure may be caused by release of radionuclides into the atmosphere or running water and water pools. These media may cause direct exposure of persons and represent the external component of exposure, which depends on the presence of a person in the harmful environment. This type of exposure includes exposure from radioactive cloud (this term should not be associated with an idea of a visible cloud, it means a contaminated volume of air that moves depending on wind direction and rate) and exposure from radioactive substances deposited on the ground after dry or wet (due to precipitation) fallout. The measurement of environmental photon dose equivalent input may provide information about the components mentioned above. This measurement is not very demanding from both technical and organisational point of view. The results are expressed in Sv/hour (usually µSv/hour, or nSv/hour) and can be used directly for the evaluation of exposure of persons based on effective dose.

Another exposure component is due to internal contamination, i.e. penetration of radioactive substances into the human body through inhalation, ingestion, or, as the case may be, through injured or intact body surface (less important way). The evaluation of this exposure component is more problematic and includes several steps. The first stage is determination of the *radioactive substance intake*, i.e. determination of the type of radioactive substance (radionuclide, chemical entity and other characteristics) that caused the contamination, and radioactive substance quantification, usually using *activity* - the value related to the number of conversions per time unit. The activity unit is 1 becquerel (Bq). Determination of the intake in the human body is possible only in the case of excessive radioactive substance intake, e.g. after radiation accidents - in such cases, it is possible to use whole-body measurement and examination of activity excreted through urine and faeces. Under the normal operation and for the presumed discharge quantities, the methods mentioned above are not suitable for use. Another method of intake evaluation is calculation based on the knowledge of concentrations (activities per volume or weight) in the air (for contamination through inhalation), and for any ingestible materials including foods and water (for contamination through ingestion). The evaluation of intake through ingestion is possible provided that the "shopping basket" for the given population group is known.

The necessary quantitative parameters for the calculations may be found in Article 47, Directive No. 184/1997 Coll. of laws under the title "Jednotné postupy pro hodnocení velicin merených v rámci monitorování" (Unified methods for the evaluation of parameters measured within the framework of monitoring). The methods described above make it possible to quantify the total intake of a radioactive substance or a mixture of radioactive substances, i.e. to determine the activity taken in (in Bq).

The relation between the activity in the human body (in Bq) and the equivalent dose in the respective organs, or, as the case may be, the effective dose, is not simple. It is necessary to obtain further information about the behaviour of the radioactive substance in the human body, i.e. about its kinetics including the dynamics of excretion. In a simplified fashion we could say that it is necessary to determine the *source organ*, i.e. an organ or tissue of preferential radionuclide deposition (e.g. thyroid gland for iodine). Using complex mathematical methods, the effects of the radiation emitted from the source organ on the other bodily organs (*target organs*) is determined. The doses absorbed by the target organs are expressed in Gy or Sv. The conversion from activity in Bq to dose or, as the case may be, to effective dose in Sv is very important, as the basic limits are expressed as dose-related values.

The conversion must also take into account that the radionuclides persist in the human body for a certain time. This time varies depending on the physical and biological half-life of the radionuclides. It is recommendable to include in the regulatory system (system of limits) of the yearly intake of radioactive substances the equivalent dose (or effective dose) that is expected to be taken in the future. A new value has been introduced. The name of this value is *equivalent or effective dose load*; this value is a summary expression of the radiation load caused by internal contamination and provides a solution to the problem of evaluation of risks caused by internal exposure.

The aim of the previous sections was to show the complexity of the methods to be used. The conversion of the intake values to the effective dose load for the individual inhabitants is presented in Tables 5 and 6 of Appendix 3 (scope: 45 pages) to Directive No. 184/1997 Coll. of laws.

The items of this table may demonstrate the range of conversion factors in the Sv/Bq direction. E.g. the range between polonium ^{210}Po and tritium ^{3}H is 5 orders, which means that the intake of 1 Bq ^{210}Po causes the same effective dose (and, consequently, the same health hazard) as the intake of 100 000 Bq ^{3}H.

2.4.7.1 External radiation monitoring

External radiation monitoring is partially performed by sections of the Temelín NPP operator, i.e. by the *Laboratory of Environmental Radiation Control (Laborator radiacní kontroly okolí, LERC).* There are 5 *Stations of Environmental Radiation Control (Stanice radiacní kontroly okolí –SERC)* operating in the emergency planning zone. These stations perform the measurement of aerosol particles and atmospheric fallout (see later in this document) and the evaluation of the external radiation through continuous monitoring of the photon dose equivalent input using termoluminiscence dosimetry - TLD. Other measurement sites for photon dose equivalent measuring are located in two circles in the settlements around the power plant.

An important supplement to the external radiation monitoring is represented by several measurement systems operating within the framework of the Radiation Monitoring Network (radiacní monitorovací sít, RMN) of the Czech Republic. The following institutions co-operate in the RMN activities: the State Institute of Radiation Protection (Státní ústav radiacní ochrany, SIRP), regional centres of the State Office for Nuclear Safety (Státní úrad pro jadernou bezpecnost) and the Czech Hydrometeorological Institute (Ceský hydrometeorologický ústav, CHMI). A continuous measurement of the photon dose equivalent input is performed at 58 sites of the Early Detection Network (*sít vcasného zjištování* - EDN). The average values are measured every 10 minutes. The data obtained are electronically transferred to the RMN Centre and centrally evaluated. If any of the signalling levels is exceeded, a group of selected professionals is automatically informed. Another important network serving for the evaluation of external radiation is the *territorial network of 184 measurement sites* using termoluminiscence dosimetry. The RMN also uses the data measured by the local network of 86 measuring points in the surroundings of the Dukovany and Temelín Nuclear Power Plants. This network extends the LERC activities. The RMN also co-operates with the measuring sites of the Czech Army.

2.4.7.2 Monitoring of radioactivity in air, water, soil and the food chains, whether undertaken by the operator or by competent authorities

The SRKO stations operated by the LERC as mentioned above are located in the municipalities of Bohunice, Zverkovice, Litoradice, Nová Ves and Sedlec, with respect to the prevailing direction of wind. One station is located directly in the power plant estate. The stations perform continuous sampling of the aerosol particles using a filter. The filters are replaced and used for measurement at regular intervals. The measuring is performed at the LERC in Ceské Budejovice. Furthermore, the stations are equipped with large-area devices catching the atmospheric fallout.

The concentration of tritium in precipitations (rainwater) is performed by rainwater collection at the meteorological observatory of Czech Hydrometeorological Institute in Temelín and by LERC in Ceské Budejovice.

Surface water control and control of sediments in the Vltava downstream from the discharge outlet, down to the Vltava - Solenice profile, is performed at regular intervals. Furthermore, the surface water and sediments are regularly monitored above the dam of the Korensko submerged stage, in the Vltava - Hnevkovice reservoir (with respect to the intake of water for the Temelín NPP from this reservoir) and in the Belohurecký pond.

The underground water monitoring is performed in the NPP estate and the near vicinity, both in the shallow and deep horizons using a network of monitoring wells. The underground water monitoring is also performed in the NPP estate in the selected drainage wells.

Drinking water control is performed in selected municipalities - both the tap water and water from public wells is sampled. In general, water control is performed through sampling and subsequent evaluation at LERC.

The frequently communicated concern about the increased level of tritium in the Vltava is understandable and founded, as through time the increased levels of tritium will occur both in the Vltava and in the wells. However, the resulting doses from this source will be very low and the related risk will be practically imperceptible.

Agricultural crops, fruit, and fodder are checked to the distance of approximately 5km from the power plant; for the Temelín, Všemyslice, Kocín, Sedlec, Zverkovice and Litoradlice municipalities, the safety zone borders are taken into account. The sampling locations are selected flexibly, according to the cultivation plans for the respective areas. In the Lhota pod Horami dairy farm, the samples of milk are regularly taken. The samples of fish are taken once a year in the water reservoir of Orlík and in Belohurecký pond. The samples are analysed by LERC.

Once a year, the occurrence of radionuclides in uncultivated soil is checked. The monitoring is performed by laboratory analysis of samples. Furthermore, the surface contamination is checked regularly by a gammaspectrometric measurement in situ and by measuring of dose input at selected locations. 4 measurement points, evenly distributed around the Temelín NPP have been selected in the protection zone for the cultivated soil control by gammaspectrometric measurement in situ.

Most measurements are performed by LERC. Some special sampling procedures and measurements are organised in co-operation with external organisations (Research Institute of Water Supply and Distribution of Tomáš Garrigue Masaryk - Výzkumný ústav vodohospodárský T.G. Masaryka, Czech Technical College - CVUT, Prague, Czech Republic).

Other subject participating on the monitoring of air, water and foods is the RMN, which is operated by the State Institute of Radiation Protection and regional centres of the State Office for Nuclear Safety and the Czech Hydrometeorological Institute. A territorial network of 11 measuring sites has been in operation and the samples are evaluated by a network of 9 laboratories (including the LERC laboratories in the power plants). The RMN is working on a plan of measurement for the respective environmental components and the respective foodstuffs (aerosols, fallout, soil, drinking water, water sediments, milk, dairy products for children, meat, fish, potatoes, crops, vegetables, fruits, wild fruits, mushrooms). RMN also measures the residual contamination of the soil in the Czech Republic with ^{137}Cs caused by the Chernobyl accident. In this respect, measuring of the ^{137}Cs content in the bodies of selected persons using the whole-body measurement and urine examination is important. The results of the measurements mentioned above are published in annual reports on radiation-related situation in the Czech Republic and are open to the public.

Conclusion of Section 2.4.

The release of radioactive substances into the environment in the vicinity of the Temelín NPP and the human health protection during the NPP operation meet the criteria of acceptability for the population exposure to radiation defined by the legislation of the Czech Republic in accordance with the international recommendations, namely with the documents of ICRP No. 60 as of 1991 and Basic Safety Standards (IAEA,WHJO etc.) as of 1994, and comply with the EURATOM Directive 96/29. Both key requirements, i.e. the ALARA principle (maintaining external exposures As Low As Reasonably Achievable with respect to the society needs) and the principle of not exceeding the basic limits have been met (the latter with an extensive reserve, as the limits authorised by the supervisory body are more strict).

Key problem: Radiation hygiene – atmosphere

According to the current survey it may be stated that:

During normal NPP operation, the discharges of radioactive substances into the atmosphere will not cause population exposure that might represent a health hazard.

Recommendation:

Within the framework of the Radiation Monitoring Network (radiacní monitorovací sít, RMN) of the Czech Republic, it is necessary to organise the monitoring of radioactive aerosols and the photon dose equivalent input in the atmosphere. The current monitoring program is sufficient with respect to the health protection requirements. The system is capable of signalising atmosphere contamination in the case of a major ("supra-project") accident. In such a case, the results of monitoring using the advanced monitoring mode would help to organise the operational control of population protection .

Key problem: Radiation hygiene – water

According to the current survey it may be stated that:

During normal NPP operation, the discharges of radioactive substances into running water and water reservoirs will not cause population exposure that might represent a health hazard. Within several years, the presence of detectable concentrations of tritium may be found in some drinking water sources. The health effects of such contamination would be negligible, as the exposure caused by the doses expected would be less than 1 per mille of the natural background.

Recommendation:

Within the framework of the Radiation Monitoring Network (radiacní monitorovací sít, RMN) of the Czech Republic, it is necessary to organise the monitoring of radioactive substances in surface water, underground water and drinking water sources. The current monitoring program is sufficient with respect to the health protection requirements. The system is capable of signalising water contamination in the case of a major ("supra-project") accident. In such a case, the results of monitoring using the advanced monitoring mode would help to organise operational control of population protection .

Key problem: Radiation hygiene – food chains

According to the current survey it may be stated that:

During normal NPP operation, the discharges of radioactive substances into the atmosphere and water will not cause such food chain contamination that might represent a health hazard.

Recommendation:

Within the framework of the Radiation Monitoring Network (radiacní monitorovací sít, RMN) of the Czech Republic, it is necessary to organise the monitoring of radioactive substances in the respective foods (foods of a "shopping basket"). The current monitoring program is sufficient with respect to the health protection requirements. The system is suitable for the operational control of population protection in the case of a major ("supra-project") accident.

Key problem: Communal hygiene (factors unrelated to radiation)

According to the current survey it may be stated that:

During the Temelín NPP operation, the indicators of environmental pollution and health hazards unrelated to radiation will not represent an additional risk for the population.

Recommendation:

The respective components of the environment must be monitored, with respect to the indicators of chemical and microbiological contamination of water and other components of the environment. The monitoring should be performed by the Public Health Authorities (hygienists) and the authorities responsible for water supply and distribution.

Key problem: Well-being of the inhabitants

According to the current survey it may be stated that:

The well-being of the inhabitants living in the vicinity of Temelín NPP has been negatively affected during the NPP construction. Further development of the attitudes may be expected. The attitudes shown by the inhabitants are both negative (e.g. due to the landscape alteration, publicity related to anti-nuclear activities etc.) and positive

(due to the offer of job opportunities, support to communal investments and other activities).

Recommendation:

It is necessary to deal with the psychosocial problems, i.e. to organise a systematic sociological research and to apply appropriate measures in the fields of information science and cultural and/or educational activities.

2.5. Nature and Landscape (Fauna, Flora, Ecosystems)

2.5.1. Potentially Affected Environment and Nature

2.5.1.1. Animals and Plants

The Documentation gives a concise description of the animal groups living in various types of biotopes in the surroundings of Temelín Nuclear Power Plant (pages 145-147), including an evaluation of the watersheds of Paleckuv potok and Strouha. Localities with incidence of specially protected animal species are listed (e.g. both of the water courses used by Temelín Nuclear Power Plant to discharge water, i.e. Vltava and Strouha, are a biotope of specially protected animals, which holds also for the downstream part of the watershed of Paleckuv potok, which receives the rainwater from the construction facilities site). The Documentation includes also a concise evaluation of specially protected areas. Neither the construction facility sites out of the power plant area, nor the developments induced by Temelín Nuclear Power Plant construction are considered in the assessment.

With respect to the limited time available for this Assessment, a direct on site biological survey of Temelín Nuclear Power Plant surroundings could not be carried out, which would include the substantial aspects of seasonal evolution. Therefore, the Assessment is based on the current information available to its authors and on the review of the available documentation on the area from the time before the construction and in particular, from the time of updating the documentation of the local Territorial System of Ecological Stability (TSES).

2.5.1.1. Characteristics of the Affected Biosphere, Including the National and International Protection Zones

Agricultural land prevails in the area around Temelín Nuclear Power Plant, larger forested areas can be found north-west of the plant (about 1500 m from the limit of Temelín Nuclear Power Plant area, the complex of Velký a Malý Kamík) and east to south-east of the plant (about 1200 m from the limit of Temelín Nuclear Power Plant area, towards the river Vltava), smaller woods and bosques are rather few; also sparsely, smaller ponds can be found. The area around Temelín Nuclear Power Plant is a water spring area on the local watershed divide. Most of the small watercourses are regulated (with a significant level of technical lining, rectified, without any marked signs of natural revitalisation (see Section 2.2.2. for more details).

The Documentation treats the local territorial system of ecological stability at the planning level (Wimmer, 1997). Reviewing this material, particularly the following issues can be found:

1. The bio-corridor of the river Vltava together with the forest corridor running in parallel (dry path) constitute the core of the SES. This is fully coherent with the parameters of the EECONET network, where Vltava likewise forms the bio-corridor axis.
2. The plan of the local TSES is based on the previous documents – General Plan of the Local TSES Temelínsko (Wimmer, 1994), reviewed with respect to the new regional and supraregional SES (Bínová, 1995). It is organically interconnected with the neighbouring TSES Zlivsko a Dívcicko (Popela, 1995) and TSES Žimuticko (Kubeš, 1995).
3. The above document is the only one describing in detail the current state of the landscape including detailed phytosociological characteristics (according to Mikyška) as well as the characteristics of the forest vegetation, including the areal distribution of wood species. The concept of the plan was adopted from the general plan, while the bio-centres were further specified and their essential core parts as well as the proposed parts beyond the

minimal parameters were distinguished. Also the bio-corridors are delimited in an extent exceeding the minimal parameters, which is very important, particularly in the considered area significantly influenced by humans. The local system is based mostly on the “wet path”, which includes watercourses, reservoirs and land depressions. The “dry path” is used to a lesser extent, involving mainly forested areas. With respect to the size and to the ecology, the former military exercise grounds Litoradlice are important, which are partly included in the SES forming its interaction elements, and a part is proposed in the TSES plan as a significant landscape element (see Section 2.5.1.1.2 for more details).

4. Overlying the developed regional plan of the settlement area Temelín a Litoradlice and the TSES plan, no conflicting propositions were found. The recultivation plan for the areas of the liquidated construction facility site of Temelín Nuclear Power Plant is treated by the Forest Management Institute, and more recently, a complex recultivation plan was developed for the plots of the construction facility site (ENERGOPROJEKT Praha, a.s., October 2000).

In order to coordinate the recultivation of the construction facility area with the needs of the ecological stability of the environment, it is appropriate to consult the author of the Local TSES Plan as regards the updated bitope map of the landscape.

2.5.1.1.2. Types of Plants and Plant Societies

According to the Documentation, no specially protected plant species were found in the considered plant societies in the surroundings of Temelín Nuclear Power Plant (page 147), however, localities with specially protected species can be found in the wider surroundings (Dvorcice in Temelín Nuclear Power Plant protection zone, and Litoradlice – the Documentation identifies *Iris sibirica* – critically endangered species, and *Dactylorhiza majalis* – endangered species, in both localities). Sporadic incidence of *Hottonia palustris* – endangered species was recorder in the area.

The societies conditioned on human activities (agricultural land societies, intensive meadows with few species) prevail. There is a discontinuous system of waterlogged meadows of the hydric areas of incidence of the kinds *Calthion, Molinion*. Description of forested areas – see Section 2.5.1.1.5.

With respect to its size and to the ecology, the former military exercise area Litoradlice is important, which is located about 2 km east of Temelín Nuclear Power Plant. It is partly included in the SES, and a part of it is proposed in the TSES plan as a significant landscape element, in particular the part with grass and herbs drying societies (mesophile to semixerophile *Arrhenatherion* localities – a suitable monitoring area of a sufficient extent relatively close to Temelín Nuclear Power Plant area, however, on condition that at least some forest management will be in place, suppressing the wood species succession).

For more detailed and comprehensive biological data on the area around Temelín Nuclear Power Plant, it is recommended to consult the Czech Botanical Society.

2.5.1.1.3. Bitotopes and Their Mutual Biotic Relations

The Documentation gives the bio-geographic, zoo-geographic and phyto-geographic characteristics pursuant to the TSES Plan. From the bio-geographical point of view, the area of interest is located on the border of the bioregion No. 1.21 Bechynský, and 1.30 Ceskobudejobický (Culek (ed.), 1996). As regards zoo-geography, the area constitutes a part of the Czech section of the province of deciduous forests. In terms of the regional phyto-geographic division, the area is situated in a mesophytic phyto-geographic region, in the

Bohemian-Moravian mesophytic region, in the district of Jihoceská pahorkatina (South-Bohemian Downs) and sub-district of Písecko-hlubocký hreben (Písek-Hluboká Ridge).

The following part treats the local system of ecological stability on the planning level (see Section 2.5.1.1.1.).

However, the Documentation includes no systematic description of the biotic relations in the landscape. The area around Temelín Nuclear Power Plant is a water spring area at the local watershed divide. Most of the small watercourses are regulated (with a significant level of technical lining, rectified, without any marked signs of natural revitalisation (see Section 2.2.2. for more details). With respect to the local erosion proneness of the agricultural land and to the absence of protective filtration belts along most of the regulated watercourses, a marked tendency towards the state of human affected and nitrophilic localities can be identified, connected to water erosion of the finest soil particles from the slopes and elevated parts of larger plots of agricultural societies. At the same time, significant activities concerning filling of small reservoirs and ponds can be documented, accompanied by an increased eutrophication of water and marsh ecosystems.

2.5.1.1.4. Fauna - the Range and Interrelation of in Particular the Rare and Endangered Species

The Documentation specifies the localities with incidence of specially protected animal species (page 146), but does not discuss their mutual interrelations. The information coming from reviews is presented with objectivity. Endangered species can be found mainly by watercourses, ponds and the remnants of marshlands (molluscs, amphibians, reptiles, birds, mammals).

The range of species present in the area is described also in other materials. The company ENERGOINVEST Praha contracted a natural science survey of the prospective Nuclear Power Plant construction site by Temelín (Final Report for years 1982 – 1983, VIDEOPRESS MON). It is in fact the only material that evaluates the state of the environment from the natural science point of view, although limited in extent to specialist fields corresponding to the respective professional backgrounds of the individual authors (molluscs, butterflies, fish, amphibians, birds, and selected groups of hymenopterous, beetles, dipterous, a small reptiles). The part of the study concerning the herpetofauna (by Dr. Cihlár) is the only one noting the existence of four small ponds in the territory of the construction site and the fact that the site is in a water spring area, while the ponds were not exploited for wishing at the time of the study. This assessment evaluates the locality as poor in both the diversity and the number of the animals. None of the identified species belongs to rare species. The report recommends observing the species composition of herpetofauna and ichtyofauna in the warmed-up waters discharged from Temelín Nuclear Power Plant, which may promote the development of amphibians. The impact on water ecosystems in relation to plankton organisms is discussed by Lellák et al. (1988). Further, generally unpublished information is available from the Czech Ornithological Society and the institutes of the Academy of Sciences of the Czech Republic.

Common synatropic species and species of open cultivated landscape completely prevail in the area, and in the forests, respectively, the common species of coniferous and mixed forests prevail. In the area of Temelín Nuclear Power Plant itself, sporadic incidence of specially protected species can be documented in the recultivated drying areas (e.g. bumble bees – *Bombus sp.*, lizards –*Lacerta agilis*). These are not representative or unique populations, but species resettling the areas quietened by completing the construction, namely in the southern and south-western part of the site. Biologically valuable are also the remnants of fruit orchards east of the site for being the habitat of the birds settling the tree hollows. Higher biodiversity can be found on the slopes of Vltava around the Hnevkovice reservoir and upstream of Týn nad Vltavou. Subxerophilous species were found in some of the biotopes of the former military area Litoradlice.

For evaluation of the zoological part of the biota, a further consultation of the Ceské Budejovice branch of the Nature and Environment Protection Agency of the Czech Republic and of the South-Bohemian branch of the Czech Ornithological Society may be appropriate.

2.5.1.1.5. Forest (Present Areas and Their Respective States)

In terms of forest areas (Plíva & Žlábek, 1986), the territory belongs to the area No. 10 – Stredoceská pahorkatina (Mid-Bohemian Downs), and on the south-west and west to the forest area No. 15 – Jihoceská pánev (South-Bohemian Basin), sub-area a) – Cesko-budejovická pánev (Ceské Budejovice Basin). The area includes the second forest vegetation phase (FVP) of beech and oak (0.25%), 3rd FVP of oak and beech (83.5%) and 4th FVP of beech (16.25%). In terms of forest types, the prevailing types are acid (42%), nutritive (40%), gleisaited (17%), the minority types include water-enriched, waterlogged or extreme types.

Forestation of the considered area is far below the national average, amounting for 16%. With the exception of the north-west with reaches of the forest complex of Písecké hory, and the south-west with the forested areas above the slopes of Vltava, forests are represented by small isolated clusters, formed mainly by two coniferous wood species (spruce 53%, pine 31%) representing 84% of the total woods. The following species with substantially lower representations are oak (3.3%), larch (2.7%), birch (2.6%), beech (2.3%), fir (1.4%). The remaining wood species, which include hornbeam, acacia, ash, lime, alder, aspen, make less than 1% of the woods. It can thus be concluded that the species composition of the forests corresponds to the established practice in forest management, being determined by composition of the individual forest systems of the forest industry exploitation. With respect to the markedly human affected character of the landscape around Temelín Nuclear Power Plant, forests with natural species composition have practically not been preserved.

2.5.1.1.6. Primary Sources of Food in the Area (Harvests, Livestock, Fishing)

In the protection zone, there are ponds used for intensive fish breeding. Arable land prevails in the agricultural areas, and large fruit orchards are planted in the eastern part of the area of interest (Documentation page 148). However, neither the agricultural cultures, nor the extent of livestock breeding are specified. For example, description of the land uses (a simple division into arable land, meadows, pastures, forests) in terms of proportion or the respective areas is quite missing. Nevertheless, for the immediate surroundings of Temelín NPP, it can be shown that over 80% of agricultural land is being cultivated, while other land uses include intensive meadows and extensive orchards, pasture cultures have practically not been preserved. Land use structure can also be derived from the results of remote survey of the Earth.

For more detailed analysis of food chains, it is referred to Chapter 2.4.

2.5.1.2. Landscape

2.5.1.2.1. General Characteristics of the Landscape

The characterisation of landscape in the Documentation (pages 148-149) is concise and quite apposite. The missing information: quantification of land uses, more accurate and detailed assessment of the landscape character (dominants, determining, main and secondary elements), specification of the change of the landscape character.

In terms of the usual characterisation of the landscape, the wider area of interest is an intensively agriculturally exploited countryside, with prevailing arable land, smaller countryside settlements (villages) and smaller ponds, with horizons of larger forests on the edges. In terms of the assessment of the coefficient of ecological stability, it is an area intensively used for agricultural production, with weakened self regulative mechanisms, ecologically unstable to very unstable, and with a continuous input of additional human efforts necessary to maintain the functions of the landscape system. According to the Míchal typology, the area classifies as an anthropogenetic cultural landscape, while most of the South-Bohemian landscape belongs to the type of a harmonic cultural landscape.

2.5.1.2.2. Significant Features

As discussed above, the surroundings of Temelín Nuclear Power Plant are an urbanised landscape, with extensive new infrastructure, artificial surfaces and new dominants, set in the wider region of the South-Bohemian countryside. In terms of the coefficient of ecological stability, it is a landscape with maximal disruption of natural values and ecological functions, which are being permanently and intensively replaced by technical interventions with continuously high inputs of human efforts. The network structure has been fairly simplified, most of the smaller watercourses regulated, the accumulation potential markedly weakened; with the exception of smaller reservoirs, accumulation space is practically missing.

2.5.1.2.3. Protection Zones

Protection zones in terms of special regulations on protection of the environment and its components in the surroundings of Temelín Nuclear Power Plant are described objectively in the Documentation. There is no contact between the site and the protection zones of neither the specially protected natural areas, nor of forests. Protection zones of water sources are discussed in Chapter 2.2, the issues of protection of the geological environment in Chapter 2.3.

2.5.1.2.4. Protection of the Environment, Recreational Uses, and Exploitation of Natural Resources and Land

In the surroundings of Temelín Nuclear Power Plant, there are only small protected areas, which are sufficiently described in terms of extent and location in the Documentation. In wider context, areas of natural parks connect to the area (for description, see Documentation page 149). In relation to the construction of Temelín Nuclear Power Plant, no changes occurred with respect to the territorial protection of the specially protected natural units. The issues of exploitation of natural resources and of land use are discussed in Chapter 2.3.

The recreational potential of the area is described in Sections 2.4.1.6. and 2.4.5.4.

2.5.1.3. Real Estates and Cultural Heritage

2.5.1.3.1. Description of the Current Real Material and Cultural Values (Including Archaeological Sites)

The main result of the archaeological activities on Temelín Nuclear Power Plant site was the survey of the area, which significantly complemented the registration on the known historic sites, and the preservation surveys of the localities partly or completely disrupted by the construction.

a) archaeological preservation surveys

Brezí – early Middle Ages settlement (Na kolejích), archaeological survey.

Hosty – survey of a Bronze Age settlement, large area disrupted nowadays by the regulation of the Vltava riverbed

Knín – survey of Bronze Age tumulus burial grounds.

Krtenov – burial ground (the forest Hroby), 10 tumuli examined, Bronze Age. Most of the tumuli grounds continues to be protected.

- Bronze Age settlement (Na farárském), archaeological survey.

- st. Prokop church, archaeological supervision during construction adaptations.

Purkarec – preservation activities during the liquidation of a larger part of the village centre.

Temelín – discovery of a Paleolitic industry.

Temelínec – burial tumuli found in 1981, 7 tumuli, archaeological survey carried out.

Týn – historic centre of the town, preservation survey during construction adaptations (housing construction, etc.).

b) survey and documentation of real estate archaeological sites in the hinterland of Temelín Nuclear Power Plant concentrated on the administrative area of the municipalities of Temelínm Týn nad Vltavou, Dríten, Všemyslice.

2.5.2. Potential Environmental Impacts

2.5.2.1. Animals and Plants

2.5.2.1.1. Loss of Natural Habitats (Including Forests) due to the Construction

The Documentation contains only a general description of the site extent and the information that the plots were bought out (page 84). The site includes 143.14 ha of area altered by the construction, while the fenced area for two blocks amounts for 123.34 ha. The Documentation presents no opinion on the impact of the implemented changes of the natural environment. The significance of demolition of some settlements of the protection zone of Temelín Nuclear Power Plant is emphasised. The Nuclear Power Plant complex is perceived as negative. The Documentation gives no assessment of the construction facility grounds and no assessment of the impacts of the induced investments and of indirect influences.

Based on a review of the available documentation, the following can be said about the construction time impacts:

A significant impact was the change of the local topography during the construction in the 80's. It was implemented mainly at the expense of large plots of arable land , less intensive meadows and gardens; the system of local watercourses was disrupted in their spring parts with respect to the location of the site on a watershed divide. Structural elements of smaller size were with respect to their actual absence in the intensively cultivated landscape affected only marginally. The intervention contributed to the already substantial simplification of the landscape structure and functionality. The intervention has a character of permanent structures, the impacts on the functional arrangement of the landscape are therefore irreversible.

For the purposes of operation of Temelín Nuclear Power Plant, two areas with core elements of watercourses were adapted:

1. The major intervention concerns the discharge of rainwater from Temelín Nuclear Power Plant area to the watershed of Strouha with a system of ponds below Býšov (Mlýnský and Nový ponds), which included heightening of levees, construction of concrete spillways,

rock and concrete paved channels and a new storage reservoir above the pond Nový. Above this storage reservoir, the watercourse of Strouha was trained into a trapezoidal section channel, in the left bank micro-watershed above the new storage reservoir, a system of safety reservoirs was constructed with objects of mostly technical design (rectangular reservoirs, concrete channels, technical spillways, sampling and monitoring objects). Below the pond Nový, only a short stretch of Strouha was trained to strengthen the first couple of dozens of meters below the stilling basing of the safety spillway. This regulation work on Strouha is the most downstream part of the rainwater draining and accumulation system of Temelín Nuclear Power Plant site. ("Draining of rainwater and industrial water", Hydroprojekt Praha, Nov.1983). Based on the current assessment of this area, it can be said that the new storage basin was constructed taking consideration of preservation of the valuable clumps of alders above the left bank, and of the nowadays registered and valuable societies of sedge meadows. The areas by technically trained watercourses were partly reclaimed by wind spread alders, the belts along the streams sometimes show signs of human affected land with spreading of nitrophilic species. Although the solution chosen was not the recommended option (the stream Strouha was trained and a storage reservoir was inserted), the regulation was implemented rather sensitively and the new storage reservoir allows for a formation of a new, relatively large marsh biotope, which will be suitable for observation of the impact of surface discharge of waste water on the ecosystems. The impacts on the watershed of Strouha in the construction period may be assessed as moderately adverse to adverse, less significant to apparent, nowadays however, the area is already rather stabilised.

2. The second intervention area concerns the discharge of rainwater from the construction facility grounds to the watershed of Plackuv potok, connected with further training of this already highly regulated stream in its spring area east of the community of Temelín. This watershed was recommended already in 1983 as more suitable for discharge of rainwater also from Temelín Nuclear Power Plant site grounds. Within the recultivation project, it may be suitable to revitalise parts of this area.

The most significant indirect impact of Temelín Nuclear Power Plant in the construction period was reclaiming of land for cultivation purposes required as a replacement for the claimed agricultural land by the Act 124/1976 Coll. in the extent several times exceeding the area claimed for Temelín Nuclear Power Plant. Following this requirement, areas not suitable for agricultural use were reclaimed for cultivation, so for example in the 80's the valley mead of the river Stropnice by Nové Hrady was virtually destroyed, whereby the watercourse was trained into a straight concrete lined channel and the surrounding area was drained. According to the Ministry of Environment science and research project study, compiled by the South-Bohemian University in Ceské Budejovice, an area of 541 ha was reclaimed for the above purposes (almost four times the total area of Temelín Nuclear Power Plant site and the construction facility grounds) at the cost of 82 mil. CZK (151.5 thousand CZK/ha). These impacts must be considered as very adverse and very significant, because the retaining capacity of the watershed of Stropnice was markedly decreased, which involved a decrease of the accumulation capacity of the area related to training of watercourses and draining of the mead land (loss of accumulation of about 3 mil. m^3 of the flood wave volume at a flood level of about 0.5 m). Revitalising of the damaged part of the watershed will be necessary.

Missing information

The Documentation presented contains no systematic information on the water management arrangements project in the spring area of the stream Paleckuv potok for the purposes of the construction facility grounds that are a property of the contractor (presently Vodní stavby Bohemia, a.s.). It was not possible to obtain these information for the purposes of this Assessment. Likewise, it was not possible to obtain the original documentation for the preparation of Temelín Nuclear Power Plant construction site itself. These materials are to be additionally provided for the future purposes of arrangements of the area after termination of Temelín Nuclear Power Plant operation. It is thus not possible to obtain the documentation for the decision on the construction permit according to the former law on state protection of the environment (Act 40/1956 Coll.) in relation to the transposition into the current legislation (in particular with respect to the revitalisation connected to the damage of important landscape element due to the legal requirements).

Crucial Issues

The decisive impacts on the fauna, flora and ecosystems took place already during the construction period, an with the exception of Temelín Nuclear Power Plant site, their magnitude and significance decreases. The major impact was the claiming of the agricultural cultures and the general adverse changes in the structure of the area. The crucial issue of the construction period is the indirect impact in terms of the substitute land claims for cultivation in the watershed of Stropnice, which has a major contribution to the relatively adverse assessment of the documented impacts of Temelín Nuclear Power Plant on the nature and landscape.

Proposed Measures

Consider the revitalisation of the area in the immediate surroundings of Temelín Nuclear Power Plant in relation to the TSES documentation as a compensation for the impacts on Temelín Nuclear Power Plant surroundings in the construction period (with respect to Art. 10 of the Act 17/1992 – Aspects of the environmental damage occurred). Apply the revitalisation procedures within the project of biological recultivation of the construction facility grounds, in particular as concerns the spring area of the watershed of Paleckuv potok.

Maintain and revitalise the regulated stretch of the stream Strouha, preserve and maintain the sedge meadows by the storage reservoir. Revitalise parts of the area next to the safety reservoirs with respect to the measures of protection of the landscape character.

Consider the restoration and revitalisation of the damaged parts of the Stropnice watershed.

Ambiguities, Lack of Knowledge, Uncertainties

A detailed specialist evaluation of the state of the landscape before commencement of the earthmoving works and terrain reshaping for the construction is not available. The use of the aerial photographs available from VPÚ Dobruška may not be conclusive, as it can only provide information on the areas of the present site before the construction, not about the ecosystems.

Comment

This is a retrospective evaluation of a construction that already took place, whereby the level of significance of the impacts other than in the permanently built-up area decreases with time. Certain aspects can be retrospectively re-evaluated using the remote survey of the Earth (land use permit in 1985, construction permit in 1986).

2.5.2.1.2. Impacts on the Terrestrial and Water Environment, Including Forests, and on the Animal and Plant Societies due to the Operation (Direct Impact due to Air Pollution, Radiation, Water Separation)

The Documentation contains an assessment of the prospective impacts of operation of the power plant cooling towers on the climatic factors of the area (page 196) – on thermal and water balance of air and soil, on temperature, humidity and wind conditions, on vertical stratification and weather phenomena in Temelín Nuclear Power Plant area and its immediate vicinity. A mathematical model CT-PLUME was built and applied on data from Temelín area. An evaluation of the influence of plumes on the near-ground temperature and humidity and of shading by plumes was performed. Also the possible influence on precipitation, fog and hoarfrost was examined. The computational results are listed in a tabular format (page 198). The results of assessment of the climatic impacts are given in Sections 2.1.1. and 2.1.2.

The Documentation assesses also the impacts on the system of draining of the area, the changes of the hydrological characteristics (underground water level, discharges, yield of water sources), and the quality of surface and underground water. The predicted evolution of the air quality and of the amount and quality of surface water does not indicate any changes of such significance that they could in a any substantial extent influence the plant and animal societies in the vicinity of Temelín Nuclear Power Plant (page 211). More details of the results of the assessment of impacts on the water environment are given in Section 2.2.3.

According to the Documentation, Temelín Nuclear Power Plant has no direct impact on the spreading of epidemics, and has also no direct bearing on the spreading of allergens (page214). However, it must be said that the areas around the construction facility grounds, around the landfill Temelínec and along some roads turn into human affected grounds, and therefore, an increase of the biomass of allergenic weeds cannot be ruled out. In this context, a comprehensive recultivation of the area left after the facilities site and of all areas affected by the construction or operation of the machinery, except for the paved ground, becomes more important. The Documentation does not give details of the predicted impacts on agriculture, forest management and livestock breeding. However, based on monitoring of agricultural production around Temelín Nuclear Power Plant (documentation of the South-Bohemian University, 1991-1999), it can be concluded that no significant changes are predicted in the composition of cultures and the impacts on the production capacity of the soils around Temelín Nuclear Power Plant. A further apparent shortcoming is the absence of assessment of the impacts of the facilities site and of the induced investments.

Based on the analysis of the prospective discharges of Temelín Nuclear Power Plant into the environment, the following statements can be made:

3. As regards the climatic impacts in the immediate vicinity of Temelín Nuclear Power Plant, only impacts of low importance can be expected in terms of a gradual rise of humidity of the climate. Within the range defined in Section 2.1.2., there are in principle no ecosystems that would be sensitive to changes in the hydric conditions, as the area is mostly made up by agricultural systems and intensive meadows. 5947 m^3 of water per hour, i.e. approx. 1600 litres per second evaporates from the cooling towers. On pages 199 and 200 of the INVEST*projekt* Documentation, the evaporation of water from the cooling towers is compared with the evaporation from a pond per year (675 mm). Such consideration and approach in principle holds for the yearly water balance due to evaporation. The evaporation of water from a water surface and in particular from vegetation (evapotranspiration) is a dynamic phenomenon of conversion of solar energy by its binding in water vapour. Water evaporates from vegetation and water surfaces only when in is necessary to cool the environment, it is a perfect retroaction between the solar energy input by its binding into the water vapour and its release at cooler places, which are thereby warmed up. Unlike in this natural dissipation system, the cooling towers produce water vapour constantly regardless of the ambient temperature and solar radiation. This water source – the cooling towers – may eventually have a positive impact with respect to the fact that water is brought into the countryside suffering from lack of water. However, comparing the evaporation with the yearly balance of a pond lacks objectivity. Likewise, the production of water vapour by the cooling towers can be compared with production of water vapour by vegetation well supplied by water. The highest values of evapotranspiration in the local conditions reach 0.5 mm/h (0.5 litres per square metre per hour), that is 500 m^3 per hour from 1 km^2. The cooling towers emit as much water as 12 km^2 of vegetation saturated by water. Usual values of evapotranspiration may be several times lower. The emissions of water vapour are thus

comparable to the evapotranspiration of 20 – 30 km^2 of vegetation. Besides that, evapotranspiration takes place only in sunny weather in the vegetation season.

4. An exception from the rule is the area of the former military exercise grounds Litoradlice with incidence of subxerophilous localities, where successive shifts could occur in the flora towards a decrease of the xerophilous species. It cannot be expected that the changes will occur fast, as an indication of adverse and significant impacts. However, this area is listed in the proposals of biological monitoring.

5. With the exception of the waste water, Temelín Nuclear Power Plant area is not a source of pollution that could substantially change the trophic conditions of the surrounding ecosystems. This influence is related to the addition or admixing of the discharge into the epilimnium during the summer stratification, when undesirable massive blooming of algae. This discharge brings additional phosphorus to the epilimnium (which has been previously used up by the algae). The amount of the water discharge added to the epilimnium may be increased, which may bring about an increased stability of the epilimnium with respect to is sensitivity to mixing by wind and cooling down of the weather. These changes can result in a faster movement of water in the epilimnium from the inflow towards the dam and at the same time into an increased phosphorus load if the epilimnium. Warming up of the inflow will increase the eutrophication of the reservoir and counteract the efforts towards improving the present critical state of water quality. If only two blocks of Temelín Nuclear Power Plant are in operation and the temperature at the river section by Korensko increases in terms of the monthly averages by 0.1 – 0.55 °C, the impact of Temelín Nuclear Power Plant may be regarded in view of the annual variability of meteorological conditions as negligible. However, this influence may well not be negligible with respect to short-term impacts on the reservoir, in particular in hot and dry years (Justýn et al., 1992; Liška et al., 1999). The extent of this possible impact will be lower if the discharges into the Orlík reservoir will be decreased and vice versa. (For more information refer to Section 2.2.3.). The waste water management system is provided with sufficient control in relation to occurrence of events that could result e.g. in eutrophication and thus an impact on the water ecosystems benefiting the euryvalent species (plankton, benthos).

6. Rainwater is drained from the site into the safety reservoirs above Býšov and the new storage reservoir in the watershed of Strouha. The problem of local eutrophication of the safety reservoirs occurs due to the fact that one of the reservoirs at a time is not operated, serving as a reserve, and therefore processes usual in stagnant water occur. This feature subsides in the new storage reservoir above the pond Nový in the watershed of Strouha. To mitigate partly this impact, it would be appropriate to alternate the use of the reservoirs, nevertheless, it is not a marked impact. The system of pre-treatment of rain water collected on the site is discussed in Section 2.2.3.

7. Tritium is present in the discharges of the VVER type reactors in relatively high concentrations, but it has only a low toxicity for water organisms due to its low energy. The problem of tritium was treated in detail in the literature review by Justýn (1982). Based on this review, it can be said that the proposed limit of 5000 $Bq.l^{-1}$ for the tritium content of surface water is appropriate with respect to the possible impact of this radionuclide on the water biological societies. Observation of the biological life in the reservoir Mohelno, into which cooling waters from Temelín Nuclear Power Plant Dukovany have been discharged for 15 years already, showed that the societies of water organisms are not poorer in diversity. The average concentrations of tritium in the reservoir Mohelno exceed 200 $Bq.l^{-1}$, with maxima of up to 378 $Bq.l^{-1}$ (1991 values), whereby 133 species of algae were identified in the reservoir after 10 years of operation (Kocková et al., 1998). Even in the stream Skryjský potok, which is a direct recipient of cooling waters with tritium content sometimes exceeding 4900 $Bq.l^{-1}$ (a maximum

recorded in 1998, see Kocková et al., 1999), no decrease of diversity of the biological societies was observed – the waterbed is densely moss-grown with fibre algae and accompanying society of microscopic algae and other organisms. The river Jihlava downstream of Mohelno (reference section for monitoring of the Dukovany Nuclear Power Plant impacts) is after 15 years of Temelín Nuclear Power Plant operation still rich in life with oligosaprogenic to betamesosaprogenic society of water organisms, with growths of fibre algae, mosses and superior water plants, accompanied by a varied society of small algae and animals. This provides a certainty that also the biological societies in Vltava downstream of Temelín will not be disrupted by the discharges of tritium waters, with respect to the fact that the impact on the biological societies will be much lower due to the much higher dilution, and due to the lower tritium levels of the water background (Dukovany Nuclear Power Plant: background – 10 $Bq.l^{-1}$, Jihlava downstream of Mohleno – 1990 average 168 $Bq.l^{-1}$, 1991 average 189 $Bq.l^{-1}$. Temelín Nuclear Power Plant: Vltava at Týn 1990-91 – 3.3 $Bq.l^{-1}$, 1999-2000 – 1.5 $Bq.l^{-1}$; predicted increase in Vltava at Korensko: 87 $Bq.l^{-1}$). For more details, see Sections 2.2.1.3.5. and 2.2.3.2. of this Assessment.

8. Changes of chemical properties of the environment cannot be conclusively ruled out (these would in turn influence the trophic parameters of the area), which could arise as a result of earthmoving during the recultivation works, in case the soil and materials would be contaminated by foreign matters (in particular with oil products, chemical substances from stores of special construction materials, etc.). Depending on the extent and the nature of the contamination, also significant impacts cannot be excluded. For this reason, appropriate preventive measures are proposed, based on an updated series of soil (and water) analyses in the area of the construction facilities.

9. In view of the conclusions of the chapters Air, Climate, Water, Soil, it can be concluded that the assessed project of operation of Temelín Nuclear Power Plant will under normal operation circumstances have no appreciable impact on the primary sources of food.

Missing Information

The present Documentation does not give any systematic information on the assessment of Temelín Nuclear Power Plant impact on the structure of the agricultural land as before the construction (division in terms of cultures – arable, meadows, pastures, gardens, orchards, forest, water surfaces). Furthermore, the up-to-date data on chemical properties of soils and water on the construction facility site are not available (survey contracted in 2001) as a basis for direct handling of soils and materials during the demolition and recultivation works.

This is a supplementable information for the prospective treatment of the area in the surroundings of Temelín Nuclear Power Plant and an input for the solutions for the area after the termination of Temelín Nuclear Power Plant operation.

Crucial Issues

Impacts on forests, agricultural cultures, and ecosystems. For the operation phase, these effects are considered to have low significance. The above issues include the effects of climatic changes on the ecosystems in the surroundings of Temelín Nuclear Power Plant, the influence of the drained rainwater discharged into the watersheds of Strouha and Paleckuv potok, and the impacts of the wastewater on the ecosystems in the reservoir Orlík.

Proposed Measures

Within the construction facilities grounds recultivation project, it is necessary to carry out a thorough preventive analysis of contamination of soils that may have occurred in the construction phase, in order to provide for timely and correct decisions on use of these soils and materials in relation to the place of their final laying and to the spatial arrangement of the different kinds of biological recultivation, which should be designed as a combination of forestation, restoration of arable land and promotion of the natural succession.

Provide for maintenance (suppression of undesirable succession) of the subxerophile localities of the former military area Litoradlice as well as of the more valuable marshland areas around the new storage reservoir in the watershed of Strouha.

Proposed Monitoring

According to the Documentation, the observation of changes in the biological systems includes a number of studies being performed. These concern in particular the floristic and phytosociological evaluation of the area with an emphasis on the endangered and the indication species in the spring, summer and autumn contexts. Selected societies are observed in the areas where warmed up water is discharged, as well as the changes in the contact zones, including the population density (fish, amphibians, birds, mammals, with a particular interest in game). As regards the influence of radiation, a pre-operation and operation monitoring of biota is in place, observing the contamination of fish, forest fruits, mushrooms, mosses, humus, pine bark, green fodder, vegetables and fruits. Further more, a series of observations over several years has been established, monitoring the agricultural production in the surroundings of Temelín Nuclear Power Plant in the context of the influence on agricultural systems.

It should be noted that observing the impacts on the biota cannot be separated from the remaining environmental parameters, and the individual indicators without a reference to changes in the entire ecosystems may be regarded as rather unrepresentative and subjective. On the other hand, the established series of observations of the accumulation of radionuclides in biological materials – mosses, forest soil and pine bark (VÚOZ Pruhonice, 1999) – is regarded as a very valuable monitoring effort. Similarly, the monitoring of radionuclides in fish should carry on. However, separating the agricultural systems from the biota seems illogical with respect to the functioning of ecosystems. The entire area of interest is directly influenced by human activities and separating out the agricultural systems in an anthropogeneous region is inappropriate with respect to its functions and structure. It is therefore necessary to recommend that the two parts BIOTA and AGROSYSTEMS be combined into a single element – ECOSYSTEMS.

In this context, the long-term observation (also retrospective) of changes of the landscape by analysis of multispectral satellite data appears quite useful, whereby an on-site survey is necessary in case of detecting a change, which does or does not confirm a human impact on the region. It is particularly useful for monitoring of the humidity and temperature changes in the region related to a change in the structure and functions of the vegetation. Therefore, an evaluation of the satellite data on a annual basis is recommended. For these purposes, developing an identification key for terrestrial entities corresponding to the satellite data should be established, defining the key biotopes including forests on the satellite picture. In view of the extent of the satellite shots, an objective assessment of the impacts across the border to Austria and Germany is possible. More details of the methods and their use are described in the final comment (Procházka, Hakrová et al., 2000; Procházka, Šíma, 2001).

Also the so called secondary operations my have a direct bearing on the biota around Temelín Nuclear Power Plant. Also the impact of the waste and rainwater appears to be important, which should be subject to a separate monitoring (both chemical and biological), which concerns in particular the system at Býšov in the watershed – for more details of the monitoring proposal, see Section 2.2.3. As a part of the monitoring of changes in the surface waters, it is recommended to consider the possibility of widening the scope of monitoring also to observation of the oxygen and temperature zoning at selected sections of the river Vltava and the reservoirs Hnevkovice, Korensko, Orlík and selected reference ponds in the vicinity of Temelín Nuclear Power Plant, focussing on algae as organisms very sensitive to temperature changes of the environment. In this context, it would be appropriate to, in particular:

10. Maintain and possibly extend the monitoring of chlorophyll concentrations in the reservoir Orlík with a focus on the assessment of the proportion of algae, establishing one sampling point below the Korensko reservoir.
11. Extend the monitoring of water ecosystem changes by observations of changes in the composition of zoo-plankton as a sensitive indicator of a change of the trophic structure of the water ecosystems induced by an increase of water temperature (and also as a possible preliminary phase of monitoring of radionuclides in the food chain).

Post-Project Analysis Proposal

Evaluation of the standard relevant monitoring, which may really yield information on the contribution of the power plant to environmental change in the region, on an annual bases, if changes are detected, increase the monitoring frequency, and in particular, if chemical load of the area increases, ensure immediate mitigation measures.

The results of the methods of remote survey of the Earth should be generalised on a five-year period basis to evaluate the trends. Subsequently, appropriate measures may be required if unambiguously interpretable differences in the essential parameters of temperature and humidity changes in the structure of the region and its surroundings are found, including initiation of the necessary remedial actions.

Ambiguities, Lack of Knowledge, Uncertainties

A detailed specialist evaluation of the state of the landscape before commencement of the earthmoving works and terrain reshaping for the construction is not available. So far, one of the first Landsat satellite shots from 1984 could not be obtained, which would provide a better basis for interpretation of changes on Temelín Nuclear Power Plant site since the commencement of the essential earthmoving and terrain reshaping works on the site.

Final Comment

Use of multispectral data from the satellite Landsat for analysis and monitoring of the landscape within the influence range of Temelín Nuclear Power Plant

The assessment methods of the interference of Temelín power plant construction with the regional ecological system should not neglect the information potential of satellite imaging of the Earth, namely of the data collected from the satellites Landsat 5 and 7 by multispectral scanners of high resolution Thematic Mapper or Enhanced Thematic Mapper. For retrospective analysis, data collected since 1984 can be used. From the other point of view, Landsat missions are scheduled until at least 2010 and will certainly have successors.

For the purposes of the present “Environmental Impact Assessment of Temelín Nuclear Power Plant”, so far only the borrowed satellite shots Landsat TM of July 7, 1995 and Landsat ETM+ of June 13, 2000 were available for use. The source raw data were subjected to geometrical and coordinate transformation into the Gauss-Krueger map projection / S-1942. Thus, all the interim outputs so far generated have the form of the so called satellite map, and as such, they allow for locating in the terrain any of the information contained in the map with the accuracy of 1 second of the degree of arc.

Before the report hand-over deadline of March 26, 2001, the following digital maps were generated and their surprints made

Colour RGB data syntheses from June 13, 2000 for the area of 45 by 45 km with a centre at Temelín Nuclear Power Plant (with line scale):

- RGB 3-2-1: simulation of a colour satellite photograph

Intuitive interpretation of the image of the landscape structure elements similar to a topographical map of a medium scale 1 : 100 000 – 1 : 50 000. Unlike in a topographical map, the elements are not generalised inside or their borders, watercourses and water surfaces are not displayed distinctly.

- RGB 4-5-3: maximal colour resolution of landscape structure and state components

  Using the incorporated near- and short-wave infrared bands ETM-4 and RTM-5, the identifiable water elements are highlighted and the coniferous forests (dark green) are distinguished from the deciduous forests (ochre). Areas and points without a vegetation cover are displayed in light blue, agricultural cultures and meadows are shown depending on the amount of green mass and moisture in hues ranging from green (little biomass with low water content) through violet (medium amount and moisture of biomass) to red (largest amount of biomass of a high moisture content). Settlements are indicated by a mixture of image elements (pixels) of various colours with an overall light blue tint.

- RGB 6-5-2: indication of the warmest structures of the landscape (red-violet and whitish spots)

  A combination with the thermal infrared band ETM-6 results in highlighting both the settlements and areas of technical origin (construction sites, airfields, etc.), and the temporarily bare areas of cultivated agricultural land. As a result of higher evaporation, the temporarily bare areas are less moist and are thus displayed in this combination in blue-white to white colour, while the relatively higher moisture of urbanised and industrial area causes their red-violet colour. In the remaining area, surfaces with higher relative temperature with respect to the other surfaces are indicated by a reddish tint. (This colour effect can be observed also in the case of forest glades in coniferous forests and to a certain extent in case of coniferous forests as such).

Layout and thematic maps of the area of Temelín Nuclear Power Plant and MAPE of the size 13 by 19 km (with a numeric scale 1 : 50 000 / A3 size):

- Greyscale panchromatic “shot” of the area (Landsat-7 ETM+ / band 8 – resolution 15 by 15 m)

  When superposed with the images of the structural or state arrangement obtained from the standard bands 1-5 and 7, this image of a high resolution supports the interpretability of band images and their syntheses by the topographical details contained in it. (However, the panchromatic channel is only included in the ETM+ scanner on Landsat-7 launched in April 1999, and cannot thus be fully exploited in retrospective analyses.)

- Colour RGB synthesis 4-5-3 (see above)

- Map of equiareal classes of landscape cover temperature – as on July 10, 1995 (legend included)

  An output image for prospective total area evaluation of the relation between the structural and state arrangement and the temperature regime of the area. The image contains the information necessary to identify and evaluate the dissipation of solar energy in the region. (The relevant research is presently carried out under the research contract of the Ministry of Environment VaV 640/3, while the respective results will be useful for the retrospective as well as current monitoring of the influence range of Temelín Nuclear Power Plant.)

- Map of equiareal classes of landscape cover temperature – as on July 10, 1995 (legend included)

  The spatial resolution of the thermal sensor in the ETM+ scanner was increased from the original 120 by 120 m (see above) to 60 by 60 m, giving 3 data point per hectare of the sensed area. It is estimated that due to this higher resolution, the information potential of Landsat-7 will increase up to sixteen-fold. Improved possibility of data calibration to the actual temperature and in particular the possibility of synchronous terrestrial measurements may render this channel one of the most important tools of the future ecomonitoring of the influence area as well as the wider region.

Numbered outputs:

- 1a – Change of the water component 1995-2000 (red – less in 2000, green – more in 2000, blue – no change)

  This map illustrates the possibility and the attainable accuracy of locating (and also of quantifying, although not discussed herein) of the differences or "changes" in the distribution of an arbitrary structure or state component of the landscape cover. The water component (as well as the forests discussed below and other landscape cover components not discussed here) may be identified in the satellite images with higher quality than was technically practicable within this very time constrained study.

- 1b – Change of the forest component 1995-2000 (colour key as in 1a) (the output contains noise caused by the preliminary evaluation method)

  Forest, as a very stable component of the landscape cover, should constitute one of the key objects of the real application of satellite monitoring of the influence range of Temelín Nuclear Power Plant, applied retrospectively (retromonitoring). The expected changes of the mesoclimatic conditions after the full start-up of the power plant may be observed and evaluated using precisely the large area observations of state parameters of forests.

- 2 – Change of the vegetation cover in terms of green biomass measured by the normalised vegetation index NDVI (red – more in 2000, light turquoise – less in 2000, in grey or similar hues and tints – insignificant or no change, the more intensive the vegetation cover, the lighter the hue)

  There is a number of methods of evaluation of vegetation cover from the satellite data. The NDVI index used herein hopefully indicates the potential of the data sufficiently. The images coming from different times can be mutually compared (and if more are available, analysis of trends can be done) also by other methods than the two-term synthesis indication used herein.

- 3a – Change in distribution of bare areas in terms of the BGI index (colour key as in 2, maximal bare areas are shown in the lightest hues of grey)

  Mapping and time comparison of bare surfaces is an essential precondition for correct interpretation of synoptic satellite images of temperature of the area and the subsequent analyses of the energy conditions of the landscape and their alteration. However, this analysis has a pre-stage involving classification of bare surface according to further parameters, in particular the moisture of the soil kinds.

- 3b – Locating of the limits of the largest changes in the BGI index as potential ecotones (red – contact lines of the most significant time changes of the bare areas distribution between the two terms)

  The possibility of highlighting the contact lines of two different environments or ecotones and the subsequent possibility of weighting of these lines with respect to different aspects means a great potential contribution of satellite data of medium and high resolution and their computer processing for the regional ecology. Note that it is possible to perform such ecotone detection and analysis both on the basic images from a single term and on the derived change images. The latter case represents a tool for evaluation of the significance of the change occurring between two observations as well as of changes established from the analysis of a larger number of images.

The digital pattern of all of the above graphical outputs is stored in the format GEOTIFF. Thus, using software working with geographical coordinates, it is in principle possible to utilise any of the patterns as a full-value digital map or a GIS layer. Besides that, if not most importantly, the outputs can be in this way compared and evaluated more objectively than just by a visual inspection.

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The presented results described above involve several objective and subjective limitations:

- The originally intended comparison of the state before the commencement of the construction with the state just before the start-up of Temelín Nuclear Power Plant could not be done, because the satellite shot Landsat TM 191-026 of July 11, 1984 could not be obtained in time; the shot of July 7, 1995 employed instead was useful but for a substitutional methodical purposes.
- Comparing only two shots, it is possible to identify and to a certain extent interpret the differences in the structure and state arrangement of the landscape at the given times, however, not even to just identify the change trends. However, detection and any prospective control of the future impacts of Temelín Nuclear Power Plant on the surrounding territory must be based on the knowledge of the eventual trends.
- Disk drive failure in the middle of the time available for the study destroyed the results of the previous work, and having repeated it, it was not possible to carry out all the intended assessments in the time remaining, in particular the controlled mutispectral classification of none of the two shots could be done. Without this classification, it was neither possible do establish in greater detail the main categories of the landscape cover (see description of the image 1b above), nor to de-mask the surface of agricultural plots due to the detection and highlighting of the changes of the more stable landscape components.
- Due to time constraints, also the intended details of the presented satellite images for the area and the immediate vicinity of Temelín Nuclear Power Plant could not be generated. However, with full information resolution, every user of the digital patterns can generate these himself using any bitmap editing tool.
- Due to time constraints, digital patterns and surprints of satellite maps could only be provided with incomplete descriptive labels of not very good technical quality. Upon a decision on the future exploitation of the maps serving thus far only for the purposes of the authors of the “Environmental Impact Assessment of Temelín Nuclear Power Plant”, this shortcoming can be rectified relatively fast.

Nevertheless, the purpose of the presented results of processing of the two satellite shots is to demonstrate the quite unique information potential of multispectral data as well as the necessity of their use in every study and in particular in the long-term monitoring with the objective and extent that can be expected for the purposes of evaluation of the environmental aspects of Temelín Nuclear Power Plant. A monitoring project using the above methods and its implementation should constitute a part of such evaluation, if this is to be trustworthy, objective and unbiased.

2.5.2.2. Landscape

2.5.2.2.1. Impact of the Construction on Landscape Character and the Protection Zones

The Documentation contains only a general description of the landscape character, an evaluation of its essential components is missing. The assessment of impacts on landscape character does not evaluate the magnitude and significance of the impacts, it is limited to a statement regarding the substantial impact on the aesthetic values of the area, mainly due to the cooling towers, and the significance of demolition of some settlements in the protection zone of the power plant is emphasised. The complex of Temelín Nuclear Power Plant is regarded as negative. The assessment of impacts of the construction facilities site and of the induced investments is missing.

However, the construction changed the landscape character significantly. On the one hand, a new landscape feature was created on an area of 140 hectares with a substantial proportion of paved surfaces (including built-up structures), and on the other hand, a permanent change in the landscape components occurred in terms of increasing the imbalance to the benefit of the negative components (mainly converting the negative component of intensively cultivated arable land into built-up areas, in lesser extend affecting the positive components – meadows, gardens). The area of the construction facilities site amplifies the character of highly technically urbanised territory (temporary impact). In the context of impairing the visual perceptions, the effect of mass and height dominance of the area arises (158 m tall cooling towers exceed about three times the average size of the terrain shapes). The area and the objects are of a large scale. In the near horizons, the dominant visually perceivable spaces of the cultural landscape are being blotted out in all viewing directions. The location of Temelín Nuclear Power Plant on the top of the local watershed divide emphasises its domination, also after the relevant arrangements. In distant views, the cooling towers are dominant, rising above the medium horizons. With growing distance from Temelín Nuclear Power Plant, its domination becomes of a more point-like nature, and the importance of terrain elevations of the intermediate horizons increases. The construction of Temelín Nuclear Power Plant thus gives rise to very adverse and very significant impacts essentially due to the erection of visually dominant objects accompanied by suppression of the original scale of the landscape (erection of new objects distinctive due to their size or concentration, partial liquidation of some structural elements (gardens, orchards, settlements)).

The construction of the induced investments resulted in many cases into only marginal changes of the landscape character (storage and safety reservoirs in the watershed of Strouha, draining of rainwater from the construction facilities site to the stream Paleckuv potok). However, certain developments constitute dominant line elements of technical infrastructure (VHV 440 kV mains), sometimes with a dividing effect (the strip of water supply mains from the reservoir Hnevkovice). Landfills (e.g. Temelínec) constitute a temporary adverse impact on the aesthetic parameters that can be remedied by an appropriate recultivation. A significant impact is also the construction of the reservoir Hnevkovice at the expense of a several kilometres long stretch of the river phenomenon of Vltava. However, in terms of landscape effects, its magnitude does not reach the effects of altering of the river phenomenon by the construction of the existing reservoirs Lipno or Orlík. For objectivity, it should be noted that the power plant only accelerated the construction of a reservoir at this section.

Missing Information

The present Documentation does not provide synoptic information on the assessment of the impact of Temelín Nuclear Power Plant on aesthetic values of the area. The town-planning documentation – the applicable land use plans – does not include an assessment of the landscape character. With respect to the time the construction documentation of Temelín Nuclear Power Plant was developed – before June 1, 1992 when Act 114/1992 Coll. became effective – it did not have to include an assessment of the impacts on landscape character and aesthetic values of the area. Therefore, documentation for decision on construction permit pursuant to the presently applicable legislation cannot be obtained any more, classifying effectively as unavailable documentation.

Developing new studies may be counterproductive, with the exception of a comprehensive landscape specialist evaluation of the phase after termination of Temelín Nuclear Power Plant operation. These documents are supplementable, for the purposes of prospective arrangements in the territory.

Crucial Issues

The impacts on the landscape character are regarded as very significant and very adverse. The development created a dominant structure of a technical nature and an extraordinary size, inconsistent with the harmonic relations in the landscape in an area which thus already suffered a permanent impact due to the construction.

Proposed Measures

With respect to the size of the construction (in particular of the cooling towers), there are no realistic direct or mitigation measures to reduce the impact of the site. Areas with structures not higher than three floors may be only partly integrated in the area by complex tree planting schemes. Prospectively, an evaluation of the distant views in the settings where the cooling towers rise only partly above the horizon should be carried out. In some of these settings, tree planting may then be used in some of these settings to shade out the distant views. The area of the safety reservoirs of technical design at Býšov should be incorporated into the landscape by means of group plantations of suitable tree species. No measures are necessary to incorporate the new storage reservoir. Tree planting should also be used to integrate into the landscape the operations building of the process water takeoff installations at the reservoir Hnevkovice.

The recultivation of the construction facilities grounds has only a supportive effect, which however has to be implemented in agreement with the principles of functional arrangement of the area in terms of ecological stability (see Section 2.5.2.4.).

Monitoring and post-project analysis are not relevant for protection of landscape character.

Ambiguities, Lack of Knowledge, Uncertainties

A detailed specialist evaluation of the state of the landscape before commencement of the earthmoving works and terrain reshaping for the construction is not available. The use of the aerial photographs available from VPÚ Dobruška may not be conclusive, as it can only provide information on the areas of the present site before the construction, not about the ecosystems. Documentation of alternative solutions for the exterior of visually dominant objects of the site is missing. It is not possible to define the changes of aesthetic values of the site and its surroundings in case of significant emergency events.

2.5.2.3. Real Estates and Cultural Heritage

2.5.2.3.1. The Impact on the Integrity and Use of Material Estates and Cultural Values

The construction of the power plant meant a considerable intervention in the historic cultural landscape, which was settled already from late Bronze Age. For this reason, already the preparatory measures for the construction in the area involved great cultural losses. These induced the demolition of five village centres in the immediate vicinity of Temelín Nuclear Power Plant (Brezí, Knín, Podhájí, Krtenov, Temelínec), destruction of a part of Purkarec and extensive interventions in the historic centre of Týn nad Vltavou. Liquidation and damage of the above settlement structure on the one hand gave rise to a culturally destroyed area of

15 km^2, but on the other hand induced the preservation of two important historic monuments – 1 church was reconstructed and 1 former stronghold (renaissance manor house) restored.

However, the construction activities involved also a complete or a partial destruction of prehistoric and medieval archaeological sites in a rather wide neighbourhood of Temelín Nuclear Power Plant. A destruction of a large part of a prehistoric settlement area at the confluence of Vltava and Lužnice belongs to the most significant cultural losses.

The branch of the Archaeological Institute of the Academy of Sciences of the Czech Republic, in particular A. Beneš, P. Braun, P. Brichácek at that time, were commissioned to carry out the archaeological activities related to the construction of Temelín Nuclear Power Plant.

The main result of the archaeological activities on Temelín Nuclear Power Plant site was the survey of the area, which significantly complemented the registration on the known historic sites, and the preservation surveys of the localities partly or completely disrupted by the construction.

The impacts on material and cultural heritage are discussed in Section 2.5.2.3.3.

Missing Data, Ambiguities

With respect to the nature of archaeology, the knowledge of the area cannot be regarded as complete. Even after the intensive archaeological survey in connection to the construction of Temelín Nuclear Power Plant, the present list of archaeological sites cannot be considered complete and closed. The available methods of archaeological registration can despite the intensity of the survey, continuous construction supervision etc. disclose only a part of the total preserved archaeological heritage.

Crucial Issues

The impact on cultural heritage, which is considered significant with respect to the substantial intervention into the historic structure of the region and to demolition of certain archaeological sites during the construction phase.

Proposed Measures

From archaeological point of view, the region of Temelín Nuclear Power Plant does not require any special measures. The basic requirement applying also to the present case is to observe conscientiously the legislation on historic sites, i.e. to report in advance all intended interventions in the terrain and to adhere to the rules of archaeological supervision or terrain survey. The map of registered archaeological values becomes an important documentation for the area of Temelín Nuclear Power Plant, which nowadays makes it possible to delimit the basic zones in terms of the archaeological care requirements.

The execution of the above archaeological activities is in the territorial competence of the Museum of South-Bohemia (contact address: Dr. P. Zavrel, Archaeological Department, Jihoceské museum, Fráni Šrámka , 370 00 Ceské Budejovice).

However, it is necessary to establish to what extent should the operator of Temelín Nuclear Power Plant carry the responsibility for the future of the destroyed countryside (due to liquidation of the historic structure), which is a result of the construction. In the area of interest around the Temelín Nuclear Power Plant, there are about 65 other cultural sites, the future of which depends on their maintenance, for which, however, an appropriate cultural use is a precondition.

Proposal of Monitoring and Post-Project Analysis

Except for continuation of the archaeological survey, no further analyses are required in the immediate vicinity of the site.

2.5.2.3.2. Impact on Non-Material Cultural Heritage

The operation of the power plant will not influence cultural values of spiritual nature, except for the influences of the perceivable changes in the aesthetic quality of the landscape, which are rather difficult to describe (the nature of these impacts is discussed in Section 2.5.2.2.1.), on the inhabitants, especially on children and young people in the age of formation of a personality. Distinct impacts of this and similar kind occurred already at the lime of locating the power plant due to demolition of villages in the protection zone of the power plant and its construction. However, it is probably not possible to evaluate retrospectively the magnitude and significance of such impacts for the construction phase of Temelín Nuclear Power Plant.

For the operation phase of Temelín Nuclear Power Plant, the conclusions of INVEST*projekt* Documentation on page 212, stating that no impact on cultural values of non-material nature will occur in the operation phase, can only be confirmed.

2.5.2.3.3. Mutual Influences and Relations of the Above Values that Are Worth Protecting

Real estates and cultural heritage objects are of a material nature and when exposed to the environment, they are subject to changes which may result in their gradual deterioration if effective anti-corrosive measures were not applied. Unlike the remaining components of the ecosystem, real estates deteriorate also under normal natural conditions, while pollution accelerates the process already when entering the environment, not only after reaching the critical levels. The response of the individual materials differs depending on their composition and other characteristics. Interaction of materials with the environment is assessed with respect to the corrosion aggressiveness of atmosphere or soil, which is defined as the capacity of the environment to cause corrosion in the given system (environment – material). Deterioration of materials exposed to atmospheric actions and to the soil is an involved process causes by a combination of many factors. The processes involved are of chemical, physical or biological nature. The processes of deterioration in atmosphere and in the soil, respectively, are specific, although there are certain relations (acid atmospheric depositions change the soil properties). Most of the materials exposed to atmosphere are sensitive to action of sulphurous substances, chloride aerosols and acidity of precipitation. Recently, negative effects of the actions of nitrogen and ozone have also been noted for some materials. Most of the processes occur in moist environment or directly in electrolyte layers.

Ionic products have negative effects also in case of corrosion in the soil. The aeration rate is a very important criterion when assessing the corrosive aggressiveness of soils, which can differ significantly from case to case.

The predicted climatic effects of Temelín Nuclear Power Plant were discussed in the studies of the Institute of Atmospheric Physics of the Academy of Sciences, the Czech Hydrometeorological Institute, and the company Ekodataservis Brno (see Chapter 2.1. for more details). The waste heat released from Temelín Nuclear Power Plant as well as the change in the green areas will result in an appreciable impact on the distribution of the individual climatic parameters in its vicinity. These impacts have a bearing on the temperature and water balance of the atmosphere and soils, on the temperature, humidity and wind conditions, as well as on the vertical stratification and weather phenomena in the area of the power plant and its immediate vicinity, and in a wider region, respectively. This will demonstrate itself mainly in terms of temperature and humidity characteristics, cloud formation, sunshine, visibility, and the incidence and frequency of various weather phenomena (storms, hoarfrost, etc.).

The following factors have a secondary influence:

- heat transfer from heated buildings and warm wastewater into atmosphere and soil
- increased evaporation from warm wastewater surfaces
- reduced evaporation due to the change of the original soil surface in the power plant area (replacing vegetation by artificial surfaces such as concrete or asphalt)
- change of the character of the surface and the original landscape relief within the power plant area (the construction changes the thermal capacity, heat conductivity and moisture of the soil, the roughness and shape of the landscape with respect to flow properties)

Atmospheric changes may occur due to the interventions into the energy balance (additional energy sources of human origin), interventions into the chemical or physical properties of the air (emissions of gaseous and solid pollution), changes of the active surface and its subsoil (change of thermal conductivity and humidity properties of the subsoil, and of the physical geo-morphological and dynamic properties of the active surface).

Based on the above general analysis (see Krieslová, Knotková 2001 for more details), the following conclusions can be made:

12. The real estates and the cultural heritage in the area are exposed to a low to medium aggressiveness, the start-up of Temelín Nuclear Power Plant will not increase the degree of the environmental load. The information provided by the client is sufficient on the generalising level.
13. With respect to the assessment of corrosive aggressiveness of the atmosphere, the material estates including the cultural heritage in the area of interest are presently exposed, under the conditions of the external atmosphere, to a low to medium aggressiveness that corresponds to the properties of the natural environment and low pollution levels.
14. The area assessed includes the area within the range of 30 km from Temelín Nuclear Power Plant (more distant exposition zone). At the outer border of this area, the castle of Hluboká nad Vlatvou is located, which is probably the most important cultural monument in the considered region. The predicted changes of the atmospheric environment will result in no increased atmospheric load of the materials of this cultural monument.
15. Corrosive aggressiveness of interior environments will be very low to low, if not influenced by the operation activities in these environments.
16. The predicted climatic changes (temperature, relative humidity, precipitation) and pollution concentrations will have practically no bearing on the speed of the material degradation processes.
17. In relation to the corrosive aggressiveness of the soil, it can be concluded based on the documentation obtained, that both the present and the predicted properties of the atmospheric environment do not constitute any danger in terms of acidification of soils or pollution by ionic products.
18. The composition of soils in the surroundings of Temelín Nuclear Power Plant was changed during the construction. The Documentation states that inert construction waste was deposited. At most an insignificant increase of the content of oil substances can be expected during the operation phase of Temelín Nuclear Power Plant.

Missing Information

A direct determination of the corrosive aggressiveness in the considered area in the period 1995 – 1999 was not carried out. With respect to the present and the predicted corrosive aggressiveness of the atmosphere, the information provided is considered sufficient. The corrosive aggressiveness of the atmosphere in the region of interest can be classified by the level C2 (low) with a possible crossover to C (medium). This corresponds to the optimal conditions attainable in the climatic conditions of the Czech Republic.

Crucial Issues

Impact on material estates based on determination of the factors that can influence the changes in the materials in the surroundings of Temelín Nuclear Power Plant as a result of impact on atmosphere, water and soil, and determination of the influence threshold for changes in the materials and possibly the lifetime of certain immovable cultural monuments.

Proposed Measures

Based on the analysis performed, no special measures are necessary so far, which would go beyond the proposals for protection of atmosphere, water, soil and archaeological sites.

Proposed Monitoring

It is recommended to continue to monitor the atmospheric pollution. At selected places, corrosive aggressiveness can be evaluated by a direct corrosion test contracted from a specialist company.

Proposal of a Post-Project Analysis

Equivalent to the post-project analysis proposal for climatic change. After an identification of possible unambiguously interpretable differences in the essential parameters of temperature and humidity changes in the structure of the region and its surroundings, the aspects of protection of the cultural heritage, e.g. in the South-Bohemian of Aleš Gallery in Hluboká, may constitute a part of the appropriate measures introduced.

Ambiguities, Lack of Information, Uncertainties

Description and listing of all economic and cultural values of the valuable material estates and cultural heritage is a demanding task and would only be useful if a loss of these values could reasonable be expected, unless it would be understood as an extract from various registers. SVÚOM s.r.o. participates in international projects focussing on determination of the kind and quantity of materials exposed to environmental effects (stock at risk) and the subsequent cost/benefit analysis. For the present case, applying these methods is not considered necessary.

2.5.2.4. Management of the Area

Described in Section 2.5.2.1. in relation to the proposal of measures, monitoring and post-project analysis. In this context it should additionally be noted that it is necessary to provide for maintenance of the valuable ecosystems in the surroundings, implement the proposed elements of the TSES and maintain these elements. The documented impacts of Temelín Nuclear Power Plant do not require special management of the area in terms of a special protection of the nature, with the exception of monitoring the incidence of the specially protected species in the documented localities of their occurrence, namely as concerns the species with habitats in subxerophile areas. However, these aspects are being implemented within the framework of the system NATURA 2000 and the schemes for protection of the landscape and the areas specially protected by the Ministry of Environment, beyond the scope of the environmental impact assessment of Temelín Nuclear Power Plant.

2.5.2.4.1. Conformance with the Existing (Regional, National) Planning Documents

As regards the compliance with the land use planning data and land use planning documentation, the construction of Temelín Nuclear Power Plant is not in contradiction with these documents. It is accounted for in the plan of a large territorial unit – the regional settlement conurbation of Ceské Budejovice, approved by the decision of the Czech government No. 147/1986. It is not in contradiction with the land use plan of the settlement formation of Temelín (A+U design, s.r.o. Ceské Budejovice, 1996). These issues are stated objectively also in the Documentation (pages 178 – 179).

The aspects of ecological stability of the landscape in relation to the land use planning documentation of the municipality of Temelín are reflected in the TSES Plan (Wimmer, 1997, see Section 2.5.1.). Overlaying the Plan with the land use planning documentation, no contradictions were found in these documents. The most recent design of recultivation of the construction facilities site (Energoprojekt, a.s., 10/2000) also relates to these documents, combining reforestation areas, areas intended for cultivation, and areas supporting the natural succession. The area of Temelín Nuclear Power Plant is not in contradiction with the areas and spaces protected as elements of the international network EECONET,

The project of construction and operation of Temelín Nuclear Power Plant is not in contradiction with the existing planning documentation for the development of the Czech Republic in terms of the decisions of the Government of the Czech Republic as described in the introductory chapters of this Assessment.

2.5.2.4.2. Effects on the Transportation Infrastructure in the Region

The Documentation (pages 212 – 213) objectively indicates the insignificant level of the effects of operation of Temelín Nuclear Power Plant on the traffic services in terms of the general use of roads in the context of the Act 13/1997 Coll. On Surface Roads.

In the following, it is objectively stated that all regulations of the Czech Law apply strictly to the transportation of radioactive material (Act 18/1997 Coll. including the procedural regulations, Act 111/1994 Coll. On Road Traffic in the wording of later amendments, Act 266/1994 Coll. On Railways in the wording of later amendments). The relevance of the appropriate European agreements is also emphasised (ADR for road traffic, RID/PNZ for railway traffic). The construction of Temelín Nuclear Power Plant contributed to the improvement of the road network quality (in particular the road II/105 Týn nad Vltavou – Ceské Budejovice was upgraded to parameters corresponding to a dual carriageway). The operation poses no requirements on traffic by the waterway of Vltava.

The impacts of operation of Temelín Nuclear Power Plant on the traffic and transport infrastructure in the area are considered insignificant. The operation of Temelín Nuclear Power Plant is not of a nature that would involve service traffic contributing to deterioration of the road network by heavy lorry traffic and the plant does therefore not belong to the subjects that would be obliged within the framework of their development to maintain the traffic infrastructure in terms of the Act 13/1997 Coll.

2.5.2.4.3. Impacts on the Settlement and Supply Infrastructure

The Documentation discusses on page 213 the effects on the development of the related infrastructure in terms of incorporating Temelín Nuclear Power Plant into the technical infrastructure of the Czech Republic (power supply network, relations to other countries). A further contribution is the use of the waterworks Hnevkovice and Korensko for power generation purposes. These aspects are stated objectively.

The location and construction of the power plant necessitated evacuation of villages and settlements as a pert of the project of their liquidation (Brezí u Týna nad Vltavou, Knín, Krtenov, Podhájí, Temelínec). At present, the settlement structure around Temelín Nuclear Power Plant is stabilised. Impacts on the settlement factors in terms of the comfort factors are treated in Section 2.4.2.4. as a part of the impacts on the comfort factor.

Key problems: **impacts on fauna, flora, ecosystems (B)**

impacts on forests (C)

impacts on agricultural cultures (D)

Based on the results of the above assessment, it can be stated:

The impacts of construction of Temelín Nuclear Power Plant on flora, fauna and ecosystems can be considered significant, in particular with respect to the changes induced by reclaiming new areas in the watershed of Stropnice for cultivation as a replacement for the claimed land of the site, and with respect to altering the hydrological conditions in the spring area of Palecluv potok and partly also of Strouha.

The impacts of operation of Temelín Nuclear Power Plant on flora, fauna and ecosystems, including forests and agricultural societies, as a result of emissions into atmosphere, water and soil can be considered to have low significance, because no such changes of the hydric or trophic conditions of the ecosystems are expected to occur that would induce fast undesirable changes in the succession processes that could result in destroying or weakening the populations of the specially protected or regionally important species.

Recommendations:

In particular, the following measures may be recommended:

1. **Consider the revitalisation of the area in the immediate surroundings of Temelín Nuclear Power Plant in relation to the TSES documentation as a compensation for the impacts on Temelín Nuclear Power Plant surroundings in the construction period. Apply the revitalisation procedures within the project of biological recultivation of the construction facility grounds, including an objective assessment of the contamination levels of soils occurring in the construction period, with respect to the use of these soils and materials in relation to the place of their final laying and to the spatial arrangement of the different kinds of biological recultivation.**
2. **Maintain and revitalise the affected spring areas of a Palecku potok and a part of the watershed of Strouha.**
3. **Consider a restoring revitalisation of the damaged parts of the Stropnice watershed.**
4. **Provide for maintenance (suppression of undesirable succession) at subxerophile localities of the former military area Litoradlice as well as in the areas of the valuable marshlands around the mew storage reservoir in the watershed of Strouha.**

In particular, the following monitoring and post-project analysis measures may be recommended:

1. **Provide for further monitoring of accumulation of radionuclides in biological material – mosses, forest soil and pine bark (VÚOZ Pruhonice) and continue to monitor the radionuclides content in fish.**
2. **Furher observe the wastewater and rainwater by means of a special (chemical and biological) monitoring:**
   - a) **of the system at Býšov in the watershed of Strouha**
   - b) **monitoring of oxygen and temperature zoning at selected sections of Vltava**
   - c) **of the reservoirs Hnevkovice, Korensko, Orlík and selected ponds in the vicinity of Temelín Nuclear Power Plant, monitor the seasonal occurrence of plankton algae, at the same time maintain and possibly extend the monitoring of changes in the chlorophyll concentration in the reservoir Orlík with a focus on the evaluation of the proportion of algae, with one sampling point below the section of Korensko**
   - d) **extend the monitoring of changes in water ecosystems by observation of changes in the composition of zoo-plankton due to its sensitivity to changes in water temperature and the resulting changes in the trophic structure of the water ecosystem**
3. **Establish a long-term monitoring (also retrospective) of the landscape environment by means of analysis of multispectral satellite data, which is particularly suitable for observation of moisture and temperature changes in the landscape related to the change in its structure and vegetation functions. Evaluation of satellite data on yearly basis is proposed, as well as establishing the related key for identification of terrestrial features in the satellite data, including the definition of the key biotopes, including forests, in the satellite image. With respect to the extent of the individual satellite shots, it is possible to evaluate objectively also the changes occurring across the border of Austria and Germany.**
4. **Generalise the results of the remote survey of the Earth on a five-year basis to establish the grounds for possible measures to be taken in the case that unambiguously interpretable differences in the temperature and humidity changes in the structure of the region and the surroundings are detected, including initiation of the appropriate mitigation actions.**

Key problem: Impact on the landscape character (A)

Based on the results of the above assessment, it can be concluded:

The impact of Temelín Nuclear Power Plant on the landscape character is in total very adverse and very significant, in particular with respect to erection of visually dominant objects accompanied by suppression of the original scale and historic structure of the countriside (destroying the settlement structure).

These impact are a result of an in principal completed construction development, for which land use and construction permits were granted and which was mostly implemented in the time before the effectiveness of the legislation on protection of the landscape character.

Recommendations:

With respect to the volume and height parameters of the structures, no direct technical or compensatory measures to mitigate the effect of the entire site are practicable.

To mitigate some of the impacts, it is recommended to:

1. **Study the evaluations the of the distant views in the settings where the cooling towers rise only partly above the horizon in relation to the possibility of shading out of these distant views by means of suitable tree planting**
2. **Integrate at least partly the areas with structures not higher than three floors by means of complex tree planting schemes**
3. **Integrate the area of the safety reservoirs of technical design at Býšov into the landscape by means of group plantations of suitable tree species**
4. **Integrate into the landscape the operations building of the process water takeoff installations at the reservoir Hnevkovice by means of tree planting**
5. **Recultivate the construction facilities grounds in agreement with the principles of functional arrangement of the area (combination of agricultural and forest recultivation with areas for the support of natural succession).**

Monitoring is not relevant for protection of landscape character.

Key problem: **impacts on cultural values (E)**

impacts on material values (F)

Based on the results of the above assessment, it can be concluded:

The impact of Temelín Nuclear Power Plant on cultural values can be considered significant with respect to the substantial intervention into the cultural landscape during the construction period, which included a complete or a partial destruction of prehistoric and medieval archaeological sites in a rather wide neighbourhood on Temelín Nuclear Power Plant.

The operation of the power plant will not influence cultural values of spiritual nature, except for the influences of the perceivable changes in the aesthetic quality of the landscape, which are rather difficult to describe, on the inhabitants.

In the context of operation of Temelín Nuclear Power Plant, no apparent impacts on cultural monuments are expected.

The real estates and the cultural heritage in the area are exposed to a low to medium aggressiveness, the start-up of Temelín Nuclear Power Plant will not increase the degree of the environmental load.

Recommendations:

The basic recommendation is to report in advance all intended interventions in the terrain and to adhere to the rules of archaeological supervision or terrain survey.

As a compensation for the impact on the historic structure of the countryside due to the construction, it is recommended that the operator of Temelín Nuclear Power Plant accepts the responsibility for the future of the preserved remnants of real estate cultural monuments in the territory around Temelín Nuclear Power Plant, including the estimated aprox. 65 cultural monuments.

If substantial changes are detected based on the results of monitoring of atmospheric pollution, it is recommended to contract specialist companies to determine the corrosive aggressiveness by a direct corrosive test on selected objets.

In relation to identification of unambiguously interpretable differences in the essential parameters of temperature and humidity changes in the structure of the region and its surroundings, it is recommended that also the aspects of protection of the cultural heritage in the South-Bohemian of Aleš Gallery in Hluboká constitute a part of the appropriate measures introduced.

2.6. Waste (including the radioactive and chemical ones)

The various types of waste arising at the nuclear power plant as a result of its operation are classified according to their contamination by radionuclides into non-active waste (management of this waste is determined by the Waste Law No. 125/1997 Sb.) and radioactive waste (RAW – its management is regulated by the Law No. 18/1997 Sb. and first of all by the Regulation of the SONS No. 184/1997). The technical structure of the power plant does not allow releasing solid waste from the main production unit area directly into the environment. If some solid waste arises, it is transported into the auxiliary active operation building for processing, treatment, or disposal.

Waste – inactive

Organization of the waste management control system

In the control system of the CEZ a.s. Prague– Temelín Nuclear Power Plant Division (further on ETE) a department of conventional safety, environment and licensing procedure is organizationally included within the framework of the licensing section. Its mission is defined as independent supervision, methodical guidance of the ETE sections in solving the questions associated with the care of environment including the waste management and representing ETE in the contact with the public service organs in this region. The authority of control, assessment and making statements to the waste problems is confided to the department 4582. The sections of the administration and maintenance perform the actual tasks of the waste economy. The authority for the functional control of the waste management is confided to the department 4413.

The waste management procedures are adjusted by the decision of RŽP PkÚ Ceské Budejovice of 7. 12. 1998 and 19. 4. 1999 and specified by an internal regulation of the company **No. 270510 "Procedure for quality assurance – Waste management".** The ETE also has a waste economy program, which was not yet actualized according to the § 5, paragraph 1 of the amendment of the Law No. 125/1997 Sb. on wastes, of 18. 1. 2000, because the respective implementary regulations have not been published until now.

The regulation No. 270510 marks out the waste management principles, which are in compliance with the strategic documents and legislation valid in the Czech Republic. The principles also are in compliance with the strategy of European Union **(COM(96)399 final).** According to these principles the priority is the prevention of waste arising, limitation of the hazardous substances content, valorization of the waste formed and its safe disposal.

594 tons of waste arose in ETE in 2000, out of it 339 tons of hazardous waste and 255 tons of other waste (including the communal ones) – without including the construction concrete waste resulting from the activity of the Bohemia company. From the viewpoint of the waste production ETE does not belong to significant producers, in addition, the decrease of waste amount arising in the course of construction can be expected. In the course of investigation on the spot no shortcomings were found in the classification and designation of waste, which is performed in compliance with the valid Waste catalogue (corresponding with the respective waste registers used in the European Union).

Prevention of waste arising and minimization of hazardous properties

Principles of waste arising prevention are given in the regulation No. 270510. In practice the principles are fulfilled for example in the preparation of technological procedures, in selecting environmentally suitable materials and packages, in determining requirements on the supply of products which do not contain hazardous substances (PCB, asbestos, etc.) and so on.

Valorization of the formed waste

In the regulation No. 270510 a requirement on the classification and separated collection of utilizable waste is included. Classification of the communal waste is a duty of each employee. The requirement on the back taking of utilizable waste and packages applied in contracts with suppliers of products or with firms ensuring the taking of waste formed also is a contribution to the environment protection. According to my ascertainment, the requirements are fulfilled.

Disposal of the formed waste

The waste intended for the disposal is separately collected in containers and in the collecting yard and according to its nature passed on to the disposal (or utilization) to the competent specialized firms or in an own dump.

Hazardous waste stored in the collecting yard in buildings No. 1–3 and in the spent oil store is passed on to the external firms competent for the hazardous waste management operating on the base of long-term contracts.

Other solid waste is deposited on the S III – Temelínec dump operated by ETE. Using containers carries out transport of solid waste to this dump. The operation rules of this dump correspond with the requirements of the Regulation of MŽP No. 338/1997 Sb. on the details of waste management. The waste is deposited in the dump in compliance with the approved operation rules.

A pipeline to the S II – Temelínec dump transports sludge from the water treatment plant. The operation rules of this dump were presented to me. These rules correspond with the requirements of the Regulation of MŽP No. 338/1997 Sb. on details of waste management. . The waste is deposited in the dump in compliance with the approved operation rules.

In the framework of the ETE construction the Brezí dump and the Knín dump were constructed, intended for the building debris and soil only. The Brezí dump is closed already and it is reclaimed. The S II – Knín dump is still in operation, the waste being deposited in compliance with the approved operation rules.

ETE has established a waste management system. According to my opinion, the system organization in the ETE is on a very good level and corresponds with the requirement of environment protection. The inspections carried out by the Czech environmental inspection in 1999 and 2000 did not find any shortcomings. ETE does not belong to significant waste producers, the changes in the amount and quality of the waste are not assumed.

2.6.1. Disposal of the solid radioactive waste from the installation

The solidified low- and medium-level RAW will be deposited at the URAO Dukovany repository – it is not the object of appraisal. The repository is a state owned property and it is operated by a public organization SÚRAO (in compliance with the Law No. 18/97). This repository serves only for the deposition of the RAW produced by the Dukovany and Temelín nuclear power plants. The repository safety was verified by the safety analysis carried out in 1995. The URAO repository capacity corresponds to the expected RAW production from both nuclear power plants within their entire service life, including the expected low- and medium level RAW production from the decommissioning of both power plants.

Impact assessment – impact into the environment is not the impact of the actual power plant operation but the impact of URAO Dukovany repository operation. This impact can be rated in the range from low to average because criteria of radiation protection are fully respected.

2.6.1.1. The category of solid radioactive waste, including, where suitable, spent fuel and the expected amounts

Non-radioactive waste – the categories given in (2) correspond to the actual legislative modification, the management of it is regulated by the decision of the RŽP OkÚ Ceské Budejovice (see 2).

The waste category N (Dangerous) is worth to mention – it is a category appearing usually at this type of operation, the production being minimum in most cases, of the order of magnitude of tens up to hundred kilograms and in the case of various waste sludges up to 1 ton. In the range up to 1 ton the production of fluorescent lamps and other mercury containing waste can be expected. Disposal of these wastes, in line with the pertinent permission of the RŽP OkÚ, does not bring a significant burden to the environment.

<u>The waste production impact can be assessed as a small one.</u>

Low- and medium-level RAW – the annual production from the Temelín NPP operation in categories:

Solidified liquid RAW (bituminized) – expected production

Before treatment 335 m^3 /year

After treatment 200 m^3

About 4×10^{13} Bq of activity, approx. 15 % out of it in the bitumen concentrate and approx. 85 % in bituminized sorbents is in the assumen bitumen product transported for the disposal in the amount approximately of 200 m^3/year. The volume activity of the bitumen product increase by a factor of approximately 2 in comparison to the liquid concentrate due to the volume reduction, whereas it does not change for sorbents, where volume changes do not occur in the course of bituminisation. The volume activities of long-lived radionuclides in the bitumen product are as follows:

radionuclide	half-life of transformation	volume activity of bituminized concentrate [Bq/l]	volume activity of bituminized sorbents [Bq/l]
^{90}Sr	28 y	1.0×10^{3}	7.7×10^{2}
^{99}Tc	212000 y	8.5×10^{-3}	1.5×10^{-2}
^{129} I	16000000 y	3.3	6.0
^{134}Cs	2.1 y	3.2×10^{6}	2.4×10^{8}
^{137}Cs	30 y	8.8×10^{6}	7.5×10^{8}
^{144}Ce	285 daysí	1.1×10^{3}	8.2×10^{2}
^{94}Nb	22000 y	3.3×10^{-1}	1.2
^{63}Ni	120 y	1.4×10^{6}	4.3×10^{6}
^{59}Ni	75000 y	7.4×10^{3}	2.2×10^{4}
^{60}Co	5.2 y	1.0×10^{6}	3.0×10^{6}
^{55}Fe	2.9 y	1.5×10^{7}	4.4×10^{7}
^{54}Mn	0.8 y	1.1×10^{6}	3.0×10^{6}
^{14}C	5570 y	9.4×10^{4}	1.1×10^{5}
^{239}Pu	24400 y	5.3	1.0×10^{1}

^{241}Am	458 y	1.8	3.3
^{41}Ca	103000 y	0	0
in total		3.0×10^7	1.0×10^9

Pressable solid RAW

Before treatment 200 m^3/year

After treatment 56 m^3/year (low-pressure pressing)

8 m^3/year (high-pressure pressing variant).

Large-size RAW

Before treatment 20 m^3/year

After treatment 20 m^3/year

Air-conditioning filter inserts

Before treatment 35 m^3/year

After treatment 5.8 m^3/year (low-pressure pressing)

8 m^3/year (high-pressure pressing variant)

The impacts of low- and medium-level RAW can be assessed as small ones (in comparison, for example, with the production of other power plants)..

High-level waste – HLW

The waste will be formed by metallic materials – scrapped (exchanged) sensors from the reactor core with induced radioactivity (thermoelements, neutron flux sensors, ionization chambers, and surveillance material samples). The total volume of this waste **will not exceed 20 m^3** in the course of the entire power plant service life. This volume does not represent the net volume of RAW, but the volume necessary for the safe storage, i.e. including the package.

In spite of the relatively dangerous nature of the HLW arising in the course of power plant operation, the assumed amount of it is rather small and, therefore, the impact can be also assessed as a small one and not leaving the average in comparison with other power plants operated all over the world.

Spent fuel

is not a waste in line with the Law No. 18/97 Sb. – § 24, paragraph 3.

The expected production of spent fuel in the course of power plant operation (40 years of operation, four-year runs) is 1787 t.

The impact of the arising spent fuel, although it must not be a waste in the future, can be assessed as a medium one, average, corresponding to the equipment character and to the applied handling and protection system.

2.6.1.2. Treatment and packaging

Liquid RAW – concentrates
1st step – concentration technology

The objective of the RAW production minimization is reached by the primary assortment of wastewaters in the point of their arising into several branches with the independent subsequent handling.

Potentially non-active waters – are discharged into the water course if the limits of the radiometric checking are fulfilled. If the limits are exceeded, the wastewater is purified by mechanical and ion-exchange filtration, sorption procedures, sedimentation, centrifugation, or coagulation. Application of a particular technology or technologies is given by the technological procedure and its optimization.

Special sewerage waters

They are collected in collecting reservoirs, then pass through sedimentation reservoirs and the sludge is separated by centrifugation. The waters are then evaporated – the concentrate is directed into the concentrate reservoir, whereas the condensate is purified on ion-exchange filters and used again in the technology, its excess being discharged into the water courseafter radiometric checking.

The concentrate and the sludges are fed separately into the RAW storage reservoirs for the future treatment.

Laundry waters and air-lock waters

The waters containing radioactive substances in excess to the set limits are fed into the RAW system, whereas the laundry waters with lower radioactivity are centrifuged and after radiochemical check drained through the sanitary sewerage to the biological wastewater treatment plant.

Concentration step assessment

The waters intended for treatment as the RAW and reusable waters are consistently separated in the system. The waters of technological origin are reused as much as possible, thus minimizing their effect on the environment. The laundry waters, after separating portions with above-limit radioactivity, are treated by a procedure currently used for wastewaters from other non-chemical technologies – COV. The system mentioned can be characterized as an up-to-date one with all the above listed attributes – first of all with the effort to minimize any impact on the environment.

2nd step – concentrate bituminisation

The bituminisation technology is used for liquid concentrate solidification into solid RAW complying with the LaP for the disposal into the URAO Dukovany repository.

The advantage of this technology is above all in the **minimization of the RAW production for the disposal**. Owing to the higher degree of matrix filling with waste, the favorable effect of this procedure manifests itself by saving the storage space at the repository, high resistance towards water (the matrix is practically insoluble and hydrophobic). **low leachability of salts from the product** (much lower in comparison with cementation), and **satisfactory chemical**

inertness (materials of various type can be incorporated). Bitumen together with glass, cement, and polymers is one of the standard matrices used in the RAW solidification. The application of the same technology as in the Dukovany nuclear power plant can be also considered an advantage.

Drawback of the bituminisation technology consists in the **fire hazard** caused by the combination of the present salts and heated bitumen in the evaporation. The fire hazard is generally known and, therefore, measures are taken for its elimination. This type of measures are also introduced in the bitumen technology realized at the Temelín NPP. They consist in:

measures of a technological character – continuous temperature monitoring of the output product from evaporator and differential thermal analysis (DTA) before processing each charge at the bitumen line,

existence of an efficient monitoring system of the bituminisation process and of the subsequent bitumen product cooling in carousel (chamber system, temperature sensors, spatial smoke sensors)

existence of an stable system of drums aftercooling with water for the case of the rise of fire hazard conditions,

separation of the bituminisation line into an independent fire division – preventing the fire product spread into other parts of BPAP,

installation of a ventilation system enabling to clear the fire products of the released radioactivity in the case of a fire – allowing the total radioactivity reduction by a factor of 100 000.

Under similar fire protection precautions the bituminisation technology is operated for example in Belgium (Belgoprocess), France, Japan, Russian Federation, Lithuania, and Slovakia.

Overall assessment – liquid RAW

The bituminisation plant at the Temelín NPP was delivered by a renowned French company SGN, the technology is equipped with fire fighting precautions for the elimination of the arisen fire. The precautions correspond with the current requirements and recommendations. The operation schedules of RAW treatment are also adjusted to the enhanced fire hazard The operation impacts and hazards can be evaluated as low to medium ones, especially owing to the realized system for the elimination of the possible non-standard process situations.

Solid RAW

Solid RAW arise at various work stations – controlled zones of the power plant. The process of their elimination proceeds in three steps:

1. Collection. All the work stations are provided with collection vessels. The collection and primary waste classification (according to the method of the subsequent treatment – pressable, combustible and non-pressable waste) is carried out here. In the regular schedule the solid waste is transported to the BPAP for further processing, namely for

2nd step – Classification. In the BPAP at the solid RAW treatment station the waste from the reception store is continually classified according to the radiometrically determined dose rate. In accordance with the measured dose rate (contamination) the waste is managed as follows:

At the dose rate less than 1 mGy/h – the waste is cleared for further handling outside of the RAW system. It is delivered over to the storage at the CEZ storage area at Temelínec.

At the dose rate between 1and 3 mGy/h – the waste is temporarily stored at the "cooling" stores. The dose rate measurement is repeated after 2–3 months. After the dose rate decreases below 1 μGy/h the waste is managed as in the preceding case.

At the dose rate between 3 and 20 mGy/h — the collection bags are sorted in a special glove box with the aim to separate materials contaminated up to 3 μGy/h, which are managed as in the preceding cases, and materials for disposal.

When the dose rate is higher than 20 mGy/h – this waste is treated as RAW without classification – this waste is prepared for further treatment.

3rd step – Pressing. The sorted out RAW freed from materials with lower contamination level are pressed by a low-pressure press (with the volume reduction factor of 4–6) into drums of 200 l. The spent air-conditioning filters are also pressed into these drums. Non-pressable solid RAW is inserted into the 200 l drums directly and then prepared for the transport into URAO Dukovany.

4th step – Storage. Drums with pressed solid RAW are stored in the respective store before their final treatment and subsequent disposal at the URAO Dukovany. According to the current project, this treatment technology may be high-pressure pressing ensuring relatively high volume reduction (6–8) and thus saving the storage space of the URAO. This technology is not at this power plant at present. Processing of 200 l drums with pressable RAW, likewise as in the Dukovany NPP, is assumed to be carried out in runs by using a loaned equipment, maybe in the contemplated central plant for waste processing from both power plants. Until the realization of the high-pressure technology the drums with this waste will be stored at a certain location in the power station (see above).

Overall assessment – solid RAW

The solid RAW management is conformed to the main objectives – minimization of their total production and minimization of the RAW determined for the disposal into URAO Dukovany. From this point of view the system realized at the NPP can be assessed as a system with small impact on the environment.

High-level waste – HLW

HLW arising at the power plant are only stored, namely by a way enabling:

safe handling of HLW in time of their arising already – at the location of their arising they are deposited in a storage container, transported to the place of their temporary storage by using a special transport device and then inserted into storage nests (specially adapted storage positions of vertical metallic shafts with a special shielding)

safe handling after completing the power plant operation – it should allow the final disposal (final management) together with other HLW resulting from the NPP decommissioning.

All the handling procedures are remotely operated – that means they should minimize the radiation hazard of the service personnel. The handling of HLW is carried out in facilities designated for these purposes (hot cells provided with remotely operated instruments). The manipulation in the store is not performed with the actual active parts, but only with storage containers.

Overall evaluation – technology of HLW management

The HLW management can be assessed as fully conformed to the hazard minimization of both the service personnel and impact on the environment, namely in the course of power plant operation as well as in the future during its decommissioning. Impact of this activity can be evaluated as small.

2.6.1.3. Equipment of stores

Waste water purification

The entire system of radioactive wastewaters purification is based on the line of consecutive processes of their collection, centrifugation, evaporation and filtration:

Radioactive wastewaters purification – tanks

Sedimentation tank – 150 m^3 – 2 pieces

Sludge tank – 1 m^3 – piece

Overflow tank – 8 m^3 – 1 piece

Waste water tank – 200 m^3 – 3 pieces

Condensate control tank – 70 m^3 – 2 pieces

Tank for water for own consumption – 200 m^3 – 2 pieces

Water works tank – 5.5 m^3 – 1 piece

Washing water tank – 70 m^3 – 1 piece

Laundry water purification – tanks

Collecting tank – 29 m^3 – 2 pieces

Sludge tank – 4.5 m^3 – 2 pieces

Control tank of the purified water – 30 m^3 – 2 pieces

The individual technological tanks are manufactured from high-quality materials corresponding with the nature of the collected waters, especially from the viewpoint of corrosion resistance. The design and situation of these storage tanks allows the collection of the entire volume of stored liquids in the case of an accident release at their failure, without coming to a release outside the technological area regime, i.e. in the environment.

Liquid RAW concentrate storage

The mentioned store or intermediate store serve for the collection of concentrated radioactive waste produced in the processes of radioactive waters purification before their final treatment by fixation into bitumen.

Sorbent tank – 100 m^3 – 2 pieces

Reserve tank – 200 m^3 – 1 piece

Concentrate tank – 200 m^3 – 2 pieces

Concentrate tank – 60 m^3 – 2 pieces

Overall evaluation – liquid waste storage represents a small or negligible effect for the environment.

Solid RAW storage

The small-sized waste is transported to the central station for the solid RAW conditioning. This station is provided with several stores, where the waste is situated because of the fire safety reasons either in closed pallets or drums.

store type	capacity
receiving store for waste below 100 µGy/h	approx. 750 bags
receiving store for waste above 100 µGy/h	approx 200 bags
„cooling“ store	approx. 250 bags
store of waste for pressing	approx. 500 bags
store of inactive waste	approx. 300 bags / 75 drums
store of treated waste	50 drums

8 storage cubicles, accessible only from above by a 16 t cage overhead traveling crane, situated in the same building and story (+13.2 m, building 801/03) are intended both for the storage of the above mentioned treated and conditioned waste (pre-pressed in 200 l drums or freely stored on pallets) and as a reserve for the storage of other low- and medium-level solid (solidified) waste before or after treatment. The technically usable capacity of the storage cubicles is about 560 m^3 (out of the total geometrical volume of 930 m^3). About 200 m^3 out of it can be used for inflammable waste. If filling this space with 200 l drums is considered, it represents the total capacity of 2100 drums in 4 layers bound with pallets, while 750 drums can be filled with inflammable material. In addition to this there also is an intermediate store of conditioned waste with the capacity of approximately 50 drums at the central working station.

HLW storage

Highly active in-core KNI type sensors, surveillance specimen holders or type WR ex-core sensors and thermoelements will be deposited into 2 specially equipped cubicles with a thick shielding (1.5 m of concrete) in the building 801/03 accessible only through the upper filling openings at the +13.2 story. These parts will be contained in a single-purpose steel cases with a lid, which will be inserted into a tube system (totally 32 tubes 11 m in length), out of which the cases may be taken if it will be necessary. The procedure of handling the cases ensures satisfactory shielding of the service personnel towards the cases by using shielding transport containers, a so-called intermediate sheet, covering bell with an equipment for fixing the lid and a system of shielding stoppers into the individual inlet openings. Using the 16 t cage overhead traveling crane performs all handling operations in the store proximity.

Overall assessment – storage of solid RAW and HLW represents only a negligible effect on the environment.

2.6.1.4. Transport at the site and out of the locality

The annual estimate of RAW transported to the disposal in the URAO Dukovany corresponds to the assumed annual production of all the low- and medium-level RAW in the power plant. In reality this amount could be lower and that for two main reasons:

on the base of lower liquid concentrate production (the data given are the design estimates, in practice it could be significantly lower as it was in the case of Dukovany NPP)

if the pressable solid RAW will be compacted by a high-pressure pressing before its transport to the URAO, then their amount for disposal could be lower even by 50 % in comparison to waste pressed by a low-pressure press operated currently at the power plant.

The actual transport is passing according to the ADR rules. The hazards connected with the transport vehicle accident can be assessed as very low up to negligible – this is true from the viewpoint of the radioactivity release. The properties of the cold bituminized RAW prevent the radioactivity release during a short contact with water. The fire hazard also is very low, because considerable energy input is necessary for the fire initiation. In addition, the bitumen is in a strong metallic case of a 200 l drum and the drums will be transported in an ISO container. Thus, there are two metallic fire resistant barriers. The bitumen product could catch on fire during a very improbable accident, for example in a collision with a tank truck transporting highly inflammable liquid – probability of this event is very debatable itself and very low. The radiation hazards and impacts can be also assessed as negligible or very low with respect to the requirements of tehe SONS Regulation No 143/1997 Sb., i.e. that the dose rate at the case surface should be lower than 2 mGy/h and the effective dose rate in the distance of 1 m from the container should be less than 0.1 mGy/h.

The peculiar impacts of the transport could be, therefore, assessed as very low to negligible.

2.6.1.5. Radiation hazards for the environs and the accepted measures

Radiation hazards for the environs can be separated into two areas.

Hazards **in the case of a fire** of a warm bitumen product from the BPAP bitumen line area associated with a potential release of radionuclides into the ventilation system and environment were eliminated by providing the technology with technical and organizational means for preventing the fire arise. They are:

The bitumen line is an independent fire division, provided with a ventilation technique enabling efficient elimination of the fire products and released radionuclides. The efficiency of fire products and released radionuclides capture (expressed by the reduction of the radionuclides concentration by a factor of 10^5) is sufficient with respect to a safe prevention of irradiation a critical group of population and is sufficiently below the limits given by the SONS Regulation No. 184/1997 Sb.

A system using cameras for monitoring the area where the drums with bitumen product are cooled. The system allows visual inspection of all drums on the carousel transporter behind the bitumen line.

Spatial temperature and smoke sensors together with a stable cooling system enabling to manage the fire situation.

Evaluation of the concentrate properties from the point of view of its thermal behavior (DTA analysis) for each charge of the waste processed on the bitumen evaporator allows to set technological parameters of its subsequent treatment in order to minimize the hazard of non-standard situations appearance

Owing to the accepted above-mentioned measures the impacts can be characterized as small or average ones.

Loss of control hazard over the stored concentrates – cracking of a tank with concentrates (this applies for all tanks in which hazardous liquids are stored) and subsequent release of radioactive concentrates into the environment. The design of the storage tanks (materials applied and situation in isolated pits allowing the hold up of the total volume of the stored liquids) sufficiently eliminates the possible hazards as well as impacts on the environment.

Impacts on the environment can be assessed as negligible or small ones.

Radiation hazards associated with the HLW storage. The adopted storage technology and the method of HLW handling at the NPP together with the very small expected volume of HLW formed are a guarantee of a full control and handling ability of this waste even after termination of the power plant operation. This is a very important moment reducing irradiation during handling this waste both at its arising and in future at its final disposal (possibility of its handling resulting in the volume minimization of waste intended for disposal into a geological repository at the simultaneous minimization of the dose obtained by the service personnel).

The impact on the environment can be assessed as a small one, concentrated only in the region of small radiation burden of actual workers servicing the handling equipment, transport and storage containers.

2.6.1.6. Measures for transport to localities where the particular waste categories are transported outside of the power plant site

In the case of non-radioactive waste transport to the particular disposal areas or to the final disposal no special measures are taken with respect to the produced waste nature and any such measures over the scope of usual ones are not necessary according to the meaning of the person performing the assessment. In addition, the greatest part of the arising waste will be disposed in the dumps of the CEZ a.s. in a no great distance from the Temelín NPP. In the case of a transport to the final disposal of the "N" waste outside of these facilities the transport is the matter of each operator of these services and of the respective District Office Department of Environment permitting operation of this service.

In the case of RAW transport by the operator no extraordinary measures are anticipated. The RAW will be transported in the total volume of about 1250 drums annually to the URAO Dukovany repository. The transport of non-shielded drums in a standard ISO container with a capacity of 35 drums is assumed as the basic transport method. This means approximately 36 transports annually taking place in compliance with the conditions for hazardous waste transport according to the European agreement on the international road and railway transport of hazardous goods (ADR and RID) valid in the Czech Republic, as well.

In the case of a transport of fixed RAW in drums with higher absorbed dose rate at their surface (e.g. bituminised sorbents) transport will be carried out in a shielded container (for each 200 l drum) fixed in special transport frames. According to the type of containers used 12, 6, or 4 transport units (drums in containers) will be transported simultaneously. In compliance with the SONS Regulation No. 14/1997 Sb. the type A containers are considered where the dose rate at the surface of a cover (or of a container if the drum is situated inside) must not be higher than 2 mGy/h in the case of a transport and the effective dose rate in the distance of 1 m from the surface of the cover or container with a RAW containing drum must not exceed the value of 0.1 Sv/h.

Impact assessment

The operator does not anticipate other than legal recommendations. According to the opinion of the person performing the assessment, some measures above the framework should be taken (see the recommendation) – even in a limited extent increasing the operator' credit at the public. In spite of it the impact can be assessed as minimum to negligible ones.

2.6.1.7. Criterions for contaminated materials, which can be released on the Basic Safety Standards requirements

The existing valid criteria for releasing radionuclide-contaminated materials into the environment are contained in a detail in the SONS Regulation No. 184/1997 Sb. (§ 5). Conditions set here issue from the international requirements, first of all from the IAEA and ICRP-60 recommendations. Not exceeding the irradiation limits is one of the basic assumptions – that means of the average effective dose of an individual out of the critical population group, 10 μSv/year and at the same time the collective dose of this critical population group should not exceed 1 Sv. In other paragraphs, in compliance with the international recommendations, the regulation also sets down in detail the mass activities permissible for releasing solid substances into environment and volume activities for releasing discharged waters and materials into air.

The assessment is in compliance with the adopted principles.

2.6.1.7.1. Releasing levels set by the supervising organs

By the decision No.10491/4.3/00 of 28. 7. 2000 SONS permitted the release of radionuclides contained in solid materials and objects into the environment by the way of deposition on the communal solid waste dump Temelínec under the following conditions:

The waste will not contain discarded fire-alarm detectors, etalon emitters and discarded equipment containing radionuclide emitters defined in §6, paragraph 4 and 5 of the Regulation No. 184/1997 Sb.

The dose rate equivalent including the natural background must not exceed 0.4 μSv/h in the distance of 1 m from the dump surface.

Uttil January 30, 2003 The Temelín NPP will submit the evaluation of results radionuclide-contaminated waste monitoring from the point of view of their composition, activity, dose rate equivalent at the surface and the total volume formed and the dump and its environs monitoring from the point of vies of dose rate equivalent in the distance of 1 m from the dump.

The set conditions issue from the documentation worked out and from the evaluation of the critical group of public irradiation by the released radionuclides in line with the Regulation No. 184/1997. SONS has evaluated this documentation and has decided on the base of this documentation. This procedure and the limits set are in line with the Regulation No. 184/1997 Sb.

The limiting values of the volume activities of disposed of radionuclides for the disposal of RAW on the URAO Dukovany repository processed by the SÚRAO and approved by the decision of SONS are given in the following Table 7.

Radionuclide	Volume activity (Bq/m^3)
^{14}C	3.10^{8}
^{41}Ca	8.10^{11}
^{59}Ni	1.10^{10}
^{63}Ni	1.10^{11}
^{90}Sr	4.10^{12}
^{94}Nb	1.10^{8}
^{99}Tc	1.10^{10}
^{129}I	4.10^{8}
^{137}Cs	1.10^{12}
^{239}Pu	2.10^{7}
^{241}Am	1.10^{7}

Notes:

The volume activity limitations for other nuclides are not set.

The alpha activity can be measured as a sum, but when the value of 2.106 Bq in a 200 l drum will be exceeded, the measurement of radionuclide alpha spectrum is obligatory.

The solution is in agreement with the adopted principles.

2.6.2. Spent fuel management

The fuel delivered by WESTINGHOUSE company is of VVANTAGE 6 type with fuel rods from enriched uranium in a hexagonal arrangement in the form of uranium oxide cylindrical pellets in a Zircaloy-4 tube. Another type of fuel rods also can be used in some fuel assemblies, namely with the application of an integrated burning up ZrB_2 based absorber.

2.6.2.1. Spent fuel storage on the premises

The nuclear fuel is continually burning up in the power plant and is discharged out of the reactor after attaining a certain burnup. As the VVER 1000 core contains 163 fuel assemblies and the WESTINGHOUSE company is delivering fuel for a four-year run, 41–42 fuel assemblies are changed every year.

The capacity of the spent fuel pool is 680 positions for fuel assemblies and 25 positions for gastight cans. Thus, the spent fuel can be stored in the pool for 10 years. The spent fuel assemblies discharged from the reactor are placed in the spent fuel pool below a sufficient water layer serving as:

shielding medium

service personnel protection

coolant taking away the residual heat

This residual heat is transferred to the cooling pools of technical water through an inserted cooling circuit.

After the cooling time, in the course of which the fuel assemblies are stored in the spent fuel pool, the assemblies are transported in a transport container to the spent fuel store. They are stored safely there until their reprocessing of final storage. According to the § 24 of the Law No. 18/1997 the responsibility for the spent fuel management is carried by the radioactive waste owner (originator), i.e. the nuclear power plant operator. After declaring (by a legal procedure) the spent fuel a radioactive waste, the state guarantees its safe disposal by means of the "Radioactive Waste Repositories Authority" (SÚRAO). The originators are obliged to pay means to cover the expenses of SÚRAO. The Czech government decided in March 1997 that the best variant for spent nuclear fuel storage in this republic is the construction of dry stores at the sites of Dukovany and Temelín NPP. According to the balance calculations the store in Temelín will be necessary after 2010.

Assessment – it is in compliance with the adopted principles – the effect on the environment is negligible.

2.6.2.2. The spent fuel storage

Spent fuel storage is worth considering in a case that its owner, CEZ a.s., will declare it a waste. Then the state instituted organization SÚRAO is obliged, in compliance with the Law No. 18/1997, to assure safe disposal of the spent fuel. Until this will take place (the owner does not declare spent fuel a waste) is the spent fuel managed in a way not making difficult its possible treatment in the future.

The Law No, 18/1997 also sets that all expenses connected with the spent fuel disposal in the future as well as the expenses connected with the disposal of all the wastes (RAW, HLW) bears the spent fuel producer.

At present, SÚRAO is trying to find suitable disposal space –- deep geological repository (HÚ) in the Czech Republic for the disposal of spent fuel and HLW. With respect to the geological situation in the Czech Republic, suitable localities are looked for in a granitoid environment (like for example Sweden, Finland, Switzerland or Canada). According to the available information (SÚRAO) the finding of a suitable locality is assumed before 2015 and opening of the repository after 2065.

The nuclear power plant operator pays to the "Nuclear account", in compliance with the law, 50 Kc per each MWh produced to cover the expenses connected with the locality exploration, design of the repository system, realization of the construction and future operation of the geological repository. The amount mentioned was derived on the basis of initial studies on the geological repository development in the conditions of the Czech Republic, worked out in 1993-1997 and on the basis of the so-called Reference project (SÚRAO, 12/2000). The assumed expenses for the disposal of spent fuel from the production of both Dukovany and Temelín NPP in the amount of 46.9 milliards Kc are comparable with the expenses for the construction of geological repository for example in Sweden or Finland. Therefore, it could be stated that the amount of transfer to the "Nuclear account" set by the Law to the operator is sufficient to cover the future expenses for spent fuel disposal – or maybe of HLW if the power plant operator will decide to reprocess the spent fuel.

The principle of the future spent fuel disposal in the geological repository is based on the maximum elimination of possible hazards and impacts to the environment and it complies with the generally adopted principles (for example in the EU). However, the effects connected with the construction and operation of the geological repositories and related facilities cannot be neglected. From this point of view the effect can be assessed as a small to medium one. After closing the geological repository the effect on environment will be negligible.

2.6.2.3. Spent fuel transport

The spent fuel transport is not considered in any available documentation relevant to this assessment. Therefore, it is proceeded from the generally valid procedures and rules following from the existing legislation and experience from the realized transports both in the Czech Republic (transport of spent fuel from Slovakia – Bohunice NPP to the spent fuel storage facility in Dukovany NPP) and abroad. The same CASTOR type containers will be used for the transport as well as for storage. This corresponds with the conception of dry storage of the spent fuel adopted and realized in the Czech Republic. The decisive moment of this conception is the absence of further spent fuel handling after cooling in the cooling pool and insertion in the CASTOR container and gas tight closure. However, future spent fuel handling is not excluded and can be carried out with safety again under water in the reactor pool.

The actual transport is realized in compliance with the respective permit issued by the SONS on the basis of an application for:

type approval

radionuclide sources of a special form

transport package set – (B type TOS, category III – yellow)

transport permission

approval of

accident rules

classification of the nuclear material into a respective category from the point of view of its physical protection and method of physical protection assurance during the transport

As it follows from the mentioned requirements on the permission the demands on the radiation protection must be implemented, checked and guaranteed. The dose rate on the TOS surface must not be higher than 2 mSv/h and must not exceed the value of 0.1 mSv/h in the distance of 1 m from the surface. The non-fixed surface contamination must not be higher than 0.4 Bq/cm^2.

The actual transport is realized by a special transport group eliminating any exceptional events.

The spent fuel transport impact assessment – from the point of view of essentials the spent fuel transport requires, of the attention of the supervising organ SONS and of the spent fuel transports in the Czech Republic realized in the past it could be stated that the way of transport eliminates hazards arising from non-standard situations to the maximum possible minimum and its effect can be assessed as negligible.

Key problem: **(A) liquid radioactive wastes**

(B) solid radioactive wastes

(C) spent fuel

(D) non-radioactive wastes

On the basis of done evaluation it is stated that:

The management with liquid radioactive wastes is ruled by the requirement of their minimalization with regard of the subsequent disposal. The applied concentration technologies do not present significant risk and the real consequences for the environment will be minimal.

Similarly the management with solid radioactive wastes presents minimal risk to the environment. The management with spent fuel – storage, transport, disposal in the deep repository – doesn´t mean unsolvable technical problems and doesn´t mean any significant risk to the environment.

Recommendation:

The disposal of spent fuel from NPPs in the Czech republic should be solved in compliance with the accepted spent fuel management strategy in reasonable time-frame.

2.7. Possibility of Occurrence of Accidents

2.7.1. Prevention of Accidents

Prevention of accidents is the basic safety principle of the nuclear industry, which has been applied since its early beginnings for all types of nuclear power plants. The Temelín Nuclear power plant is fitted with two units VVER – 1000/320, which belong to the typical units with pressurised water reactors (PWR), that are the most usual reactor type throughout the world.

Prevention of accidents is practised by the following means:

- choice of site such that external events (natural or manmade) do not pose a threat to the safety of operation and that the power plant is sufficiently equipped to withstand these events. This was verified and approved in 1985 by a regulatory body in the procedure of selecting a suitable site and evaluation of safety characteristics of the project (e.g. seismic resistance)

- power plant design based on a deterministic approach and following the principle of in-depth protection, which consists of four physical barriers (fuel structure, fuel cladding, primary circuit, containment) and five protection levels:

  1) conservative design, quality and inspection assurance system, 2) normal operation control and protection system, 3) set of safety systems that can cope with defined design accidents, 4) measures for control and coping with accident events beyond the design accidents, 5) measures of on-site and off-site emergency plans.

  All levels of the in-depth protection principle are sufficiently developed and secured in the Temelín power plant and are comparable with other nuclear power plants and reactors of the PWR type. Based on the assessment of safety of the Temelín Nuclear power plant given in the Preliminary Safety Report, the state regulatory authority granted in 1986 a permission to start the construction.

  The probabilistic safety assessment (level 1 PSA study) of the Temelín Nuclear power plant with VVER – 1000 elaborated in 1996 is being further developed in compliance with the recommendations and is employed to further enhance the safety of the Temelín Nuclear power plant.

- nuclear power plant operation – through observing thoroughly the approved limits and conditions of safe operation, through profound and efficient training of the operating staff using a full-scale simulator located at the site, an elaborate system of inspections, maintenance and repairs, a sufficient technical background for resolving important operation and safety problems, a system of operational regulations and regulations for non-standard operation events, by developing a feedback system using the experience from operation of plants of this type series (16 units are in operation in another three countries with operational experience exceeding 200 reactor-years) as well as the world-wide operation experience (systems of IRS, WANO), and through other activities. A very important factor is the high level of the safety culture exercised in all activities by all staff of the Temelín Nuclear Power Plant.

Prevention of accidents is exercised also through the stable regulatory regime, which was established in the Czech Republic by Law in 1984. Its effectiveness was confirmed by international missions of RAMG (1993), IRRT (2000) and was also confirmed in the country report on nuclear safety and safety regime in the candidate countries for EU membership (WENRA 2000).

Limits and Conditions of Safe Operation

Limits and Conditions of Safe Operation – a key document for securing the safety of operation of a nuclear power plant – was legally introduced in the Czech Republic by the Act

No.28/1984 Coll. and applied in starting up of the operation of the units VVER – 440/213 in Jaslovské Bohunice and Dukovany. The document is based on the standard format of Limits and Conditions of the Westinghouse company for power plants with PWR reactors. Also the recommendations of IAEA Safety Series 50 – SG –03 Operational Limits and Conditions were implemented.

Observing the Limits and Conditions ensures that the power plant will be operated safely and in conformance with the assumptions of the design; the Limits and Conditions also specify the conditions for such safe operation under the normal state as well as under operational deviations. They are based on the analyses of the safety report and use also the results of the level 1 PSA study to improve the effectiveness (risk-informed approach). Limits and Conditions cover both the normal operation on full power, and also starting up, shutdowns, as well as other operation states of the unit.

The Limits and Conditions are approved by the state supervisory body State Office for Nuclear Safety. Also any changes to this document are approved by the State Office for Nuclear Safety, including the appropriate substantiation. Pursuant to the regulation of the State Office for Nuclear Safety No. 106/1998, the Limits and Conditions include the following parts:

- safety limits that may not be exceeded
- setting of protection and safety systems that ensures that the safety limits will not be exceeded; in the event of being exceeded protection and safety systems are automatically activated
- limiting conditions for operation (operability of the safety systems, activity and compositions of the media etc.)
- requirements on the inspection of operability of the systems of particular importance
- requirements on the actions of the operating staff in the event of deviations from the specified limits and conditions of safe operation
- substantiation of the limits and conditions

All operational rules of the nuclear power plant must comply with the Limits and conditions as the ultimate safety regulation. Keeping the Limits and conditions is subject to permanent surveillance by the State Office for Nuclear Safety, and their violation may be subject to sanctions.

Strict adherence to the Limits and conditions ensures that the assumptions and input data used in the safety analyses and environmental impact assessment (normal operation, accident situations) will always be met.

All of the above is fully applicable to the Temelín nuclear power plant, while the Limits and conditions of safe operation were developed in cooperation with the experts of the Westinghouse company, which has the best experience in this area.

Based on a request by the Temelín Nuclear power plant, the Limits and conditions of safe operation were approved by the state regulatory authority on July 4, 2000.

2.7.2. Unplanned Releases of Radioactivity

2.7.2.1. Summary of Accidents Analysed in the Safety Reports

Within Chapter 15 - Safety Analysis - given in the Preliminary Safety Report and the Pre-operation Safety Analysis Report for the Temelín Nuclear Power Plant, respectively, a complete set of transient states and accident situations is analysed, as required by the

Regulatory Guide 1.70, Rev. 3. Standard format and content of Safety analysis reports for nuclear power plants, LWR Edition, (NRC, USA), which was accepted on the Czech side as a binding regulation for developing the safety documentation for the Temelín Nuclear power plant.

Further recommended lists of accidents to be analysed in the safety reports are available. For example, the "Standard content of technical substantiation of safety – the safety report – of nuclear power plants" (CSKAE – Czechoslovak Commission for Atomic Energy, 1988) lists 37 initiation faults divided into 12 groups. In MAAE material (IAEA-EBP-WWER-01, 1995) there is a similar list of 44 initiation events divided into 9 groups. These lists differ from each other only by logical ordering of the individual events and their division, not by the initiation events included.

The analysed events are categorised, pursuant to the ANSI regulation N 18.2 Nuclear Safety Criteria for the Design of Stationary Pressurised Water Reactor, into four categories:

Category I. : Normal operation and transient operational states

Category II. : Events with moderate frequency of occurrence

Category III. : Events with low frequency of occurrence

Category IV. : Limit (accident) events

The category II. events result in the worst case into a scram of the reactor, their list is given in Appendix 1.

Category III. events may occur only very rarely during the power plant lifetime, their list is given in Appendix 2.

Category IV. events (accidents) are not expected to occur during the power plant lifetime, but are, in spite of that, analysed, as their potential risk is related to a possible escape of radioactive substances into the environment. The nuclear power plant must cope also with these highly improbable events without an unacceptable threat to the environment. These events are listed in Appendix 3.

Each of the events listed in the appendices is analysed in the respective subsection of Chapter 15 and assessed based on specific acceptability criteria corresponding to the US regulations, which are again in principle compatible with the Czech regulations.

The individual subsections of Chapter 15 deal with resolving operation situations in case of the following initiation events:

- Increase of heat removal by the secondary system
- Decrease of heat removal by the secondary system
- Decrease of coolant flow through the reactor cooling system
- Anomalous reactivity and power output distribution
- Increase of coolant quantity in the reactor
- Decrease of coolant quantity in the reactor
- Releases of radioactive materials from the subsystems or the components
- Anticipated transient states without scram

The above includes more than 40 basic events that are a subject of this detailed safety analysis. In reality, many more events have been analysed and the listed items represent only a selection of such initiation events that may have an adverse impact on some of the protection barriers, which could result in an escape of radioactive substances into the environment. A group of similar initiation events is covered by a single event representing an “envelope” of events with respect to the worst consequences (conservative approach).

Acceptance criteria are based on the requirements of the Czech regulations: Act No.18/1997 Coll., on peaceful use of nuclear energy and ionising radiation, and the related Regulations, in particular No. 184/1997 Coll., on the requirements on radiation protection (dose values), and No. 195/1999 Coll., on the requirements on nuclear facilities to ensure nuclear safety, radiation protection, and emergency preparedness (basic technical requirements – criteria). With respect to the fact that Chapter 15 of the Safety Report was a subject of a contract delivered by the company Westinghouse (the supplier of the nuclear fuel and the control system), the General Design Criteria for NPP (10 CFR 50, Appendix A), together with a set of 33 special acceptance criteria were used as the criteria applied on the individual analysed events. It can be said that there are no substantial differences between the requirements of the Czech and the US regulations, respectively, and that in the safety reports of the Temelín Nuclear Power Plant, all of the required events are analysed. In addition, also the events of the type ATWS – anticipated transient without scram – are examined.

In the analyses, the following verified computer codes were employed, adapted for application to the type of unit with the VVER 1000/320 reactor:

FACTRAN – for non-stationary distribution of fuel temperatures

LOFTRAN – for modelling the thermohydraulic conditions in the unit as a whole

TWINKLE – for multidimensional computations of neutron kinetics

VIPRE-W – for subchannel analysis

WCOBRA/TRAC – for thermohydraulic computations of the coolant behaviour in the event of a LOCA accident

NOTRUMP – for the analysis of a LOCA accident up to a section of 0.1 m^2

LOCTA IV. – connects to the NOTRUMP code, use for calculation of the fuel cladding in the event of a small LOCA

LOFTTR 2 – for analysis of a non-stationary response to the rupture of a steam generator tube

Program package “D” – for analyses of transient processes initiated by faults of the unit components

INFAN – for solution of the time behaviour of fission products balance in the fuel

HEPRO – for solutions of the states in the hermetic boxes of the unit in the event of release of the primary coolant

CONT – for solutions of the time behaviour of fission products balance in the containment in the event of accident

Possible Accidents Due to External Effects

Protection against external impacts due to natural disasters or human activities was taken into account in the first place when selecting the location, such that these impacts be minimised. In the safety evaluation, events with probability of occurrence higher that 10^{-6} per year are considered.

Long Distance Gas Mains

In the distance of 900 m from the Temelín Nuclear power plant, there are three lines of long distance gas lines. Detailed analyses under very conservative assumptions showed that even in the case of a simultaneous rupturing of all three mains, there is no risk of explosion, and that the only real danger relates to the heat load of the structure from the burning gas. With respect to the distance and the protection measures, the analysed situation poses no danger for the power plant safety.

Plane crash

The probability of a commercial or a military plane crashing at the location of the Temelín Nuclear power plant was evaluated to be lower that 10^{-7} per year. Besides that, the thickness of the walls and the dome of the containment provides protection against a crash of a military aircraft.

Earthquake

To estimate the seismic resistance of the Temelín Nuclear power plant, two earthquake magnitudes were determined in compliance with the international recommendations of IAEA: the operating basis earthquake (with probability of occurrence of 10^{-2} per year), and the safe shutdown earthquake (probability of occurrence 10^{-4} per year). Based on a survey of the area, including a tectonic and seismological survey, the earthquake magnitudes were determined pursuant to the IAEA recommendations as follows: operating basis earthquake 6° MSK-64, and safe shutdown earthquake 7° MSK-64. The installations essential for nuclear safety are designed to withstand the safe shutdown earthquake, the remaining installations the operating basis earthquake.

From the above it follows that external impacts relevant for the Temelín Nuclear power plant site cannot influence its nuclear safety and cause an unplanned escape of radioactive substances into the environment.

2.7.2.2. Reference Accidents Considered by the Supervisory Bodies for Evaluation of Possible Radiological Impacts in Case of Unplanned Releases of Radioactivity

Two accident cases with releases into atmosphere were selected:

- accident due to rupture of the largest dimension piping of the primary circuit – LB LOCA (event with tight containment) – part 15.6.5.1. of the Safety Report
- accident due to rupture of the TK piping for coolant bleeding, connected to the primary piping, which passes through the containment (event with containment bypass) – part 15.6.2.4. of the Safety Report

as well as one case with releases into the water environment:

- defect of the tank for concentrated radioactive liquid wastes – part 15.7.3. of the Safety Report

  In the Supplement of the preliminary safety report, also faults on the internal side of the steam generator were considered, allowing for a bypass of the containment via the secondary circuit, which however did not qualify for including into the reference accidents category.

2.7.2.3. Description of the Accidents Considered and the Reasons for Their Selection

A detailed description of these accidents is given in Chapter 15 – Safety Analyses of the Safety Reports, and a brief description of their time evolution inside the power plant is given in chapter C.V. – Description of Operation Safety Risks of EIA Temelín, and in the Supplementary Information (1) – Radiological Impacts of Selected Reference Accidents.

The selected reference accidents belong to the most serious ones for the pressurised water reactors (VVER) and classify as category III. and IV.

The accident of the LB LOCA type, which is caused by an instantaneous complete break of the primary circuit piping of the diameter of 850 mm in a "guillotine" way is usually considered to be the maximal design accident. The probability of its occurrence is usually estimated in the range of 10^{-4} to 10^{-5} per year.

2.7.2.3.1 Maximal LOCA

The loss of coolant accident (LOCA) results from a rupture of the piping constituting the pressure barrier of the primary circuit. It is assumed that the rupture occurs on the main piping, at rated, i.e. 100% power output. The first phase of the transient process is characterised by a fast depressurisation of the primary circuit, accompanied by large discharges from the failed loop and almost complete loss of coolant and uncovery of the core. After reaching the pre-set value of water subcooling margin loss, reactor scram follows. At the same time, and additional safety function – emergency injection of coolant – is initiated. Even without the intervention of the reactor scram system, the fission chain reaction stops fast, however, the temperature of the insufficiently cooled fuel rises.

In the course of the second phase, the core is cooled from the hydro-accumulators and from the high and low pressure emergency cooling system of the core. The cessation of water discharge from the hydro-accumulators together with the formation of steam results once again in a decrease of water level in the reactor. In the third phase of the transient process, the core is uncovered the second time, which results once again into an increase of the fuel temperature. The volume of liquid in the circuit increases due to the high pressure and low pressure emergency injection until the core is flooded again. Thereby, the increase of temperature is discontinued. In the course of the long time cooling, the temperature of the core decreases to the stable equilibrium temperature corresponding to the intensity of cooling and to the developing residual heat.

In terms of releases of radioactivity it is important that two of the four barriers retain their function (fuel structure and containment). Releases of radioactivity to the environment is determined by the released radioactive substances and the allowable rate of leaking of the containment. The analysis of this impact is based on highly conservative assumptions about the released radioactive substances and the state of the containment after the loss of integrity of the primary circuit. The central task of the analysis of this impact is the detailed modelling of spreading of the radioactive plume outside the Temelín Nuclear power plant.

The reason for choosing the maximal LOCA as a reference accident is obvious – out of the wide range of analysed events, this failure represents a design accident with breaking of two protection barriers and with the largest escape of radioactive substances. Although, according to the US regulations, its occurrence is not expected during the lifetime (Category IV.), this analysis provides a good picture about the impact of the Temelín Nuclear power plant on the environment in the event of a large design accident.

2.7.2.3.2 Rupture of a Pipe of TK System for Coolant Bleeding from Primary Circuit

Several small pipe lines of the Nuclear power plant drain or could possibly drain the primary coolant out of the protective envelope (containment). These include the piping for taking of samples, piping for measurements, piping of the refilling system and boron regulation, piping of the main circulation pumps seal water, and the piping of the system of controlled escapes from the primary circuit. The reference event considered is the rupture of a pipe of the TK system for bleeding of coolant from the primary circuit of one of the considered piping systems.

The bleeding pipes of the system of normal refilling and boron regulation of each of the four cooling loops of the reactor are connected to a common collector pipe leading outside of the containment. These pipelines are equipped by discharge limiters on each branch, which control the discharge of the medium from the primary circuit to the collector pipe. Next to these limiters on each of the piping branches, the total bleeding discharge is controlled by bleeding control valves. Under normal conditions, one of these valves is in operation and regulates the discharge, while the one which is not regulating is closed. The regulation is set such that the valve bleeds out 30 m^3/h, although higher discharges are admissible. The warning signal system of the radiation monitoring system and other indicators, such as the indicator of water level in the rooms around the containment, make it possible for the operator to detect the rupture and to locate it. The collector piping is fitted with three closing values which can be closed to separate the piping in case of a rupture outside of the containment. This pipeline can thus be separated by the operator also in the case of a simple defect of the closing function of one of the values. As soon as the rupture is detected, the operator closes the closing values to effectively terminate the event. With respect to the equivalent size of the crack, the event is classified as ANSI Category III event.

This accident was selected as a reference event because it represents the limit risk of radioactivity released out of the containment. As the water escaping from the primary circuit has a high pressure and temperature, it splits under the atmospheric pressure of the containment structures into the vapour and the liquid phase at a temperature of 100°C. The escaping substances form, depending on the atmospheric conditions, an expanding radioactive plume.

2.7.2.3.3 Accident Involving Escape of Radionuclides into Water Ecosystems

Escape of radionuclides under normal and extraordinary operation, including accident states, up to the level of the Maximal Design Accident of the Temelín Nuclear power plant are included in the controlled operational discharges. Within the Temelín Nuclear power plant, there are a large number of tanks in which liquid radioactive waste is stored. However, in terms the potential risk, the storing tanks of concentrated radioactive waste play a decisive role. Under operation, more than 90% of the total radioactivity present in liquid substances in the Temelín Nuclear power plant is in these tanks.

A destruction of these tanks located in the Auxiliary Equipment Building (AEB) caused by the safe shutdown earthquake (SSE, probability of occurrence 10^{-4} per reactor year) was selected as the reference accident including an escape of liquid waste, including, next to the above event, also a further simple failure of the technological equipment (probability 10^{-2} per reactor year) such that the radioactive substances are transported towards the given point.

The reason for choosing this event is that this accident represents the highest risk of escape of radioactive substances into the hydrosphere. However, the total probability of incidence of the above scenario is only 10^{-6} per reactor year.

2.7.2.4. Evaluation of Radiological Impacts of the Reference Accidents

The first two reference accidents represent a risk of escape of radioactive substances into the atmosphere, while the third reference accident constitutes an “envelope” of the risks of radiological impacts on the hydrosphere. The basic procedure of evaluation of radiological impacts on the environment is the same for all of the considered cases:

- determination of the inventory of radionuclides released as a result of the accident considered,
- determination of the magnitude of releases from the Temelín Nuclear power plant,
- calculation of spreading of the radionuclides in the surrounding environment,
- determination of the critical population group and calculation of effective doses,
- calculation of effective doses in selected directions at the border with Germany and Austria.

2.7.2.4.1. Releases into the Atmosphere

The model and the parameters used for atmospheric diffusion

The spatial distribution of concentration of radioactive substances spreading out to the surrounding of the power plant in the event of an accident is solved by a standard diffusion (Gaussian) model, modified by the so called box or semi-box method. Using this approach, the volumetric activities of the considered radionuclides in the air can be predicted. Considering further phenomena (decay, dry fall-out, washing out, re-suspension), areal activities can be determined.

Using conversion factors, the volume and surface activities can be converted into the effective doses and the equivalent doses of the thyroid gland.

Five possible routes of irradiation of humans are considered in the calculation of effective doses for radioactive releases to the atmosphere:

- external irradiation from the radioactive cloud,
- external irradiation from the contaminated ground,
- internal irradiation due to inhaling the air,
- internal irradiation due to inhaling the re-suspended radionuclides,
- internal irradiation due to ingestion of contaminated food.

Conversion factors for calculation of doses from inhalation and ingestion are specified in the State Office for Nuclear Safety regulation No. 184/1997 Coll., which is in compliance with the recommendations of the International Commission for Radiological Protection (ICRP).

Computer Code

The computer code HERALD was employed to calculate the transport of activities in the atmosphere, effective doses and the doses of the individual organs of an individual person and the collective doses of the population.

All codes used to predict the radiological impacts of accidents were duly verified in the necessary extent pursuant the guideline VDS-030 of the State Office for Nuclear Safety.

The program HERALD was officially recommended for use in the safety documentation by the decision of the Evaluation Commission of the State Office for Nuclear Safety on October 19, 1999. The algorithm was compared on two model examples with similar codes used in the

Czech Republic (HAVAR) and Slovakia (RTARC). HERALD is similar to the code COSYMA recommended in the EU.

The algorithm considers:

- the altitude of the point source approximated as constant in four time intervals
- constant wind direction and speed within a sector of 22.5°
- six Pasquill weather categories (A-F)
- 137 radionuclides (of fission and corrosion origin) selected according to specified criteria (specific activity in the 1st circuit and half-life)
- influence of the shape and roughness of terrain on the rate of dry fall-out
- calculation at 20 points (0.5 – 100 km) from the source
- five routes of irradiation of humans
- six age categories for computation of doses
- calculation of the dose for a selected time period
- calculation of collective dose in a sector

Assumptions of the evaluation of releases escape routes, time evolution of releases, amount and physical and chemical forms of the escaped radionuclides

Source term

Source term is the activity that can escape to the surroundings in the event of an accident. It is determined by the primary circuit coolant activity, which is a sum of the activities of:

e) corrosion products in the coolant,

f) tritium,

g) the coolant itself,

h) activated aditives in the coolant,

i) fission products from the fuel due to untightness of the fuel cladding.

For the accident LB LOCA, where the fuel cladding is assumed to loose hermetic tightness, the source term is made up mainly of the activities of fission products under the fuel cladding.

The balances of activities of fission products (FP) in the core are solved by the INVAZ code, while the inventory of FP present in the whole core is obtained from the results of these computations using the code MICHUNI. The balance of tritium in the fuel is solved separately by the code TRIPAL. The temperatures, pressures, flow velocities and coefficients of removal of the activity from the containment volume (as a result of spraying, sedimentation) are calculated by the code HEPRO. The passage of the FP activities through the containment is solved by the program CONT based on the balances in the core obtained by the MICHUNI code and on the description of flows and removal provided by the HEPRO program. Next to the balances of activities in the hermetic zones and the instantaneous velocities of releases of the activities, also the integrals of the balances of the activities are evaluated, based on which the program PROSMOB establishes the source term for the analysis of the transport of the activities in the atmosphere.

a) LB LOCA accident due to rupture of the maximum section piping of the primary circuit

The accident process in the containment is initiated by an outflow of the primary coolant from the main circulation piping broke, characterised by the time history of its discharge and enthalpy. Both of these time histories were derived from the numerical data file supplied by Westinghouse. The parameters of containment vapour and air mixture reach a maximum at the time of approximately 20 s amounting for 0.47 MPa and 139 °C. A second, somewhat lower maximum at about 50 s has the values 0.425 MPa and 134 °C. The time 4800 s of the end of outflow was chosen such that the total content of water and vapour in the containment corresponds in terms of mass to the sum of the initial quantities of water in the primary circuit including the water content in the pressuriser, in the hydro-accumulators and in the tanks for emergency cooling.

The analysis of the radiological consequences of the maximal LOCA is based on the conservative assumption that due to the temperature shock, 100% of the fuel rods will loose their hermetic tightness. The assumed leaks of the containment through which the radioactive substances escape to the neighbourhood of the power plant were defined by the allowable rate of leaking over 24 hours in the event of a large LOCA (0.1% of the total mass of the vapour and gas mixture content in the hermetic space at the beginning of the accident, at the maximum accident design pressure of 0.49 MPa and initial temperature up to 150 °C).

To evaluate the radiation impact of the surroundings due to the escapes from the full-pressure envelope, a two-zone model was employed. The first zone includes the complete hermetic volume of the containment. Escape of primary coolant and spraying are considered in this zone, as well as all accumulated heat, except for the outer envelope itself. The second zone is the neighbourhood of the containment with a constant pressure of 0.1 MPa. Connection of these zones is by leaks of the containment.

The initial temperature of all walls was assumed to be 60 °C. With respect to the time evolution of the parameters after LOCA (in particular of the intensity of condensation on the walls an the related removal of fission products from the containment environment), this value is conservative, as in reality, the walls will often be cooler. Spraying is assumed to begin with a delay of 60 seconds after the instant when the pressure in the containment exceeds 0.11 MPa, and to end when the pressure decreases below 0.08 MPa. A 65 % efficiency of spraying is assumed. Only one of the spraying pumps is considered to operate. After using up of the provisions of water in the tank, the suction of the spraying pump is switched to take off fluid through a cooler from the collector sump of the containment. Spraying continues without interruption, reaching underpressure in containment can be expected after about 6 hours.

A number of highly conservative assumptions were taken in calculating the radioactive inventory released in the course of a large LOCA:

- All fuel is at the time of the accident in the state of maximal design burnout, which it attained under the rated power output, neglecting the time of shutdowns (60 MWd/kg).
- Due to the temperature shock, 100 % of the fuel rods loose their hermetic tightness.
- A “conservative” inventory of the core is considered: enrichment of 5%, and H_3BO_3 concentration of 5.72 g/kg.
- All gaseous and volatile fission products present in the free volume of the fuel rods are assumed to escape instantaneously.
- Neither sedimentation, nor removal of the inert gasses by spraying are considered.

The source term for calculation of the escaped radioactive substances includes the radionuclides contained in the water of the primary circuit at the instant of the accident. However, the dominant part of the source element is the escape of all gaseous and volatile fission products that are at the instant of the accident under a high pressure below the cladding of the fuel rods. The formation of tritium (T) in the undisturbed fuel is considered to occur as a result of fission of heavy nuclei into three parts. In the balances of activities inside the containment, removal of radioactive nuclides by vapour condensation on surfaces, gravity fall-out of aerosols and removal by spraying are considered.

The activities release from the fuel at a constant rate for a period of 800 s. Over this time, all of the considered radionuclides escape. The released fractions for the individual chemical groups are specified. Releases from the containment end at the time of 21591 s ˜ 6 hours (when underpressure is reached). The rate of releases of activities of the individual radionuclides can be obtained from the integral value of the radioactivity releases.

j) Rupture of a pipe of the TK system for coolant bleeding from the primary circuit

The leakage from the bleeding pipe outside of the containment would be limited to 30 m^3/h by the control valves TK81S02 and TK82S02, which are designed to regulate the normal bleeding discharge between the high pressure primary circuit and the low pressure system of normal refilling and the boron regulation. A crack outside of the containment combined with a discharge in the opposite direction would, however, result in a full opening of both of the valves. Therefore, it is conservatively assumed in the analysis that both of the control valves are fully open, whereby the amount of 65 tons/hour flows through each of them, so that over 30 minutes, the maximal discharge through the crack of 65 tons flows out through the two valves. This value is connected with the conservative assumption that the bled discharge can be sufficiently cooled to prevent overboiling in the valve mouth. It is assumed in the analysis that the rupture is detected and separated within the above time interval.

The balance of activities present in the primary circuit coolant constitutes the basis for establishing the source term – i.e. the inventory of activities, which release into the surrounding environment during the accident. In the assessment of the environmental impact of the analysed failure, corrosion products, tritium, products of the activation of H_2O itself, products of activation of the coolant aditives, and fission products were considered in the extent corresponding to the limit values for maximal allowable number of non-hermetic fuel rods specified in the Limits and Conditions. Considering the above, a total of 109 fission product radionuclides and 28 activation product radionuclides were identified in the primary circuit coolant.

For the analysed event, the ventilation system function is conservatively neglected. It is assumed that an open door of the containment structure allows for a free escape of the gaseous phase. It is further assumed that the coolant flowing out has the parameters of the primary circuit (in reality, the temperature of the coolant flowing out would be significantly lower). The coolant flows out into the space around the containment structure. The medium flowing out divides under the atmospheric pressure and the temperature of 100 °C into the gaseous and the liquid phase. It can thus be conservatively derived (from the isoenthalpic process) that 40% of the medium will be gas and 60% water. It is further assumed conservatively, that all activities contained in the coolant will be released from the gaseous phase into the environment. 100% of the inert gases are assumed to escape from the liquid phase, while 10% of the activities will release in the case of the remaining radionuclides.

The activity of the coolant corresponds to the maximal activity value specified in the Limits and conditions, with which the reactor may be operated (about 3 orders of magnitude higher that the normal value). An iodine spike is assumed due to the pressure drop, which results into a twenty-fold increase of iodine concentration. No favourable decrease of the coolant activity during its flowing out is considered.

Doses for adults and children

In the calculation of doses for both of the accident cases, it is conservatively assumed that the population is unprotected in a free area for the whole time of the cloud passing over, and the whole time of deposition (2 to 7 days) and that the deposed activity decreases only due to decay, and not due to secondary processes (wash-out, etc.).

Considering the weather category F in the computation of concentrations and doses, which yields the highest values, is also a conservative assumption.

It has been shown in the Safety Reports that the acceptability criteria for evaluation of radiological impacts of accidents are met in all cases:

- for Category II events (extraordinary conditions) – 12.5 mSv over 50 years
- for Category IV events (accident events) – 50 mSv over 50 years

It can be summarised that a number of conservative assumptions are introduced in the computations of doses of the population, which many times exceed the uncertainties and inaccuracies of the calculations.

Evaluation of results, i.e. doses on the border with Germany and Austria

The tables of the documentation give the results of calculation of doses for the selected reference accidents for five points (A – E) along the border with Austria and two points (F, G) on the German border.

The maximal values of the effective dose over a year of a child are around $2.4 \cdot 10^{-4}$ Sv and the maximal equivalent dose of the thyroid gland of a child over a year is $2.07 \cdot 10^{-5}$ Sv. In the case of the effective dose, the value corresponds to about 1% of the dose from the nature background received by an inhabitant of this area in a year.

The calculation results show that the doses on the border with Germany and Austria obtained for the selected reference accidents are very small, approximately at the level of 1% of the natural background per year.

Doses in the Czech territory

As can be seen in the chart attached, the highest doses in the territory of the Czech Republic (for children up to 1 year of age) at the border of the protection zone (about 2 km from the NPP) for the above accident events of Category III and IV are about two orders of magnitude higher, which corresponds to the dose from the natural background in a year.

Collective doses (man – Sv) in the event of accident were calculated in the Czech territory separately for the individual wind direction sectors. The maximal value was obtained for the sector leading across the city of Ceské Budejovice, being lower that 10 man – Sv; in the remaining sectors, the collective doses are at least five times lower.

Based on the above results and considering the risk factors recommended by international authorities, latent somatic diseases are not expected to occur in the territory of the Czech Republic as a result of the accident situations related to the Temelín Nuclear power plant project.

Collective doses in the neighbouring states were not predicted as demographic data were not available. However, these values of collective doses can be expected to be several times lower than in the Czech Republic, and therefore also in the neighbouring countries, no occurrence of neither acute nor latent somatic diseases due to accident events at the Temelín Nuclear Power Plant can be expected.

2.7.2.4.2. Releases into the Hydrosphere

Rupture of the liquid radioactive waste tank

Escape routes

The accident involves breaking of the storage tanks that contain more than 90% of the radioactive liquid wastes in the power plant, for which isotopic composition is available.

The accident scenario conservatively assumes migration of the liquid radioactive media through the installation networks of the plant to the waste water sump, and consequently by two possible routes to the recipients.

All of the exposition routes are considered in the calculation of the effective dose in the event of escape to the water environment:

- direct irradiation (transportation, sports, activities)
- direct ingestion
- fishing (water flora, fauna, sediments)
- routes via soil ending in drinking of milk (irrigation, soil, flora, fauna)

Simple formulae for the amount of activity and its dilution are employed for the escape into the water environment.

Assumptions of the computation

A rupture of all of the four operation tanks is assumed, and a duration of the escape of 100 hours is considered. The nuclides spectra is represented by the most significant radionuclide ^{137}Cs. A conservative assumption is taken that the considered individual from the critical population group will drink only the contaminated water from Vltava for a period of 10 days.

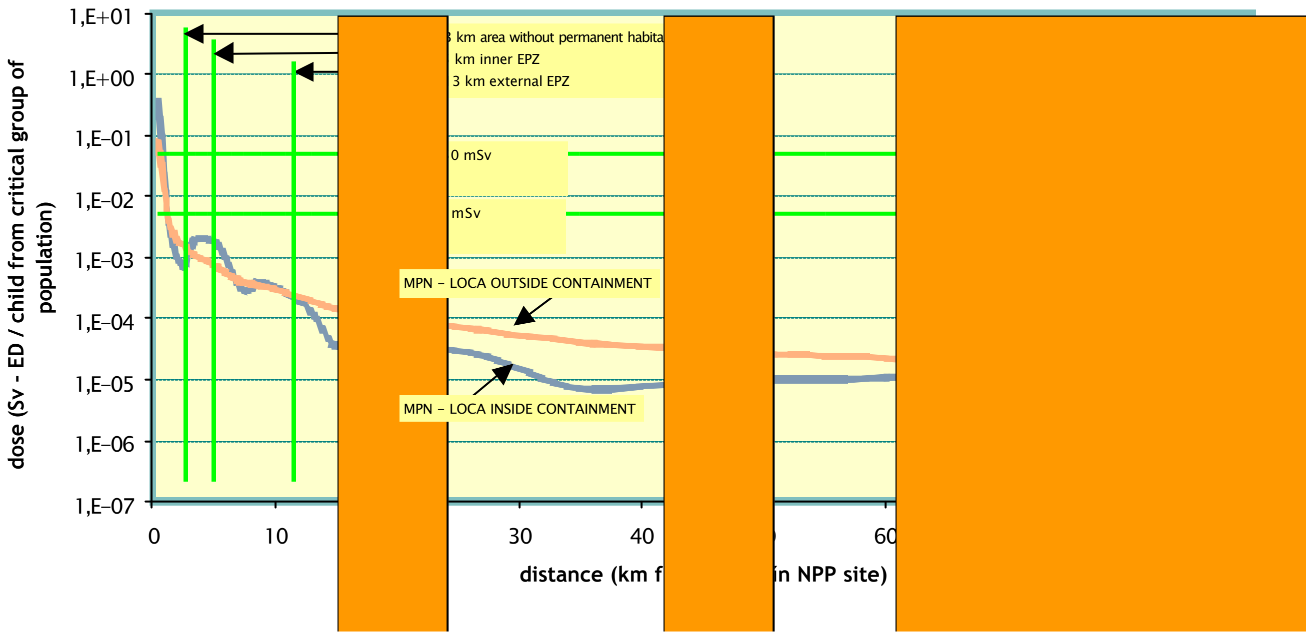
Calculation of doses

Even under the above conservative assumptions, the resulting dose of the maximally endangered individual is much lower than the dose from the natural background in a year.

There is no risk for the population of the neighbouring countries, as the area is in a watershed drained to the North Sea.

Graph No. 13

Graph of Dose against Distance for Reference Accidents at Temelín NPP (WSW direction)



2.7.3. Emergency Plans

The possibility of risk to Temelín Nuclear power plant personnel, the local population residing in the area around the nuclear power plant and the environment by ionising radiation from radionuclides that escape during a very low probable accident, brings about the necessity for emergency preparedness for the region, determined by the possible reach of the effects. Emergency planning and preparedness form the last level of defence in depth protection, which was accepted in the nuclear power industry as the fundamental safety philosophy. To attain emergency preparedness it was thus necessary to draw up and implement the possibility of immediate initiation of protective measures:

- by the Temelín NPP on-site emergency plan,
- by determining the emergency planning zones in the area around Temelín NPP,
- by the off-site emergency plan for the area around Temelín NPP,
- by determining the intervention level to individual measures and radionuclides,
- by the monitoring plan upon a nuclear accident with radionuclide release.

2.7.3.1. Brief description of intervention levels established for different types of protective measures

The **action (intervention) level** used for calculating and establishing emergency planning zones comes from IAEA recommended values, contained in International Basic Safety Standards, No.115, 1996 and are part of Regulation 184/1997 Coll.

It is necessary to introduce urgent protective measures according to basic action levels, if otherwise irradiation of individuals would lead to immediate damage to health, i.e. if the expected dose equivalent without these measures would exceed the value of action levels given in the following table during the course of 2 – day exposures:

Organ, tissue	Expected dose equivalent [Gy]
Whole-body irradiation	1
Lungs	6
Skin	3
Thyroid	5
Crystalline lens	2
Gonads	1

Urgent protective measures, i.e. sheltering and iodine prophylaxis, possibly also evacuation is advantageous to introduce for the critical group of the population to limit or divert the dose from irradiation if the dose during the course of 7 – day exposures in this group would lead to exceeding the lower limit of the action level interval, when considering the feasibility and costs and even other consequences. Upon exceeding the upper limit of the action level interval introduction of urgent protective measures is essential.

Protective measures	Effective dose	Dose equivalent in individual organs or tissue
Shelter and iodine prophylaxis	5 mSv to 50 mSv	50 mSv to 500 mSv
Population evacuation	50 mSv to 500 mSv	500 mSv to 5000 mSv

For introducing and evaluating the efficiency of urgent protective measures the following optimised action levels are given:

- for sheltering no longer than 2 days, if the value of diverted effective dose is 10 mSv
- for iodine prophylaxis, if the value of the diverted effective dose on the thyroid, caused by iodine radioisotopes is 100 mSv
- for evacuation no longer than one week, if the value of diverted effective dose is 100 mSv

Follow-up protective measures, i.e. restricting consumption of contaminated foodstuffs, water and feed for livestock and possible relocation of residents are introduced to divert effective doses or dose equivalents, obtained in 1 year, if comparison of doses when not enforcing protective measures, would show that by obtaining these doses the action levels would be exceeded.

Protective measures	Effective dose	Dose equivalent in individual organs or tissue
Regulation of distribution and consumption of contaminated food, water and feed	5 mSv to 50 mSv	50 mSv to 500 mSv
Population relocation	50 mSv to 500 mSv	500 mSv to 5000 mSv

The following action levels are given for making decisions about relocation of residents:

- for starting time limited relocation, the value of diverted effective dose for 1 month is 30 mSv
- for the duration of time limited relocation, if the value of diverted effective dose for 1 month is 10 mSv ; in the case that the effective dose over 2 years does not drop over the action level for the duration of time limited relocation, permanent relocation is considered
- for permanent relocation, a lifetime effective dose of 1 Sv is the decider

In Regulation No.184/1997 Coll. action levels of mass or volume activity of radionuclides Sr 90, I 131, Pu 239 a Am 241, Cs 134, Cs 137 and overall for other radionuclides with a half life greater than 10 days are given and also in effect.

For benchmark evaluation of the radiation situation action levels are used, taken from IAEA TECDOC 955 for the ascertained value, e.g.:

- dose rate from a passing cloud, containing escaped radionuclides

(effective for shelter and evacuation) 1mSv/hour

- dose rate from a passing cloud, containing escaped radionuclides

(effective for iodine prophylaxis) 0.1 mSv/ hour

- dose rate from a deposit, containing escaped radionuclides

(effective for shelter and evacuation) 1 mSv/ hour

- dose rate from a deposit, containing escaped radionuclides

(effective for relocation) 0.2 mSv/ hour

- mass activity I 131 (effective for food consumption restrictions) 100 Bq/kg in milk, drinking water and in kids food, in other foods 1000 Bq/kg
- mass activity Cs 137 (effective for food consumption restrictions) 1000 Bq/kg

2.7.3.2. <u>Brief description of emergency planning arrangements, including the emergency planning zones adopted for the installation</u>

The **On-site Emergency Plan for Temelín Nuclear power plant** was drawn up according to Act No.18/1997 Coll. and the relevant regulation No.219/1997 Coll. and its proposal was submitted to the State Office for Nuclear Safety, together with the proposal for establishing the size of emergency planning zones for Temelín Nuclear power plant, processed according to requirements of the Czech government Regulation No. 11/1998 Coll. The State Office for Nuclear Safety approved the on-site emergency plan for Temelín Nuclear power plant on 16.12.1999 and the emergency planning zone by its decision No.311/1997 from 5.8.1997.

The operator of Temelín Nuclear power plant provided local authorities in Ceské Budejovice with documents necessary for processing the off-site emergency plan for the district, according to the Ministry of the Interior regulation No.25/2000.

Emergency planning zones for Temelín Nuclear power plant were established by the State Office for Nuclear Safety in accordance with the recommendation of the IAEA, contained in the IAEA-TECDOC-953 (1997) document. According to this recommendation the region around Temelín Nuclear power plant is divided into delimited and permanently uninhabited parts which are directly controlled by the operator of the nuclear power plant (about 2 km) and the outer area divided into three zones – emergency planning zones labelled as:

- the inner part of the emergency planning zone for measures for preparation and implementation of evacuation of the population, zone of precautionary measures, which are automatically made effective
- external part of the emergency planning zone for measures for notification to authorities and organisations, and for warning the population and for sheltering, iodine prophylaxis and regulation of the movement of people, zone of immediate measures,
- zone of subsequent measures

All preventive measures automatically implemented in the first zone nearest to the nuclear power plant, such as iodine prophylaxis and shelter are implemented either in advance (upon delayed release after an accident situation initiation) or shortly after the escape of radionuclides from the broken down nuclear power plant and their task is the significant reduction of risk of irradiation and prevention of doses, which could have serious impacts on health. For average conditions of dispersion in the atmosphere the size of this zone covers the occurrence of 90% of serious health consequences.

In the second zone the emergency plan defines detailed conditions for reducing the risk of serious impacts to health by immediate introduction of effective protective measures according to the results of monitoring the radiation situation in the environment, which are sheltering, iodine prophylaxis and possible evacuation. Under specific circumstances the introduction of these measures for reducing dose can be limited only to part of the area of the second zone, or, during serious accidents the immediate introduction of these protective measures on the other hand can be extended even past the border of this zone. The size of the second zone represents the area where for average conditions of dispersion in the atmosphere the size of the first zone and this zone covers the occurrence of 99 % of serious health consequences.

In the third zone the external emergency plan entails preparation for effective introduction of subsequent protective measures for reducing the risk of serious and late impacts on health from longterm dose load, caused by irradiation from deposits on the earth’s surface and intake of food from local natural sources (plants, or animal products from animals fed on plant fodder from local sources). Introduction of protective measures follows results of longterm monitoring of irradiation and monitoring contamination of the food chain and consists in possible relocation, limitation of the intake of food, originating from local sources and by measures in agricultural production.

Pursuant to government Regulation No.11 from 9.12.1998 the nuclear power plant operator provided the following documents to the State Office for Nuclear Safety as basis for establishing emergency planning zones

- description of possible accidents, which could occur with a possibility equal or greater than 10^{-7}
- description of the course of the accident and the size of the region in which consequences of the accident can occur
- specification of possible consequences of these accidents, including irradiation of persons, evaluation of the possibility of exceeding action levels for urgent protective measures.

The operator of the Temelín Nuclear power plant obtained a description of possible accidents which can occur with a probability equal or greater than 10^{-7} from PSA 1., by analysis of emergency sequences with the greatest frequency and consequences with the highest importance according to results of PSA 2., i.e. with the highest source term weighted by frequency.

According to this analysis the most significant sequences are:

- large LOCA connected with a failure of the emergency core cooling system, (the function of other emergency systems remains intact).

- large leakage from the primary to the secondary circuit (steam generator), if cooling and depressurising of the primary circuit does not take place, with electrical supply failure and with serious damage to the core.

Other sequences, fulfilling the probability criterion and simultaneously leading to leakage of radioactive material, are characterised by more moderate and much longer time course and lower source terms.

The State Office for Nuclear Safety assessed the consequences of leakages of radioactive material for both selected sequences in combination with possible scenarios of further accident development, by the calculation of distances, when the effective dose equivalents for category D and F of meteorological conditions for dispersion (irrespective of the direction of dispersion) of these releases in the atmosphere reach the level of action levels for introducing urgent measures and set

- the first zone of precautionary measures - 5 km
- the second zone of urgent measures - 13 km
- the zone of subsequent measures - was not defined

In comparison with European practice both zones are set with sufficient conservatism.

Acts about crisis situations, No.238/2000 Coll., No.239/2000 Coll., No.240/2000 Coll., No.241/2000 Coll. and government Regulation No.462/2000 valid from 1.1.2001 created the precondition for a modern solution to emergency planning on a nationwide scale, even if they are not explicitly focused on managing nuclear accidents with radiological consequences and leave the Atomic Act No.18/1997 Coll. necessary space for resolving specific questions of crisis situations in this area.

District authorities and regional administration on the territory where the nuclear power plant is located, develop, according to Act No.425/1990 Coll., district, and regional emergency plans and an **off-site emergency plan.** These authorities have the task of verifying emergency preparedness in their territory and coordinating procedures for managing the impact of a nuclear accident, protection of the population, rescue of persons, providing medical assurance, and further expert and other services. Part of these plans is also a scheme for assuring detailed and advance know-how of all units which take part in the activities of emergency response.

The off-site emergency plan for response during a nuclear or radiological accident according to the Ministry of the Interior Regulation No. 25/2000 contains:

- an information section with features of the territory and assumptions for emergency response,
- an operational section with a description of tasks of individual units and a summary of envisaged measures of emergency response, including notification to institutions and warning the population,

- planned intervention of units of the integrated rescue system,
- implementation of all planned measures of the emergency response and its organisational and technical assurance,
- assurance of public order and safety,

By law local authorities of state administration, the Temelín power plant operator and the State Office for Nuclear Safety are responsible for the compatibility of regional and district, and also off-site emergency plans with the on-site Temelín power plant emergency plan.

In the case of a nuclear or radiological accident the State Office for Nuclear Safety by law is responsible for:

- coordination activities of the nationwide Radiological monitoring network,
- evaluation and predictions of the consequences of an accident on Czech territory, or possibly abroad,
- preparation of expert documentation regarding emergency countermeasures for the decision process at the local, district, regional up to nationwide level and proceed in this way to the nationwide crisis centre of control emergency response measures,
- activity of Czech Contact points, created after Czech entry into the IAEA convention about early notification on the notification of extraordinary events at a nuclear power plant, which assure:
- the issuing and acceptance of notification about nuclear and radiological accidents,
- activation of the State Office for Nuclear Safety emergency response plan
- notification of the nationwide crisis centre and control centre of the Czech Civil defence integrated rescue system,
- notification of the Czech Radiological monitoring network and transmitting the requirements on specific monitoring services,
- notification of the Czech hydrometeorological service and transmitting the requirement on the prediction of dispersion of released radioactive materials in the atmosphere,
- transfer of the recommendations of experts to local or regional authorities, creating emergency staff or operational groups and to the nationwide crisis centre in the case of resolving individual emergency response.

The Ministry of Interior governs the following contact or coordination centres if a nuclear or radiation situation:

- Control centre of the integrated rescue system, which activates emergency response in the nuclear power plant emergency planning zone,
- Control centre of regional (district) Czech police headquarters,
- and is in close contact with:
- the nationwide crisis centre, serving for coordinating rescue activities and is also responsible for organisation and mutual cooperation in this area with neighbouring countries, according to bilateral agreements.

Czech Civil defence and CEZ have access to nationwide radio and television network contractually assured with the possibility of informing the population of the Czech Republic about the occurrence of an emergency situation. Similar access is also assured at the regional level.

The Czech integrated rescue system (police, fire brigade, emergency medical service, Civil defence) is responsible for early notification and warning of the population over the teritory of the Czech Republic.

The task for the operator of Temelín Nuclear power plant is immediate notification of the occurrence of an extraordinary event to the State Office for Nuclear Safety and local authorities in the potentially endangered area. The nature of the subsequent response is dependent from classification of the situation, whose procedure is part of the on-site emergency plan and is liable to State Office for Nuclear Safety approval. This plan also contains a specification of the required activities, necessary for managing the situation according to arisen circumstances.

Pursuant to § 46 of Act No.18/1997 Coll. the Czech Ministry of Health is responsible for creating conditions for providing special medical care at selected clinical workplaces to persons irradiated in a nuclear of radiological accident. For Temelín power plant the regional medical emergency service centre of Ceské Budejovice is used. On a nationwide scale there are 3 specialised clinics: the Burns clinic of the 3rd Medical faculty of Charles University in Prague, the Centre for treatment of persons irradiated or contaminated with radioactive material of the occupational illnesses clinic of the 1st Medical faculty of Charles University in Prague, and the intensive haematological care unit at the Internal clinic of the medical faculty of Charles University in Hradec Králové.

Monitoring the radiation situation after an accident

The Czech radiological monitoring network arose after the Chernobyl disaster and for this situation showed its functionality. The radiological monitoring network was constituted legislatively by the decision of the CSSR government No.62 from 26.3.1987. The Czech radiological network relies on the activity of the National Radiation Protection Institute in Prague (NRPI) and regional centres, equipped with the necessary number of qualified personnel, necessary technology and measurement methodologies.

The Czech radiological monitoring network is coordinated by the State Office for Nuclear Safety. For normal situations it operates in its usual way, where it monitors the current radiation situation and focuses also on the possibility of early detection of emergency situations outside the Czech Republic. In the case of a nuclear accident with radiological consequences it focuses on assessing possible consequences of these accidents. It is made up of permanent parts, operating continuously and standby parts, which only take part in coordination activities when an emergency situation arises.

Parts of the Czech Radiation monitoring network are:

- an early warning network, comprising of 58 measuring points with automatic transfer of measured data; operated by Hydrometeorological institutes, NRPI and the Czech Army,
- territorial TLD network, comprising of 184 measuring points, equipped with thermoluminescent dosimetry, operated by the NRPI,
- local TLD network, comprising of 78 measuring points, located around Temelín Nuclear power plant, operated by Laboratories for monitoring the Temelín power plant environment and the NRPI,
- mobile units (helicopters, automotive technology), operated by the Army and NRPI,
- local network of 11 points, measuring contamination of the air, operated by Laboratories for monitoring the Temelín power plant environment and the NRPI,
- local network for measuring contamination of water and food, operated by Hydrological services and Food inspection,
- network of 11 laboratories, from which 9 NRPI Regional Laboratories and a

Laboratory operated by Temelín power plant

- automatic leak detection system at Temelín power plant in the hermetic zone and in the stack,
- fixed monitors on the Temelín power plant fencing with automatic output

Monitoring environmental elements and links in the food chain in the emergency planning zone during an emergency radiation situation (ERS)

Monitored element	Measured parameter	Number of places for taking samples	Frequency	Frequency of measuring/ monitoring	Required sensitivity of measurement
Atmosphere	Volume activity of radionuclides, which can arise during operation of a nuclear installation or workplace	4 places	Continuously	Once a week	Possibility to set the volume activity for investigated radionuclides, which cause an effective dose during breathing for a period of 1 month at level of 1‰ of the general basic limit
Water	Volume activity of radionuclides, which can arise during operation of a nuclear installation	Public water supplies	Every 6 hours from the start of ERS	Immediately after taking samples	Possibility to set the volume activity lower than 10 Bq/l for individual radionuclides
		1 place under the waste water outlet to the water recipient g (after mixing)	Every 6 hours from the start of ERS	Immediately after taking samples	Possibility to set the volume activity lower than 10 Bq/l for individual radionuclides
Soil	Mass activity of radionuclides, which can arise during operation of a nuclear installation	At least 2 places established by the on-site emergency plan	Every 6 hours from the start of ERS	Immediately after taking samples	Possibility to set the surface activity h lower than 1000 Bq/m^2 for individual radionuclides

Atmosphere + **soil**	Dose equivalent rate of gamma radiation	Points on the monitoring route	At least once every 6 hours from the start of ERS and always after change in wind direction to another 22.5° sector		Possibility to set the dose equivalent rate greater than 0.05 gammaSv/h
		16 places outside the nuclear installation	Continuously		Possibility to set the dose equivalent rate greater than 0.05 gammaSv/h
		16 places at the edge of the nuclear installation	Continuously		Possibility to set the dose equivalent rate greater than 0.05 gammaSv/h
Agricultural products with aboveground watered parts (at least 2 types)	Mass activity of radionuclides, which can arise during operation of a nuclear installation	1 place for each agricultural product	At least 1x every 12 hours from the start of ERS	Immediately after taking samples	Possibility to set the mass activity j less than 100 Bq/kg for individual located radionuclides d
Milk	Volume activity of radionuclides, which can occur during operation of a nuclear installation	1 place in the direction of prevailing winds	At least once every 12 hours from the start of ERS	Immediately after taking samples	Possibility to set the volume activity a less than 10 Bq/l for individual located radionuclides

2.7.3.3. Measures for Interchange of Information with Other Countries

Already in 1982, the former Czechoslovak Socialist Republic signed an agreement with Austria on the treatment of issues of common interest related to nuclear facilities. The agreement concerned in particular the transfer of information to the Austrian side about matters concerning nuclear safety of the installations in Czechoslovakia, namely in relation to commissioning of the Dukovany Nuclear power plant.

Pursuant to the provisions of the above agreement, a number of meetings of experts from both sides took place. At that time, this was a unique agreement between states of different political systems, but in particular with different attitude to nuclear energy. This agreement, first of its kind in Europe, initiated the preparation of similar agreements, e.g. between Hungary and Austria, the former GDR and Denmark, the former USSR and Finland.

The Chernobyl accident gave rise to the need of international regulations on provision of information about nuclear installations. IAEA took up this task and prepared in cooperation with experts from a number of countries two documents:

"Convention on early notification about a nuclear accident", and

"Convention on assistance in case of a nuclear or radiation accident".

Both of these Conventions were adopted by the IAEA General Conference on September 26, 1986 and ratified also by the Czech Republic, Austria and Germany.

Based on the Convention on early notification about a nuclear accident, the bilateral agreement with Austria was amended and extended, and a similar bilateral agreement was concluded with the Federal Republic of Germany.

The Protocol from Melk extends the bilateral agreement with Austria by introducing the "hotline" and the possibility of providing additional required explanatory information, introducing the early warning system and consulting on solutions to the nuclear safety issues and environmental protection.

International communication of information, i.e. to IAEA, World Health Organisation (WHO), World Meteorological Organisation (WMO) and the partners in the bilateral agreements is the task of the Contact Office of the Czech Republic, which is a part of the structure of the emergency preparedness system, and which is held by the State Office for Nuclear Safety.

2.7.3.4 Preparation, Implementation and Results of Emergency Exercises with respect to Other Countries

The emergency exercise of the on-site emergency plan of the Nuclear power plants Dukovany and Temelín take place pursuant to the developed plan, usually a yearly plan, which specifies the focus, purpose, objectives, and extent of the exercise as well as the respective terms or frequency. Emergency exercises of the off-site emergency plan in the zones of emergency planning are prepared and implemented in a similar manner.

The emergency exercise plans of the on-site emergency plan are developed based on exercising:

- intervention instructions for individuals at the respective emergency event levels (at least once a year)
- intervention procedures that coordinate the instructions and the related actions of the

task forces at various emergency event levels, except level 3 radiation accident (at least once a year)

- intervention procedures that coordinate the instructions and the related actions of the task forces in case of a level 3 radiation accident (at least once in two years)

The emergency exercises of the on-site emergency plan are organised in three activity phases:

- preparation: a scenario is developed for the planned exercise, which specifies:
    - the objective, extent and duration of the exercise,
    - the definition of the initiation, type and evolution of the emergency event,
    - the intervention procedures,
    - the appointment of the evaluators and observers of the exercise,
- implementation: the actual execution of the exercise according to the prepared scenario with all the persons responsible for management and performance of the interventions taking part, including the actions of the evaluators or observers,
- evaluation: takes the form of the final report; the reports are archived for 5 years as a document of evaluation of the planned emergency exercise; the exercises performed in a particular calendar year are collectively evaluated and this evaluation is handed over to the State Office for Nuclear Safety; the report on emergency exercise for the event of a radiation accident is handed over without delay; the shortcomings found in the emergency exercises are taken into account in:
- changes, amendments and further elaboration of the emergency plans,
- supplements and amendments of the intervention instructions and procedures,
- training of persons managing or performing the interventions,
- complementing the technical and material equipment.

Beyond the framework of the emergency exercises, also the following is verified:

- functionality of technical equipment, systems and means of communication of the intervening persons for management and execution of the interventions (quarterly),
- functionality of technical equipment, systems and means of communication for warning of the employees and other persons (half-yearly),
- functionality of technical equipment, systems and means of communication for announcing an emergency event and notification about a radiation accident (quarterly),
- functionality of technical equipment, systems and means of communication for warning of the inhabitants in the emergency planning zone in the extent and frequency specified in a special regulation.

Reports are made on verification of the above, which are archived for at least one year.

Emergency preparedness is further proved and documented through:

- the elaborated intervention instruction and procedures,
- contracts ensuring participation of other persons besides the nuclear power plant employees in case of an emergency event,
- system of training of employees and other persons for activities during the incidence

and the course of emergency events,

- verification of all matters that are a part of the system of emergency preparedness.

The on-site emergency plan of the nuclear power plant is reviewed at least every three years. In case of a prospective change of the conditions for the emergency preparedness, the on-site emergency plan of the nuclear power plant is amended or supplemented without delay.

Similar methods are used in developing and holding exercises of the emergency plan for transport (e.g. of the spent fuel). In substantiated cases, the emergency code for transportation may constitute a part of the on-site emergency plan of the nuclear power plant.

Off-site emergency plan is developed to provide for protection of the inhabitants of the nuclear power plant surroundings in the event of a radiation accident, i.e. situations, whereby radioactive substances escaped through all barriers into the environment. Emergency exercises of execution of the off-site emergency plan apply to the zone of emergency planning including a circular territory of the diameter of 13 km from the centre of the containment of the 1st unit of the nuclear power plant, and in particular the inner part of the emergency planning zone formed by a circular territory of the diameter of 5 km including also the communities situated at its border, which represents the area where next to introduction of the regular measures, also prospective evacuation of the inhabitants is planned.

In the emergency planning zone of Temelín NPP, there were by June 30, 1999:

- within the distance of 5 km, including Týn nad Vltavou 9 500 inhabitants, and
- within the distance of 13 km 26 600 inhabitant living.

Emergency preparedness in the zone of emergency planning according to the off-site emergency plan is also verified through an emergency exercise, in which all the persons and institutions take part that are planned to be engaged in the response to an emergency event that may develop into a radiation accident.

Similarly as above, emergency exercises of the off-site emergency plan for the specified emergency planning zone are organised in three activity phases:

- preparation: a scenario is developed for the planned exercise, which specifies:
    - the objective, extent and duration of the exercise,
    - the definition of the initiation, type and evolution of the emergency event,
    - the intervention procedures,
    - the appointment of the evaluators and observers of the exercise,
- implementation: the actual execution of the exercise according to the prepared scenario with all the persons responsible for management and performance of the interventions taking part, including the actions of the evaluators or observers,
- evaluation: takes the form of the final report; the reports are archived for a long time as a document of evaluation of the planned emergency exercise; the exercises performed in the calendar year are collectively evaluated; the shortcomings found in the emergency exercises are taken into account in:
- changes, amendments and further elaboration of the emergency plans,
- supplements and amendments of the intervention instructions and procedures,
- training of persons managing or performing the interventions,

- complementing the technical and material equipment,
- complementing or amendment of organisational measures for emergency response.

Recently, emergency exercises took place at the Temelín Nuclear power plant independently and in the surroundings of the Dukovany NPP in cooperation with the Austrian side. The following activities took place:

Emergency cooperation exercise CEZ – Dukovany Power Plant (DEKO 2000 – May 26, 2000)

Prior to the exercise, a common preparation took place with the institutions of Civil Protection of Lower Austria, Regional Authority of Civil Protection in Brno, County Authorities in Trebíc, Znojmo, Brno – province, and the community of Dukovany. As a part of the preparations, training of inhabitants in the border zone communities in Austria also took place, in which besides others the Dukovany NPP staff also took part. The actual exercise at the Dukovany Nuclear power plant commenced at 02:00 hours by a simulated failure, based on which the CEZ-Dukovany NPP emergency staff of the respective shift was alerted. Resolving the event, with a focus on the flows of information, was completed at the Dukovany Nuclear power plant at 07:00, whereby the simulated failure was managed without an escape of radioactive substances into the environment. To this exercise, an exercise of the community of Dukovany connected, where the community emergency staff was alerted at about 04:15, which then managed the protection of the community inhabitants not only with respect to radiation protection, but also regarding other potential risks (chemical accident, natural disasters).

At 08:00, an exercise of evacuation of the school took place. A part of the exercise was also practising of the transfer of information, in which State Office for Nuclear Safety and the Regional Authority of Civil Protection in Brno took part. Based on the information of occurrence of a simulated failure at the Dukovany Nuclear power plant, the institutions of Civil Protection in Austria were alerted, which managed an exercise in the community of Laa an der Thaya. Within the framework of this exercise, a decontamination station was erected and operated.

Results of the exercise:

The exercise was on the whole successful, fulfilled its objectives and its plan, and showed a good preparedness of the individual institutions of the on-site emergency organisation of CEZ – Dukovany NPP to resolve also events with very low probability of occurrence. Also the system of information transfer to all external institution, including those abroad, was verified.

All time limits for completing the individual actions specified by the on-site emergency plan were met with a large margin, which gives an evidence of a good training of the members of the on-site emergency organisation of CEZ – Dukovany Power Plant.

Emergency cooperation exercise CEZ – Temelín Nuclear power plant (November 30, 2000)

The subject of this emergency exercise was to examine the actions of the Temelín power plant staff in the event of a level 3 emergency event due to technological reasons. The following objectives were set out for the exercise:

- examination of early warning of employees and persons in the danger area,,

- examination of alerting of the shelter group members and members of the emergency organisation of accident response,
- examination of the reactions of the shift personnel to symptoms of an emergency event,
- exercise of the actions of the shift staff in the event of declaration of an emergency event of level 2 and 3,
- examination of communication flows in notifying the state supervisory bodies and the state administration institutions,
- verification of implementation of protective measures for the staff in the guarded area,
- evaluation of the possibility of making prognosis of the estimated escape of radioactive substances to the environment, and of the radiation monitoring,
- making a simulated press conference in the emergency press centre,
- verification of early warning of inhabitants and starting up of sirens in Týn nad Vlatavou,
- examination of the standby system of data transfer from the Temelín Power Plant to the emergency coordination centre of the State Office for Nuclear Safety by means of joint data files set by fax,
- evaluation of the communication links between the emergency coordination centre and the emergency headquarters, and between the regional emergency commission and the emergency headquarters, respectively,
- evaluation of independent assessment of radiation demonstrations of a level 3 emergency event at the Temelín Power Plant.

All of the above objectives were fulfilled in the course of the exercise. The information flows to the external organs and institutions affected by the internal emergency plan functioned without problems. The exercises proved that the shortcomings that occurred in the previous exercise in relation to monitoring have been remedied. The evaluation of the exercise was carried out in the form of a Final Evaluation Report of an Emergency Exercise.

Based on the examinations carried out, it can be concluded:

The evaluation of the radiation impacts of the selected reference accidents of the Temelín nuclear power plant showed that even when making conservative assumptions, the results do not indicate that any danger to the health of the population in the Czech Republic or in the neighbouring countries – Austria and Germany – could arise.

Emergency planning and preparedness are at a high level and fully based on international recommendations and practice, providing a guarantee of their effective implementation in the event of occurrence of an emergency event.

Recommendations:

In the future work, replace the highly conservative assumptions by the best – estimate approach and compare the local computational codes with the foreign ones.

Regular exercises of the emergency preparedness and prospective amendments of the emergency plans are necessary for fast communication of information, action alertness and coordination of emergency measures.

Interpretation of the abbreviations used

ATWS – Anticipated Transient Without Scram

IRRT – International Regulatory Review Team

- an IAEA mission for evaluation of activities and effectiveness of supervisory bodies

IRS – Incident Reporting System

- a world-wide system for reporting of defects of nuclear power plants operated by IAEA and NEA/OECD

LOCA – Loss of Coolant Accident

IAEA – International Atomic Energy Agency (headquartered in Vienna)

NRC – Nuclear Regulatory Commission

- the US state supervision body

PSA – Probabilistic Safety Assessment

PWR – Pressurized Water Reactor

RAMG – Regulatory authority management group

- group of EU supervisory bodies

SONS – State Office for Nuclear Safety ("Státní úrad pro jadernou bezpecnost")

VVER – Water circuit energy reactor (Russian modification of PWR)

WANO – World Association of Nuclear Operators

WENRA – Western Nuclear Regulatory Authorities

Appendix 1

Analysed Events with Moderate Frequency of Occurrence – Category II

1. Erroneous functions of the supply water system resulting in a decrease of its temperature

2. Erroneous functions of the supply water system resulting in an increase of its temperature

Erroneous function of the steam pressure regulator and failures resulting into an increase of steam offtake

3. Unintentional opening of the relief or safety valves of the steam generator
4. Erroneous function of the steam pressure regulator and failures resulting into a decrease of steam discharge
5. Loss of external electric load
6. Turbine fall-out (closing of the shut-off valves)
7. Uncontrolled closing of separation fittings on the main steam mains
8. Loss of vacuum in the condenser
9. Simultaneous loss of both the internal and the external supply of the power plant by alternating current
10. Loss of normal supply of water to the steam generator
11. Failure of one or more of the main circulation pumps
12. Uncontrolled drawing out of the regulating bundles from the core in subcritical state or under a low power output at start-up
13. Uncontrolled drawing out of the regulating bundles at power output
14. Erroneous intervention of the control organs
15. Start-up at a wrong temperature of a loop currently shut down
16. Erroneous functions of the chemical and volumetric regulation system, resulting in a decrease of boron concentration
17. Unintentional start-up of the emergency core cooling during power operation
18. Erroneous functions of the chemical and volumetric regulation system (or erroneous interventions of the operator), resulting in an increase of the amount of coolant in the primary circuit)
19. Unintentional opening of the safety or relief valves of the pressuriser
20. Rupture of the instrumentation pipes or other pipelines of the pressure boundary of the reactor coolant

Appendix 2

Analysed Events with Low Frequency of Occurrence – Category II

1. Spectra of damage of the steam lines inside and outside of the containment (small breaks)
2. Failure of one or more of the main circulation pumps
3. Complete loss of forced coolant flow
4. Erroneous action of the regulating bundles (uncontrolled drawing out of one regulation organ at full power)
5. Unintentional insertion and operation of a fuel set in a wrong position
6. Rupture of the instrumentation pipes or other pipelines of the pressure boundary of the reactor coolant
7. LOCA (small rupture)
8. Failures of the gaseous waste system
9. Postulated releases of radioactivity due to breaking of tanks for liquids (releases to the atmosphere)
10. Postulated releases of radioactivity due to breaking of tanks for liquids (releases to the soil)
11. Accidents due to a fall of the container with spent fuel

Appendix 3

Analysed Limit (Emergency) Events – Category IV.

12. Spectra of damage of the steam lines inside and outside of the containment (larger breaks)
13. Rupture of the feed water piping
14. Rotor seizure of the main circulation pump
15. Braking of the rotor of the main circulation pump
16. Spectra of accidents with shooting out of the regulating bundle
17. Rupture of the steam generator tube
18. LOCA (large rupture)
19. Failures inside the steam generator
20. Design accidents occurring during manipulation with the fuel

3. Nontechnical Summary

The Nuclear Power Plant Temelín has been designed, built and assembled for almost twenty years now. Five villages disappeared, the landscape changed beyond recognition. Some people are afraid. Although the process apparently proceeded within the limits given by the existing law, people were mostly left out of any discussion. New times have brought along new demands on technology and reliability of operation, but also opportunities for the public to express their opinion and sentiments. In addition to people who consider the changes in the power plant to be positive, the voice of those who feel endangered has also intensified. Mutual communication, exchange of opinion, dialogue – all have been felt as weaknesses for a long time.

It is true that potential impacts of the nuclear technology on the environment were examined during the period of power plant preparation and construction. When fundamental decisions about the construction and technology were adopted, no law laying down the necessity of comprehensive assessment of environmental impacts was in place. And when finally the Czech legislators provided a proper legal framework for the environmental impact assessment (EIA) by Act No. 244/1992 Coll. of 1992, they still failed to specify an unequivocal procedure to be followed in instances where a fundamental change on the original project takes place during the construction.

Only the recently entered judgements have however brought about the necessity to deal with the changes effected in the Nuclear Power Plant Temelín over the last several years also from the point of view of requirements included in the EIA procedure. The prime ministers of the Czech Republic and Austria, together with a representative of the European Commission, meeting in Melk in December 2000 reached an agreement *inter alia* on a voluntary and comprehensive examination of the environmental impacts of the Nuclear Power Plant Temelín.

This means that:

- all conceivable impacts of the completion and subsequent operation of the Temelín nuclear power plant will be examined within the EU legal framework,
- the public will be given an opportunity to express opinion of both the documentation describing the current state of the power plant and the assessment of its impacts on the environment and human health, including potential emergencies.

All this in a situation where the power plant has been practically completed and operating tests are already in progress. Time cannot be reversed, though. It is up to all interested parties whether and how to make use of the newly emerging opportunity for dialogue.

Over the last several weeks experts appointed by the government, together with many specialists from various universities, the Academy of Sciences and specialised firms, have prepared an "Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant" ("Assessment"). Considerable attention was devoted to the professional level of the working team members and the necessity to ensure that the appointed experts had not participated in previous projects dealing with environmental impacts of the nuclear power plant. The Expert Commission appointed by the Czech Government worked together with Austrian and German observers and representatives of the European Commission. The prepared draft Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant was then supervised by ten eminent Czech scholars and engineers. Regardless of the circumstances in which the Assessment originated (construction almost complete, tests of technology in progress, activists' protests, …), an unprecedented group of experts was assembled and all necessary data from available sources were collected and made use of. The Assessment is certainly not faultless but should not contain major errors. The public, experts and laymen alike, who are interested in the potential environmental impacts of the Temelín nuclear power plant may now review the arguments collected in the Assessment. Since this is not the standard assessment procedure under applicable Czech law, one should also take into account how to take part in the discussion dealing with the environmental and health effects associated with the Temelín nuclear power plant.

First of all, how to gain access to the complete Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant: it is available in printed form from the following sources:

Chamber of Deputies of the Czech Parliament Prague	District Office Písek Dept. of the Environment Budovcova 207, 397 01 Písek	Hluboká upon Vltava 373 41 Hluboká upon Vltava	Vodnany Nám. Svobody 18/I 389 16 Vodnany
Senate of the Czech Parliament Prague	Czech Environmental Inspection, Regional Inspectorate, Ceské Budejovice Ing. Ladislav Krátký, Žižkova 1 PS 32 370 21 Ceské Budejovice	Vlkov Post Office Ševetín 373 63 Ševetín	Ministry of the Environment – State Administration Dpt. II Ing. Václav Osovský Jeronýmova 1 370 01 Ceské Budejovice
Ministry of Agriculture Prague	Regional Sanitary Station MUDr. Jan Augustin Schneiderova 32 370 71 Ceské Budejovice	Mydlovary 373 49 Mydlovary	Embassy of the Federal Republic Germany Vlašská 19/347 101 00 Praha 1
Ministry of the Environment Prague	State Nuclear Safety Office Ing. Dana Drábová, Senovážné nám. 9 101 00 PRAHA 1	Zahájí Post Office Mydlovary 373 49 Zahájí	Embassy of Austria, Prague Viktora Huga 10 151 15 Praha 5
Ministry of Health Care Prague	Municipalities:	Zliv Námestí míru 10, 373 44 Zliv	Calla – Association for Environment Preservation Fráni Šrámka 35 370 04 Ceské Budejovice
Ministry for Regional Development Prague	Dríten 373 51 Dríten	Dívcice 373 48 Dívcice	DUHA Movement Bratislavská 51, 602 00 Brno
Regional Office, Central Bohemia Region, P.O. Box 59, Zborovská 11 150 21 Praha 5	Temelín 374 01 Temelín 104	Nákrí Post Office Dívcice 373 48 Nákrí	South-Bohemian Mothers Association Ceská 13 370 01 Ceské Budejovice
Regional Office, Budejovice Region, Žižkova 12 371 22 Ceské Budejovice	Týn upon Vltava Námestí Míru 2 375 01 Týn upon Vltava	Bechyne 391 65 Bechyne	Civic Association South-Bohemian Fathers Pražská 1 370 04 Ceské Budejovice
Regional Office, Plzen Region P.O. Box 313, Škroupova 18 306 13 Plzen	Všemyslice Post Office Neznašov 373 02 Neznašov 56	Hodonice Post Office Breznice 391 71 Hodonice	Association of Municipalities in the NPP Temelín Region Jirí Elsenvert, chairman Námestí Míru 2 375 01 Týn upon Vltava

Regional Office, Jihlava Region Palackého 53 586 01 Jihlava	Olešník 373 50 Olešník	Breznice 391 71 Breznice near Bechyne	International Civic Association Ceská 66 370 00 Ceské Budejovice
District Office Ceské Budejovice, Dept. of Environment, Mánesova 3 371 03 Ceské Budejovice	Hosty Post Office Kolodeje upon Lužnice 373 03 Hosty	Záhorí Post Office Breznice 391 71 Breznice near Bechyne	Civil Initiative for Environmental Protection Ceská 66 370 01 Ceské Budejovice
District Office Strakonice, Dept. of Environment, Smetanova 533 386 01 Strakonice	Chráštany 373 04 Chráštany near Týn nad Vltavou	Cenkov near Bechyne Post Office Breznice 391 71 Cenkov near Bechyne	Regional Centre, Czech Association of Conservationists South-Bohemian Association of Conservationists P.O. Box 9 373 16 Dobrá Voda near Ceské Budejovice
District Office Prachatice Dept. of Environment, Horní 164 383 01 Prachatice	Žimutice 373 66 Žimutice 37	Albrechtice upon Vltava Albrechtice upon Vltava 398 16 Albrechtice upon Vltava	Civic Association Prolife Ing. Vl. Hukava, CSc. Písecká 372 391 65 Bechyne
District Office Ceský Krumlov, Dept. of Environment Tovární 165 381 01 Ceský Krumlov	Becice 373 66 Becice	Protivín Masarykovo nám. 12 398 11 Protivín	Civic Association "Close to Temelín NPP", Temelín, Mr and Mrs Vlcek Na sídlišti 494 387 73 Bavorov
District Office Jindrichuv Hradec, Dept. of Environment, Janderova II/147, 377 01 Jindrichuv Hradec	Dobšice 375 01 Týn upon Vltava 1	Ždár Ždár 398 11 Protivín	
District Office Tábor Dept. of Environment Husovo nám. 2938 390 01 Tábor	Horní Knežoklady Post Office Žimutice 373 66 Horní Knežoklady	Tálín 398 15 Tálín	
	Modrá Hurka Post Office Žimutice 373 66 Modrá Hurka	Paseky 398 15 Paseky	
	Dolní Bukovsko 373 65 Dolní Bukovsko	Cícenice 387 71 Cícenice 79	

All who wish to express their opinion of the Assessment, ask a question, make critical comments or simply take part in the discussion may do so by 10 May 2001 by a letter sent to the address of the Secretariat, Commission for Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant. All input will be registered, the expert team will react in its summary opinion and will take it into account in formulating its position for the next meeting of the prime ministers of the Czech Republic and Austria and of representatives of the European Commission, to be held by the onset of summer.

All interested parties may also attend public discussions devoted to the Assessment: either on 25 April 2001 in Ceské Budejovice or (the date is only preliminary) on 9 May in Linz, and communicate directly with the authors of the Assessment. The input from these meetings will be incorporated in the summary opinion and taken into account by members of the Commission for Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant in formulating the final position.

A nontechnical review of the underlying problems cannot naturally replace the comprehensive Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant. All the same, it may inform about the key underlying problems that the authors of the Assessment faced and outline the conclusions contained in the Assessment.

The starting point must be the essentials of the technology employed in the Temelín Nuclear Power Plant. According to the project documentation underlying the results of the Assessment, the nuclear power plant involved will operate two nuclear reactors of power capacity 2 x 1000 MW. The heat necessary for driving the turbine originates from controlled fission of uranium in a reactor installed in a hermetically sealed building (containment). The thermal energy so generated heats water in the primary circuit, completely radiation-insulated from the environment. The heat from water circulating in the primary circuit ("loop") is used to generate steam in a secondary circuit, which then powers the turbine. Steam from the secondary loop leaving the turbine is cooled by cooling water and recirculated in liquid form to the steam generator. The third water circuit serves for cooling water leaving the turbine and gives rise to steam rising from the cooling towers. The technology in its entirety is controlled by three independent systems, each guaranteeing 100-% control – in the event of any defect each of the three systems is able to shut down the nuclear reaction and prevent any contaminants from escaping to the environment.

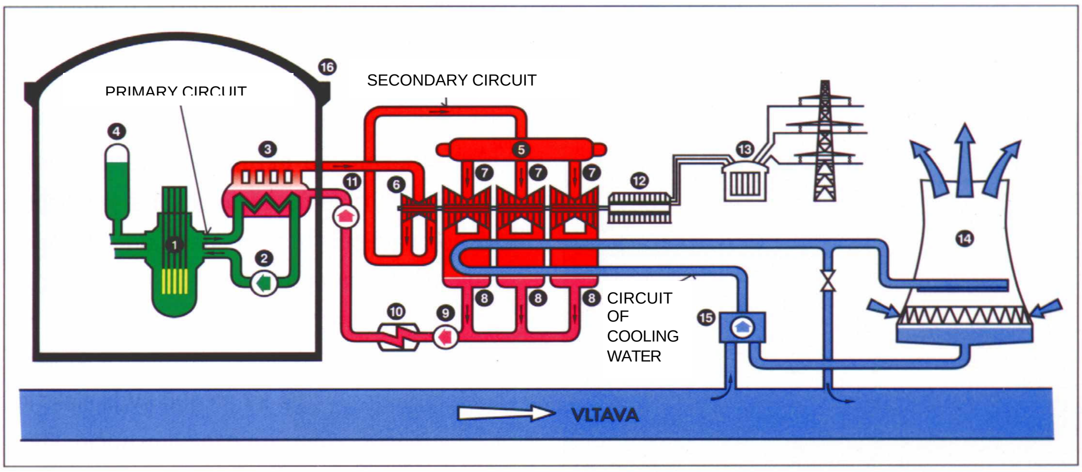


SCHÉMA JE TEMELÍN: 1. Reaktor, **2.** Hlavní cirkulační čerpadlo, **3.** Parogenerátor, **4.** Kompenzátor, **5.** Separátor - přihřívák, **6.** Vysokotlaký díl turbíny, **7.** Nízkotlaký díl turbíny, **8.** Kondenzátor, **9.** Kondenzátní čerpadlo, **10.** Regenerace, **11.** Napájecí čerpadlo, **12.** Elektrický generátor, **13.** Transformátor, **14.** Chladicí věž, **15.** Čerpací stanice, **16.** Ochranná obálka

Nuclear Power Plant Temelín – Schematic Representation:
1. Reactor, 2. Main circulation pump, 3. Steam generator, 4, Expansion joint, 5. Separator – steam reheater, 6. High-pressure side of the turbine, 7. Low-pressure side of the turbine, 8. Condenser, 9. Condensate pump, 10. Regeneration unit, 11. Feed pump, 12. Power generator, 13. Transformer, 14. Cooling tower, 15. Pump station, 16. Containment

The most often asked questions about operation of the Temelín nuclear power plant include the following:

1. Temelín vs. Chernobyl

The physical principles underlying heat generation in a Chernobyl-type reactor and the pressurised water reactor used in Temelín are the same – fission of uranium 235 nuclei by slow neutrons. Important technological and physical differences however exist that affect the safety and possible occurrence of emergencies. Without going into details we want to explain the most significant ones.

Fission of uranium 235 nuclei is caused by the so-called slow neutron capture (capture of neutrons whose velocity has been slowed down to a value corresponding to thermal motion, approximately 1000 metres per second). The existence of such slow neutrons in the nuclear reactor core is essential for the initiation, maintenance and development of the nuclear fission reaction. Neutrons originating from fission of uranium nuclei are however fast neutrons (their velocity is much higher), unable to initiate further fission, and must be first slowed down by passing them through the so-called moderator, most often water, heavy water or graphite. The presence of a moderator in the active reactor zone is thus essential for initiation, maintenance or development of the fission reaction.

And it is in this respect that the two reactor types differ significantly – in the Chernobyl reactor graphite serving as the moderator remained in the reactor after the breakdown and moreover ignited. In the Temelín nuclear reactor water is the moderator and at the same time the coolant. Water escaping from the active reactor zone means a loss of cooling capacity but at the same also extinction of conditions underlying the proceeding fission reaction.

Another important difference consists in that the Temelín primary circuit is encased in a pressure-resistant, hermetically closed containment that insulates it from the environment also in emergency situations. No comparable measures were in existence in the Chernobyl nuclear reactor. There are additional differences, but the aforementioned suffice to make it clear that what happened in Chernobyl cannot happen in Temelín.

2. Nuclear power plant vs. a coal-fired power plant

A nuclear power plant differs from the classical power plant (coal-fired or gas-fired) only in the primary source of thermal energy. Starting at the outlet of steam from the containment the equipment used in the secondary circuit is essentially identical with that employed in classical heat power plants. The thermodynamic efficiency of the secondary circuit of a nuclear power plant is lower by some 3 % than in the classical thermal power plant owing to reduced parameters of steam entering the turbine. This in turn corresponds to a somewhat higher proportion of heat entering the environment (water, air). On the other hand, a nuclear power plant does not produce and release to the environment heat contained in combustion gases leaving through the smoke stack (flue loss), greenhouse gases (carbon dioxide, sulphur dioxide), fly ash and - depending on the primary source of heat (coal) - heavy metals and other contaminants. It is a known fact that emissions of radioactive substances from burning lignite mined in the North-Bohemian basin exceed many times the radioactive substances discharged by normal operation of a nuclear power plant.

3. Turbine-related problems

Problems with the turbine upon commissioning the first 1000 MW generating set were predictable. It was namely not possible to test the turbine under operating conditions – there are no test rooms of appropriate size in the manufacturing plant. It was also not possible to calculate or model some effects beforehand. The behaviour of the set must be observed under operating conditions, analysed and the necessary modifications effected. This is nothing specific to the Temelín generating set, but rather a normal phenomenon that accompanies commissioning of all major generating sets or sets of a new design. The associated problems have however nothing to do with nuclear safety (the reactor, its controlling and safety systems behave as designed) and have no effect on the environment (escaping oil was always retained inside the plant or, in a single instance, in safety systems designed for that purpose).

4. Breakdowns

The power plant design reckons with possible operational defects and provides powerful means aimed at minimising their effects on both the technology itself and, in particular, the environment. The set of defects that the system must handle is based on the specific project solution, is defined by internationally recognised recommendations and is permanently updated on the basis of experience with and analyses of defects and accidents occurring in power plants elsewhere. The technology employed in the power plant is ready to handle the so-called maximum design basis breakdown, comprising a sudden rupture of the cold branch circuit of the main circulation pipeline of 750 mm diameter.

The often discussed problem of the so-called "non-design-basis" emergencies involves the assumption that a serious defect will occur and none of the three entirely independent safety systems earmarked in the project for its liquidation will be operative. Let us attempt to use a not very fitting analogy. It is, although only to a certain extent (since a nuclear power plant and its equipment is not only monitored and tested more searchingly and more often but also has a higher number of independent safety systems), analogous to a situation where we have a major dam, regularly control its state of repair, test its outlet facilities and ask what will happen if it suddenly breaks out of clear sky. How many people will be in jeopardy, how many villages and cities will be destroyed, what chain processes might ensue. In assessing the environmental impact of the dam we would not consider posing such questions.

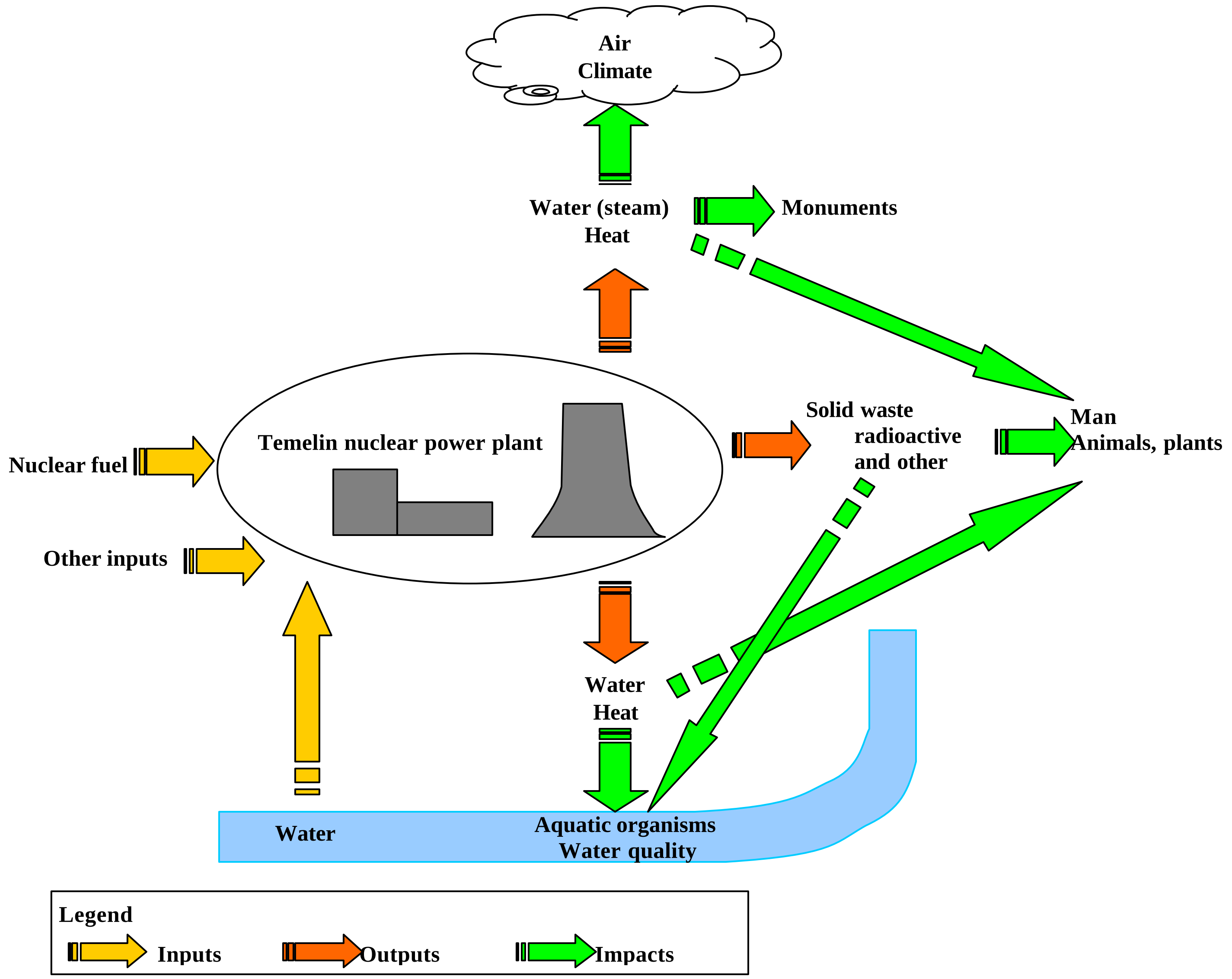
This is closely related to emergency planning. Measures are in place for all events that - if not contained - might have any negative impacts on the environment including humans, aimed at informing and protecting the general public. The underlying system was implemented for the first time in the nuclear energy sector and is at present extended by adopted legislation to other civilisation risks that might be equally or even more dangerous and whose probability of occurrence is at any rate much higher.

5. Spent fuel

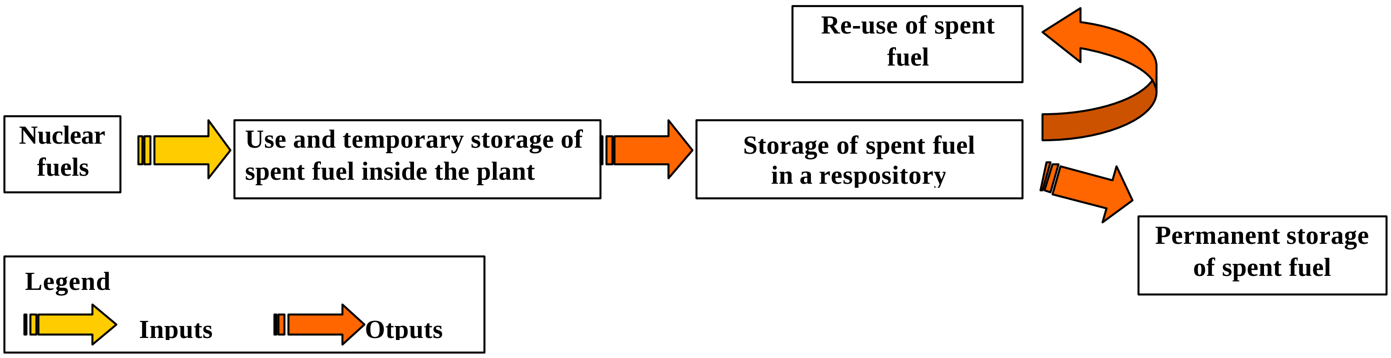
Spent nuclear fuel removed from the reactor is at first stored in a spent-fuel reception pond situated close to the reactor inside the containment. After several years it is moved to an intermediate repository. The Czech Republic reckons with storage in dry repositories in containers either inside the nuclear power plant (as already in the NPP Dukovany) or in a central underground intermediate repository in the Skalka locality. The future of the spent fuel depends on several circumstances. In principle it may be stored in appropriate geological formations. Another possibility involves reprocessing and reuse, with only the highly active components being permanently stored. This has been practised in several states. A third possibility has emerged only recently: use the spent fuel in the so-called sub-critical reactors as a further source of energy, where the content of radionuclides exhibiting very long half-life is at the same significantly reduced. And what further possibilities will emerge after several decades? Simply speaking, spent fuel is not the celebrated straw mattress of the Czech writer Neruda that we are unable to get rid of, but rather a potentially valuable raw material. And this is how it is considered in most states that utilise nuclear power.

Most of the aforementioned problems relate to the issue of nuclear safety. The task facing the authors of the Assessment comprised in particular checking possible effects on the environment of the normal nuclear plant operation as well as of even highly improbable but still conceivable emergencies. The interrelation Temelín nuclear power plant – the environment is shown schematically in the following chart.

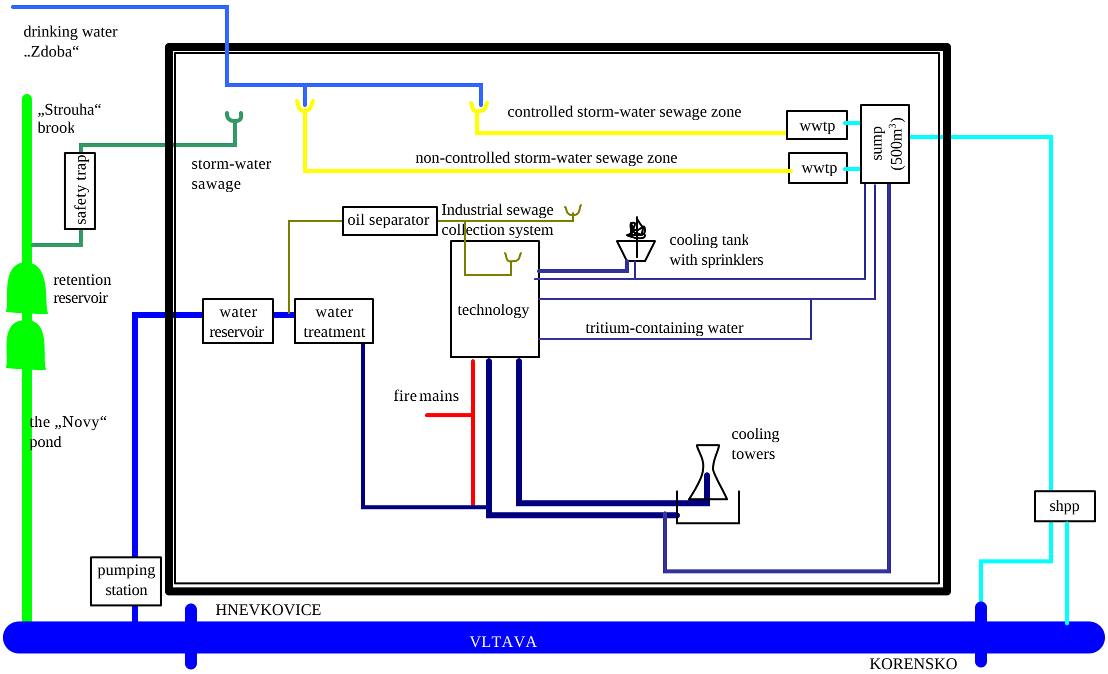
Environment



Fuel



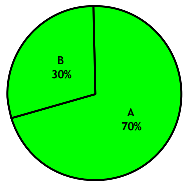
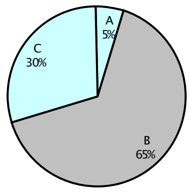
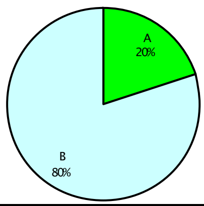
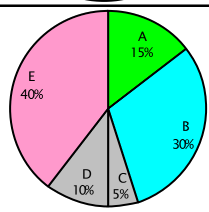
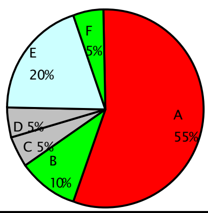
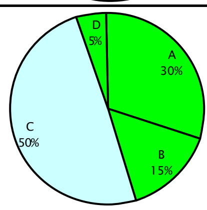
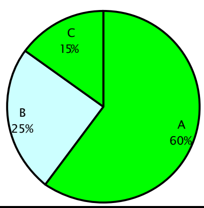
Water



wwtp	waste water treatment plant
shpp	small hydroelectric power plant

The following Table may give the first idea concerning the final results of the Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant.

KEY PROBLEMS OF THE ASSESSED AREAS AND THEIR INTER-RELATED ASSESSMENT

Assessed area	Key problem	Key problem classification - see the Reference Table	Relative importance within assessed areas	Final assessment of area as weighted average of classification
Air and climate	(A) air – introduction of radioactive substances in the environment by discharge (B) climate – potential impact of cooling tower operation on territorial climatic factors	2 2		**2.000**
Hydrology	(A) supply and quality of drinking water (B) supply and quality of industrial water (C) risk of radioactive contamination of a recipient owing to escaping tritium-contaminated water	3 1 3		**1.700**
Soil and rock environment	(A) impact on soil and rock environment (B) seismic security	2 3		**2.800**
Impacts on the population	(A) radiation hygiene – air (B) radiation hygiene – water (C) radiation hygiene – food chain (D) communal hygiene (E) welfare factor	2 3 1 1 4		**2.950**
Nature and landscape (fauna, flora, ecosystems)	(A) impact on landscape feature (B) impact on fauna, flora, ecosystems (C) impact on forests (D) impact on agricultural crops (E) impact on cultural assets (F) impact on tangible assets	5 2 1 1 3 2		**3.750**
Waste (including radioactive and chemical waste)	(A) radioactive waste – liquid (bitumenation) (B) radioactive waste – solid (C) spent fuel (D) other non-radioactive waste	2 2 3 2		**2.500**
Possibilities accident	(A) prevention of accident (B) radiological impact of accidents (C) emergency planning and preparedness	2 3 2		**2,250**
Weighted average				**2,506**

REFERENCE FIVE-LEVEL VERBAL-NUMERIC SCALE

Number of Points: 1 • Risk is almost zero – none • Environmental impact of the design is negligible • Reliability (e.g. seismic resistance) and safety are fully guaranteed • Extent of risk to physical health is zero – none • Risk of population well-being being disturbed is zero – none • Extent of impact on cultural and spiritual values is zero - none • Extent of uncertainty, vagueness and equivocation is the most favourable • Supply of water is at the maximum level possible considering the economic and technical aspects • Quality (e.g. water quality) or solution is extraordinary – above average – progressive • Incidence of contaminants, extent of disturbance, contamination, load and impact are almost zero – none • Balance of demands on inputs is the most favourable	Number of points: 4 • Risk is acceptable • Environmental impact of the design is significant with feasible compensation measures • Reliability (e.g. seismic resistance) and safety are acceptable • Extent of risk to physical health is acceptable • Risk of population well-being being disturbed is acceptable • Extent of impact on cultural and spiritual values is acceptable • Extent of uncertainty, vagueness and equivocation is high • Supply of water is low – acceptable – potentially possible • Quality (e.g. water quality) or the technical solution are below average • Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, irregular over time, temporary • Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, spatially restricted • Balance of demands on inputs is strained
Number of Points: 2Risk is insignificant • Environmental impact is insignificant • Reliability (e.g. seismic resistance) and safety are very good • Extent of risk to physical health is insignificant • Risk of population well-being being disturbed is insignificant • Extent of impact on cultural and spiritual values is insignificant • Extent of uncertainty, vagueness and equivocation is favourable • Supply of water is satisfactory – above average • Quality (e.g. water quality) or solution are very good • Incidence of contaminants, extent of disturbance, contamination, load and impact are weak, harmless • Balance of demands on inputs is favourable	Number of points: 5 • Risk is unacceptable • Environmental impact of the design is negative without feasible compensation measures • Reliability (e.g. seismic resistance) and safety are unacceptable • Extent of risk to physical health is unacceptable • Risk of population well-being being disturbed is unacceptable • Extent of impacts on cultural and spiritual values is unacceptable • Extent of uncertainty, vagueness and equivocation is extraordinarily high • Supply of water is insufficient - unacceptable • Quality (e.g. water quality) or the technical solution are unsatisfactory – incomplete – unacceptable • Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, regular over time, periodical • Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, spatially unrestricted • Balance of demands on inputs is extraordinarily strained
Number of Points: 3 • Risk is at an average level • Environmental impact of the design deserves attention • Reliability (e.g. seismic resistance) and safety are satisfactory • Extent of risk to physical health is at an average level • Risk of population well-being being disturbed is at an average level • Extent of impacts on cultural and spiritual values is at an average level • Extent of uncertainty, vagueness and equivocation is satisfactory – acceptable – at an average level • Supply of water is satisfactory – acceptable – at an average level • Quality (e.g. water quality) or the technical solution are at an average level • Incidence of contaminants, extent of disturbance, contamination, load and impact are at an average level – at the limit of acceptability • Balance of demands on inputs is at an average level	

The authors of the Assessment however concluded unanimously that the environmental impacts of the Temelín Nuclear Power Plant are low, insignificant and acceptable, both under normal operating conditions and in emergency situations. As experts in the field of nuclear safety carefully monitor the efficiency of systems installed to ensure safe operation of the nuclear power plant and its ability to react to emergency situations, experts in the field of environmental protection and health care consider it necessary permanently and systematically to monitor the environment both close to the power plant and over broader areas, regularly to evaluate the results of such monitoring and on that basis to propose measures necessary for further operation of the power plant. For this reason the proposed measures stress monitoring and post-design analysis as well as feedback and checking the correctness of assumptions underlying the opinion cpncerning the extent of the power plant impact on the environment.

Naturally, also experts are only human and feel the normal apprehension, anxiety and uncertainty. They understand that other people harbour similar feelings. The problem is to which extent the subconscious apprehension can be suppressed by acknowledging the extent of risk we are willing to accept. And this involves decisions we face each day. From a rational point of view, in this context the fear of the environmental impacts of the Temelín nuclear power plant is incommensurable with the anxiety with which we leave our homes each day, drive our cars and make our down-to-earth decisions. Each must cope with his or her anxieties. In circumstances that extraordinary as the attitude to a nuclear power plant the state is obliged to guarantee the level of risk acceptable to an absolute majority of the populace; on the other hand, civic society is obliged to control the state's activities also in this respect.

For this reason it is so important that all interested persons make use of the offered opportunity and participate in the public discussion about the environmental impacts of the Temelín power plant, by either submitting written opinions or attending the public meetings organised in Ceské Budejovice on 25 April 2001 and on 9 May (a preliminary date) in Linz. The deadline for submitting written opinions of the published Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant is 10 May 2001.

The Assessment of the Environmental Impacts of the Temelín Nuclear Power Plant is also available in an electronic form on the web sites of the Ministry of Foreign Affairs,

www.mzv.cz

4. Final Confrontation of the Assessed Areas of Environmental Impact of the Temelín Nuclear Power Plant

The members of the Commission completed their assessment of potential environmental impacts of the Temelín Nuclear Power Plant by comparing the seven examined areas using two independent methods. The comparative analysis was effected by the method of gradual steps. To this end:

- a reference, five-level **verbal and numerical scale** was defined for assessing the potential environmental impacts of the Temelín Nuclear Power Plant in relative units *[RJ]* to reflect an indirect dependence with regard to the quality of the environment according to the principle *"the higher value - the worse for the environment!"* – see **Table 1**;
- **key problems** were identified for each examined area– see **Table 2**, column 3;
- within each examined area the percentage of significance in the identified key problems was determined according to their relative importance and the experts agreed on a classification of the potential impact according to a reference scale, see **Table 2**, columns 4 and 5;
- the resulting qualitative multiplier P_j characterising the potential impact on the examined area was calculated as the arithmetic mean for individual key problems, see **Table 2**, column 6;
- individual statistical weights w_j were assigned to each area – see the values of statistical weights $w_j^{(N)}$ in **Table** 2, column 7;
- for each area the impact vector U_j was calculated for two alternative scenarios: scenario (A) assuming uniform importance of all examined areas, and scenario (B) using weighted scores assigned to individual areas, see **Table 3**.

The relative importance of the examined areas reflected in the statistical weights w_j was determined by means of an expert team method in the presence and with consensus of the Commission members by using the method of pair comparisons published by D. Fuller (1967). Pair combinations are examined for all n possible parameters. The number ofsuch pairs then is

$$\frac{n}{2}(n-1);$$

the pairs were arranged in the so-called *Fuller triangle* as follows:

1	1	1	…	1	1
2	3	4	…	(n - 1)	n
	2	2	…	2	2
	3	4	…	(n – 1)	n
		3	…	3	3
		4	…	(n – 1)	n
			…	…	…
					(n – 1)
					n

The working mechanism consisted of mutual comparisons of all pairs of all examined areas. The overall number of preferences so obtained defined the statistical weight w_j. Unitised weighting values were used to preserve additivity. The unitised weighting value $w_j^{(N)}$ was calculated from the formula:

$$w_j^{(N)} = \frac{w_j}{\sum_j w_j}$$

where

$$\sum_j w_j^{(N)} = 1$$

The impact vector U_j is defined as

$$\underline{U_j = P_j w_j^{(N)}}$$

Solution was sought under the condition that the sum of assigned preferences satisfies the equation

$\sum_j w_j = 0.5n(n-1)$ and at the same time $\sum_j w_j^{(N)} = 1$.

The results of the analysis are visualised by means of bar charts. **Figure 1** depicts the impact vectors U_j for both scenarios A and B, and **Figure 2** shows the final sequence of the extent of adverse impacts of the examined areas under scenario A (uniform significance).

Table 1: Reference Five-level Verbal Numeric Scale

Number of Points: 1

- Risk almost zero – none
- Environmental impact of the design is negligible
- Reliability (e.g. seismic resistance) and safety are fully guaranteed
- Extent of risk to physical health is zero – none
- Risk of population well-being being disturbed is zero – none
- Extent of impact on cultural and spiritual values is zero - none
- Extent of uncertainty, vagueness and equivocation is the most favourable
- Supply of water is at the maximum level possible considering the economic and technical aspects
- Quality (e.g. water quality) or solution are extraordinary – above average – progressive
- Incidence of contaminants, extent of disturbance, contamination, load and impact are almost zero – none
- Balance of demands on inputs is the most favourable

Number of Points: 2

- Risk is insignificant
- Environmental impact is insignificant
- Reliability (e.g. seismic resistance) and safety are very good
- Extent of risk to physical health is insignificant
- Risk of population well-being being disturbed is insignificant
- Extent of impact on cultural and spiritual values is insignificant
- Extent of uncertainty, vagueness and equivocation is favourable
- Supply of water is satisfactory – above average
- Quality (e.g. water quality) or the technical solution are very good
- Incidence of contaminants, extent of disturbance, contamination, load and impact are weak, harmless
- Balance of demands on inputs is favourable

Number of Points: 3

- Risk is at an average level
- Environmental impact of the design deserves attention
- Reliability (e.g. seismic resistance) and safety are satisfactory
- Extent of risk to physical health is at an average level
- Risk of population well-being being disturbed is at an average level
- Extent of impacts on cultural and spiritual values is at an average level
- Extent of uncertainty, vagueness and equivocation is satisfactory – acceptable – at an average level
- Supply of water is satisfactory – acceptable – at an average level
- Quality (e.g. water quality) or the technical solution and financial costs are at an average level
- Incidence of contaminants, extent of disturbance, contamination, load and impact are at an average level – at the limit of acceptability
- Balance of demands on inputs is at an average level

Number of points: 4

- Risk is acceptable
- Environmental impact of the design is significant with feasible compensation measures
- Reliability (e.g. seismic resistance) and safety are acceptable
- Extent of risk to physical health is acceptable
- Risk of population well-being being disturbed is acceptable
- Extent of impact on cultural and spiritual values is acceptable
- Extent of uncertainty, vagueness and equivocation is high
- Supply of water is low – acceptable – potentially possible
- Quality (e.g. water quality) or the technical solution are below average
- Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, irregular over time, temporary
- Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, spatially restricted
- Balance of demands on inputs is strained

Number of points: 5

- Risk is unacceptable
- Environmental impact of the design is negative without feasible compensation measures
- Reliability (e.g. seismic resistance) and safety are unacceptable
- Extent of risk to physical health is unacceptable
- Risk of population well-being being disturbed is unacceptable
- Extent of impacts on cultural and spiritual values is unacceptable
- Extent of uncertainty, vagueness and equivocation is extraordinarily high
- Supply of water is insufficient - unacceptable
- Quality (e.g. water quality) or the technical solution are unsatisfactory – incomplete – unacceptable
- Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, regular over time, periodical
- Incidence of contaminants, extent of disturbance, contamination, load and impact are strong, spatially unrestricted
- Balance of demands on inputs is extraordinarily strained

Table 2: Key Problems of the Examined Areas and Their Assessment

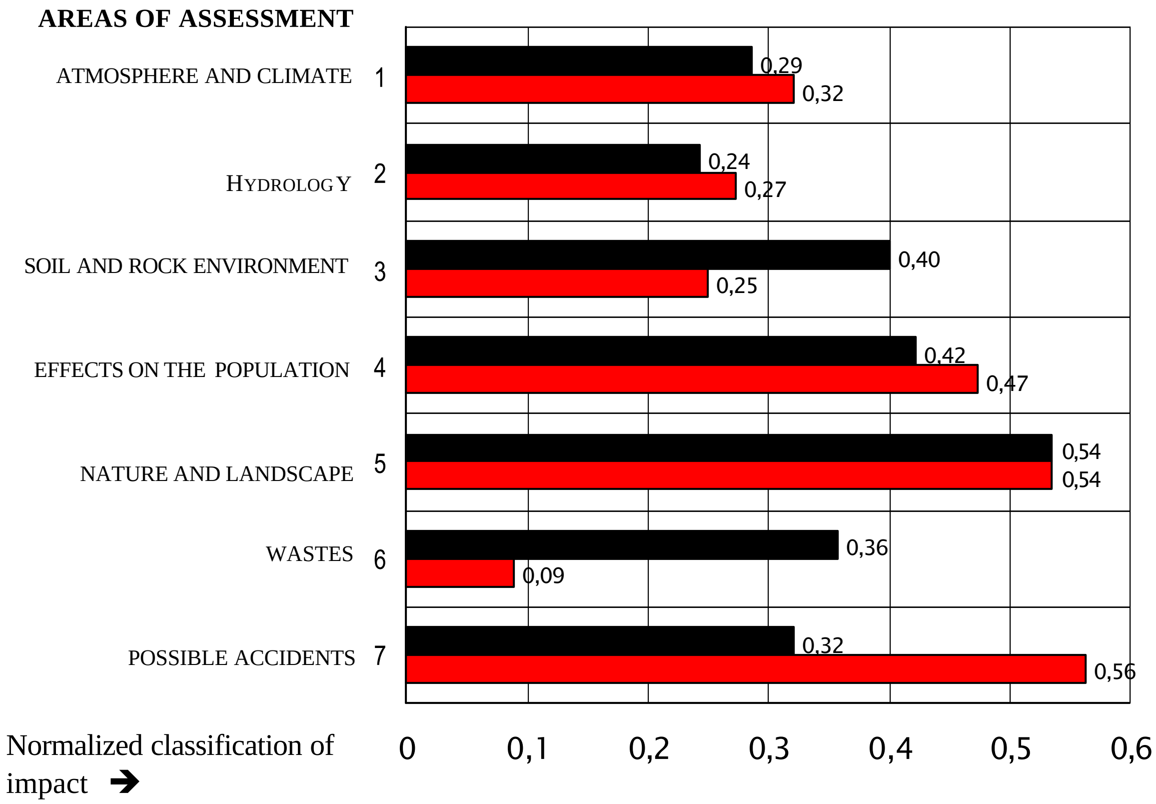
Assessed area		Key problem	Key problem classification - see the Reference Table	Relative importance within the assessed area [%]	Final assessment of area as weighted average of classification P_j	Unitised weight of the assessed area, $w_j^{(N)}$
1	**2**	**3**	**4**	**5**	**6**	**7**
O_1	**Atmosphere and climate**	(A) atmosphere – introduction of radioactive substances in the environment by discharge (B) climate – potential effect of cooling tower operation on territorial climatic factors	**2** **2**	 **30**	**2**	**0.16071**
O_2	**Hydrology**	(A) supply and quality of drinking water (B) supply and quality of industrial water (C) risk of radioactive contamination of a recipient owing to escaping tritium-contaminated water	**3** **1** **3**	**5** **65** **30**	**1.7**	**0.16071**
O_3	**Soil and rock environment**	(A) effect in soil and rock environment (B) seismic security	**2** **3**	**20** **80**	**2.8**	**0.08929**
O_4	**Effects on the population**	(A) radiation hygiene – air (B) radiation hygiene – water (C) radiation hygiene – food chain (D) communal hygiene (E) Ease factor	**2** **3** **1** **1** **4**	**15** **30** **5** **10** **40**	**2.95**	**0.16071**
O_5	**Nature and landscape (fauna, flora, ecosystems)**	(A) effect on landscape (B) effect on fauna, flora, ecosystems (C) effect on forests (D) effect on agricultural crops (E) effect on intangible (cultural) assets (F) effect on tangible assets	**5** **2** **1** **1** **3** **2**	**55** **10** **5** **5** **20** **5**	**3.75**	**0.14286**
O_6	**Waste (including radioactive and chemical waste)**	(A) radioactive waste – liquid (bitumenation) (B) radioactive waste – solid (C) spent fuel (D) other non-radioactive waste	**2** **2** **3** **2**	**30** **15** **50** **5**	**2.5**	**0.03571**
O_7	**Possible occurrence of accidents**	(A) prevention of accident occurrence (B) radiation environmental impact of accidents (C) emergency plans and preparedness	**2** **3** **2**	**60** **25** **15**	**2.25**	**0.25**
Total						**1.00002**

Table 3: Calculated Vectors U_i for scenarios (A) and (B)

Area	1	2	3	4	5	6	7
P	2	1.7	2.8	2.95	3.75	2.5	2.25
w(A)	1	1	1	1	1	1	1
$w(A)^{(N)}$	0.142857	0.142857	0.142857	0.142857	0.142857	0.142857	0.142857
w(B)	4.5	4.5	2.5	4.5	4	1	7
$w(B)^{(N)}$	0.160714	0.160714	0.089286	0.160714	0.142857	0.035714	0.25
U(A)	0.285714	0.242857	0.4	0.421429	0.535714	0.357143	0.321429
U(B)	0.321429	0.273214	0.25	0.474107	0.535714	0.089286	0.5625

Figure 1

Assessed Areas of Environmental Impact Assessment of the Nuclear Power Plant Temelin and Their Comparison



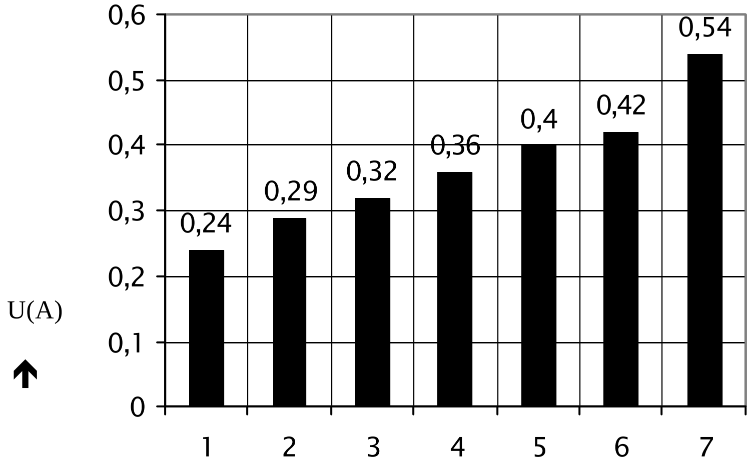
Caption:

Series 1 (black bars) expresses classification of the potential impact in case of uniform significance of the assessed areas – assessment scenario (A)

Series 2 (red bars) expresses classification of the potential impact in case of weighted significance of the assessed areas – assessment scenario (B)

Figure 2

Resulting score expressing the extent of adverse impacts of the assessed area



Area of assessment ➔ **O_2** **O_1** **O_7** **O_6** **O_3** **O_4** **O_5**

It follows from the comparative analysis of potential environmental impacts of the assessed areas of the Temelín Nuclear Power Plant that for scenario (A) the least favourable effect is that on nature and landscape (area O_5). On the other hand, among the examined areas the most favourable is the effect on hydrology (area O_2) followed by the effect on air and climate (area O_1).

The Commission experts nevertheless acknowledge the importance of possible occurrence of emergencies (area O_7), as demonstrated by the highest statistical weight assigned to this area in scenario (B). This is clearly shown by the red bar in Figure 1 (cf. the highest value of the unitised impact factor 0.56), which exceeds the least favourable value assigned to the weighted effect on nature and landscape (0.54).

On the other hand, the expert opinion assigns a lower relative weight to the areas concerning impact on soil and rock environment (area O_3) and the waste (area O_6). Except for the aforementioned differences the results of the analysis are comparable for the two examined scenarios.

The resulting score according to the expected adverse effects of the nuclear power plant on individual areas is as follows:

1. hydrology O_2;
2. atmosphere and climate O_1;
3. possible occurrence of accidents O_7;
4. waste O_6;
5. soil and rock environment (including seismic resistance) O_3;
6. effect on the population O_4;

7. nature and landscape O_5.

Overall assessment of the potential impact of the Temelín Nuclear Power Plant based on the weighted score comprising the seven assessed areas according to a verbal and numerical scale

is characterised by the value of 2.506.

The results of the overall evaluation of the assessed areas were checked independently by means of the fuzzy set theory applying the FUZZY logic and verbal propositions method (FL-VP). The solution is based on a catalogue of verbal propositions (terms) and the results of expert evaluation by Commission members. The objective was to test for each assessed area, by means of a linguistic instrument, i.e., verbal propositions from the fuzzy table, the extent of adverse effect using a model sentence of the type "the potential adverse impact of the assessed area will be in part "…" and in part "…". The obtained results are reviewed in Table 4. The verbal propositions were transformed to numeric indices at the auxiliary points (AP) according to the code EcoImpAct FORMULA authorised by J. Říha (1995). The results are presented as a bar chart in Figure 3. The numerical values correspond to a direct transformation according to the principle *" the higher value - the better for the environment!*".

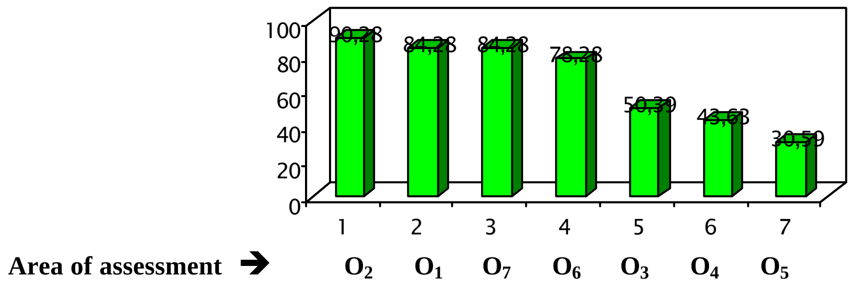
Table 4: Evaluation according to the FUZZY Logic and Verbal Propositions Method (FL-VP)

ASSESSMENT AREAS		ASSESSMENT BY THE LINGUISTIC VARIABLE METHOD (ACCORDING TO THE CATALOGUE OF VERBAL PROPOSITIONS – TERMS)	*Code [AP]* ACCORDING TO THE ECOIMPACT FORMULA
1	Atmosphere and climate	Potential effect of the assessed area will be in part "*insignificant*" and in part "*negligible*"	84.28
2	Hydrology	Potential effect of the assessed area will be in part "*imperceptible*" and in part "*minimal*"	90.28
3	Soil and rock environment	Potential effect of the assessed area will be in part "*small*" and in part "*perceptible*"	43.63
4	Effect on the population	Potential effect of the assessed area will be in part "*acceptable*" and in part "*minimal*"	84.28
5	Nature and landscape (fauna, flora, ecosystems)	Potential effect of the assessed area will be in part "*indistinct*", in part "*long-term and persistent*" and in part "*irreversible*"	30.57
6	Waste (including radioactive and chemical waste)	Potential effect of the assessed area will be in part "*small*" and in part "*perceptible*"	50.39
7	Possible occurrence of accidents	Potential effect of the assessed area will be in part "*small*" and in part "*acceptable*"	78.28

Source: Ríha J. (1995): *"Assessment of Effects of Capital Expenditures on the Environment – Multi-criterial Analysis and EIA"*. Editor: ACADEMIA Praha (348 pages).

Figure 3

Areas of Environmental Impacts of the Temelin Nuclear Power Plant Examined by the FUZZY Logic and Verbal Propositions Method FL-VV



The sequence of adverse impacts of individual assessed areas established by the FUZZY logic and verbal propositions method confirms the order arrived at by means of scenario (A) corresponding to uniform significance of individual areas. Within the set the effect on hydrology (area O_2) is again assessed most favourably and the effect on nature and the landscape (area O_5) received the least favourable assessment. The potential effect on the population (area O_4) is assessed much more favourably.

OVERALL ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF THE TEMELÍN NUCLEAR POWER PLANT

On the basis of two independent methodical approaches the assessment is as follows:

The environmental impact of the Temelín Nuclear Power Plant can be assessed and <u>low, insignificant and acceptable</u> (2.5). The most favourably assessed is the effect on hydrology, followed by the effect on the air and climate. The effect on nature and landscape received the least favourable assessment.

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