9. MITIGATION MEASURES

Any major project of the type described here can be expected to result in some degree of impact on the environment including man. One of the purposes of the EIA described here is to examine the extent to which reasonable measures have been taken to minimise any environmental impacts or to enhance any environmental benefits. This Section summarises those additional measures which have been identified and/or implemented, or which will, in due course, be taken into account during development of the Environmental Action Plan (EAP) for K2. The proposed EAP is outlined in Section 9.4.

9.1 Construction impacts

Construction impacts have not been defined by Energoatom but might include :

- dust from construction activities in summer;
- run-off of surface water contaminated with fine suspended solids in winter;
- noise from various minor construction activities;
- disposal of construction wastes;
- disturbance due to truck traffic, night working and flood-lighting;
- hazards to pedestrians due to truck traffic;
- local nuisances e.g. mud transported onto roads; and
- social impacts of construction camp for temporary workforce (2000-3000 people).

These impacts, though likely to be small, will be addressed within the EAP, for example by:

- dust control measures on site haul roads;
- collection and treatment of surface drainage water;
- application of noise control standards;
- waste management plan;
- establishment of authorised truck routes;
- control of working hours;
- use of wheel-washers; and
- supervision of the workforce;

9.2 Non-radiological impacts

The main non-radiological impacts will arise from hazardous materials, water abstraction and heat discharges. Appropriate mitigation measures are discussed below.

9.2.1 Hazardous materials

Whilst the arisings and disposal of certain hazardous materials have been identified (Table 6.9), it will be necessary to establish written EAP procedures for the auditing of all wastes and all materials used on site, in order to prepare an inventory of hazardous materials. Hazardous materials will then be controlled using a system which records the location and movements of all hazardous materials, including a licensing system for any materials which have to be disposed of off-site.

Procedures will be established within the EAP to optimise opportunities for the minimisation of waste generation and maximisation of the re-use or re-cycling of wastes, where possible on site.

9.2.2 Water abstraction

Total water abstraction for the Khmelnitsky NPP could represent a significant proportion of the flow of the Goryn river during the non-vegetative seasons. In the circumstances, it will be necessary for the EAP to include specific abstraction regulations which, for example, define the minimum amenity flow which must remain in the river at all times. Fluctations in this minimum flow must reflect the natural seasonality of river flow.

It will also be necessary to conduct a study of water-use throughout the NPP, in order to identify leaks/wastage, minimise usage and maximise the storage and use of site drainage water.

9.2.3 Heat discharges

The effects of heat exchange to the cooling reservoir are not anticipated to result in significant adverse environmental impacts but will be subject to further investigation taking into account the potential for both positive and negative impacts. The EAP will need to include procedures for monitoring and controlling such impacts.

9.3 Radiological impacts

The key element in maintaining nuclear and radiological safety and thereby minimising radiological impacts is defence-in-depth (Section 8.2). In conjunction with application of the ALARA principle (Section 5), it has been argued that K2 can be operated both safely and with minimal impact on the environment. This Section summarises those issues of nuclear safety which are particularly relevant to environmental issues (Section 9.3.1) and identifies those aspects of design and operation specifically intended to ensure environmental protection (Section 9.3.2).

9.3.1 Nuclear safety issues

At the request of the Ministry for Environmental Protection and Nuclear Safety of Ukraine, Nuclear Safety Administration, an IAEA Expert Mission was conducted at the Khmelnitsky NPP to review the modernisation programme for K2 during the period 10 to 15 June 1996. The mission was organised within the framework of the IAEA Extrabudgetary Programme on the Safety of Nuclear Power Plants in the Countries of Eastern Europe and the former Soviet Union and was supported by TC Project RER/9/035 [9.1].

The purpose of the IAEA safety mission was to review the safety aspects of the Khmelnitsky 2 modernisation programme and to advise on the completeness and adequacy of the safety improvements proposed (Section 8). The draft report "Safety Issues and Their Ranking for VVER 1010 Model 320 NPPs", IAEA-EBP-WWER 5, March 1996 (referred to as the "issue book" in the following text) was the basis for the experts' review. The IAEA NUSS standards and guides, and internationally accepted safety concepts and practices and national standards, complemented by Russian safety rules in force (e.g. OPB-88, PBJa-89), were used in the preparation of the issue book. The scope of the review covered the plant design and operational safety aspects as proposed in the modernisation programme. Those upgrading measures, which are only related to the improvement of plant availability, were not included in the review. The general conclusions of the review are discussed in Section 8.3.

9.3.1.1 Seismicity

As concerns seismic design, the measures proposed by the mission were basically with respect to documentation i.e. documentary validation of the seismic risk evaluation which had already been carried out for the Khmelnitsky site. The realisation of this measure would be on the basis of additional instrumental seismic observations and geophysical studies. It was noted by the mission that the Khmelnitsky NPP site has bedrock at a depth of 5 m and that the foundations of the structures are built about 1 m into the bedrock. Assessments performed during the original design in the 1970s had shown that an earthquake with a maximum intensity of MSK 6 (corresponding to a ground acceleration of 0.05g) could be expected for the Khmelnitsky site. Nevertheless, the design of the Units had been based on an intensity of MSK 7 (corresponding to a ground acceleration of 0.1g) in accordance with the requirements of the Unified Soviet Design. The mission concluded as follows.

- Seismic hazard studies (including the local geological conditions) should be performed to confirm the value of the design basis earthquake.
- The 0.1 g level earthquake should be associated with appropriate response spectra and time histories taking into account near, intermediate and far seismogenic sources. Low frequency seismic motions which may be generated by large and far sources (such as Vrancha) should be considered in evaluation of the structures.

The experts considered that there was no immediate urgency for these tasks and recommended it should be included for implementation at a later date.

9.3.1.2 Other natural events

As concerns other natural events, the mission noted that natural phenomena such as temperature, snow and wind had been considered in the design of the Khmelnitsky NPP and that it had been assumed that related severe conditions could occur once in every 10,000 years. This assumption was stated to be in accordance with the design requirements of Ukraine. The mission suggested that there was no special design against a tornado. Instead a pressure wave with a value of 30 kPa had been considered for the design of the safety-related buildings. An analysis of the effects of tornadoes for the Khmelnitsky site was intended, after which it would be possible to determine whether additional resources would be required.

9.3.1.3 Man-induced external events

The mission noted that the site had been assessed with respect to man-induced external events. There are no gas lines, pipe lines or chemical or industrial plants near the plant site which could pose a potential hazard. However, there is a railway line about 500 m from the site. It was therefore suggested that if a subsequent hazard analysis were to indicate that loads higher than those imposed by a shock wave of 30 kPa could result, then appropriate administrative measures would need to be enforced.

Consideration of an aircraft impact in the design of an NPP is not required according to Ukrainian regulations. From experience with western NPPs the only hazard to be taken into account on the basis of probabilistic assessment is the light aircraft (10 t maximum) when the NPP is far from an airport as is the case for Khmelnitsky. In this context, the mission noted that an analysis had been conducted for the containments for Units, assuming the impact of an aircraft of 10 t at a speed of 700 km/h; the mission considered this adequate for the containments of VVER 1000/320 NPPs. Again, if a probability value were to be obtained that was greater than that which is generally accepted, then appropriate administrative measures would need to be enforced.

9.3.1.4 Accident analysis

Concerning the scope and methodology of accident analysis, the mission noted that regulatory guidelines were to be approved by NRA and that two chapters of these regulations concerned DBA and BDBA and the scope and methodology for performing accident analysis. It was stated that the accident analysis to be performed within the framework of the modernisation programme would follow the new regulatory guidelines. The mission recommended that a complete list of initiating events to be analysed should be established rapidly, and the accident analysis to be performed should be to an internationally acceptable level.

9.3.1.5 Radiation protection and monitoring

As concerns radiation protection and monitoring, the mission noted a number of corrective actions that had been incorporated into the modernisation programme to address identified weaknesses in station radiation monitoring capabilities. The decision to replace equipment had been taken but no supplier had been selected. The new radioactive waste treatment facility (Section 4) was planned to have been completed in 1997. The mission concluded that the proposed measures and modifications were consistent with IAEA recommendations and international practices, but that ALARA principles needed to be further developed at the Khmelnitsky NPP.

9.3.1.6 Emergency planning

Concerning the new emergency centre 3 km from the plant, the mission noted the intention to complete the centre over the period 1999 to 2000 and commented that construction of the centre is not conditional to the startup of Unit 2. Nevertheless, a local emergency centre close to Unit 2 is required to be installed before the startup of the Unit.

9.3.2 <u>Environmental protection</u>

The IAEA safety mission, the subsequent modernisation programme and its associated evaluations all identify issues which may impinge on environmental protection and all of which are clearly the subject of ongoing study. They extend to issues related to monitoring and control of releases of radioactivity to the environment and to the systems that should be applied for monitoring and managing the consequences of any unplanned discharges of radioactivity to the environment. The effectiveness of any such systems depends on a number of factors, the most important of which are as follows.

- Establishment of a baseline against which any radioactive discharges can be monitored and assessed.
- Establishment of an environmentally sound culture both within the staff of the NPP and the organisations responsible for setting controls on discharge and for monitoring discharges against those controls.
- Establishment of a system of monitoring of extent and sophistication appropriate to the requirements of operator, regulator and the general public.

The existence of an operating NPP at the Khmelnitsky site has resulted in the development of an extensive baseline of environmental measurements against which the impacts of operation of K2 can be assessed. The baseline will be further extended by actions recommended in Section 9.3.3 to ensure that ALARA procedures are being applied.

The present modernisation programme is resulting in a general improvement in safety culture within the NPP staff (Section 8) This, in conjunction with the introduction of new limits for occupational safety, leads to measures which will tend to mitigate the impacts of radiation exposure of both the workforce and the surrounding environment.

A policy of minimising discharges to the environment during routine operation results in the accumulation of radioactive wastes on site. Whilst this has the advantage of allowing for radioactive decay of short-lived radionuclides, the ultimate impacts of the processing and disposal of accumulated wastes cannot be ignored as cannot those potential impacts resulting from the reprocessing of spent fuel or the management of wastes arising from decommissioning. Development of experience in decommissioning and in waste management, as is currently the case for the Chornobyl site will assist with mitigating any impacts that may arise in the longer-term future.

Given the presence of a commercial fish farm on the cooling reservoir, a detailed assessment of the radiological impacts of aquatic discharges will be undertaken. The results of this assessment will be compared with the results of an extended monitoring programme including monitoring of fish reared in the reservoir. Any adverse effects, if predicted or measured, can be mitigated by increased control of discharges or control on commercial and recreational activities associated with the reservoir.

The main environmental protection issue relates to unplanned discharges of radioactive materials to atmosphere or water. Maintenance of the sanitary protection zone in conjunction with a comprehensive and frequently tested emergency preparedness system are major factors in ensuring that environmental impacts associated with unplanned releases will be maintained within acceptable levels. The sanitary protection zone, with appropriate management, also provides an opportunity for maintaining and developing biodiversity, for example, through local nature conservation areas.

For DBA, it is recommended (Section 8) that a complete deterministic evaluation of the radiological consequences should be undertaken. This evaluation will take into account ingestion pathways and will be completed according to most recent ICRP recommendations.

A full scope BDBA study has yet to be completed. The list of BDBAs to be assessed for K2/R4 will be provided in the EAP. The source term corresponding to the “most representative” BDBA and the methodology for assessing consequences will be confirmed as part of the safety analysis report that will be submitted to NRA for approval prior to commissioning the plant.

9.3.3 Occupational radiation exposure

A recent study of ALARA progress in the EU and in the Russian Federation (RF) has compared occupational radiation exposure in pressurised light water reactors (PWRs in the EU and VVER in the RF) [9.2]. The latest design of each type that is being developed in both the RF and EU was reviewed.

At the time of the study, the only EU plants of the latest design with significant amount of operational experience were the German Konvoi PWR plants. France's N4 and the UK's Sizewell B plants had only just been constructed or commissioned. The Konvoi plants indicated that it is possible to achieve annual collective doses in the range of 0.1 to 0.2 man-Sv. This is the continuation of a steady reduction in dose at the earlier 1300 MW(e) plants and is a result of the German ALAP (as low as possible) strategy of minimising corrosion product activity levels in the primary coolant. The N4 and Sizewell B plants include most of the ALARA design features present in the Konvoi plants. The most advanced RF VVER design, the VVER-1100, also includes many of the features present in the Konvoi plants.

Annual collective doses at the N4 plants were estimated to be lower than those at the best of the earlier P4 plants, at approximately 1 man-Sv, and were estimated to fall to approximately 0.5 man-Sv when all ALARA design improvements had been adopted. The pre-operational estimate for Sizewell B was 1.33 man-Sv and was expected to fall to 0.35 man-Sv when the benefits of all the ALARA design improvements had been realised. The annual collective dose for the RF VVER-1100 was also estimated to be significantly lower than the best operating VVER-1000 plants i.e. less than 0.7 man-Sv. As concerns annual individual doses, it was noted [9.2] that these tended to reflect staffing levels with values of 2.5 mSv and 1.6 mSv for the Swedish Ringhals and French P4 plants with 486 and 823 workers respectively, compared with 0.9 mSv for the RF Balakovo units 1-4 with 2904 workers. It was noted that the ICRP 60 recommended annual limit had rarely been exceeded in recent years at EU plants (by up to 1% of the workers) and not at all at the Balakovo NPP.

The study identified the following main aspects as having the most potential for reducing occupational exposure:

- material selection;
- component reliability;
- plant layout and shielding;
- robotics and semi-remote areas;
- primary circuit activity clean-up;
- optimised primary and secondary coolant chemistry;
- health physics supervision and control;
- operational experience gathering and feedback; and
- operator training.

Two topics were chosen for further study i.e. operational experience gathering and feedback, and optimisation of primary coolant chemistry. The initial study results identified six specific areas where further study would be most beneficial. For the first topic these were:

- planned task management for dose gathering purposes;
- operational experience; and
- dose management systems.

For the second topic they were:

- pH optimisation;
- hydrogen control; and
- control of impurity levels.

The above is included here as a practical demonstration of the value of carrying out ALARA assessments and of what can be achieved by ensuring the application of ALARA principles. Figures for Ukrainian NPPs in general of an average dose of 2.0 or 2.2 mSv/yr and for the distribution of individual doses at Rivne and Khmelnitsky indicating that between <1 and 3% of workers received doses greater than 15 mSv in 1996, are not out of place when compared with the values given above. Nevertheless, it should be a requirement of the project that a detailed ALARA practice be implemented on the operational procedures for the proposed unit so as to reduce occupational radiation doses.

9.4 Environmental Action Plan (EAP)

As noted in Section 1.3.1, the terms of reference for the present study require the preparation of an outline Environmental Action Plan (EAP).

According to EBRD environmental procedures [9.3] the EAP will document the key issues, the actions to be taken to address them adequately, the implementation schedule and an estimate of the associated costs. Some actions may be needed urgently, particularly when there is a significant health and safety risk, or non-compliance with regulatory requirements and permits. The EAP typically addresses issues requiring a long-term or phased approach, such as compliance with expected future regulatory requirements including compatibility with EU or other international legal requirements, standards and practices. The EAP may also address opportunities to further improve the environmental performance of the operation and the costs of doing so. Where current operations are not in compliance with regulatory requirements and existing permits, the EAP, and the proposed actions and schedules for these areas of non-compliance, should be reviewed and agreed by the competent environmental, health and safety authorities. The EAP should be satisfactory to the Bank and Euratom prior to Final Review. The EAP should be subject to regular review and revision satisfactory to the Bank and Euratom and, where compliance is an issue, to the appropriate regulatory authorities.

The formal EAP for K2 will be prepared and refined following publication of the EIA. The purpose of this Section is to indicate the likely structure of, and the topics that will be addressed in, the final EAP. As such, it is intended to provide a basis for discussion with all parties having an interest or involvement in the proposed project.

The following Section summarises the main topics that will be considered within the EAP which, in due course, will form part of the legal documents relating to investments by international financial institutions. Some of the topics that will need to be taken into account whilst preparing the EAP in follow-on studies are expanded on in Appendix D. The final EAP will be expanded and developed in conjunction with Khmelnitsky NPP and regulatory organisations.

9.4.1 Content

9.4.1.1 Environmental policy

This section of the EAP will provide a concise statement of the overall environmental policy of the Khmelnitsky NPP and will take account of all the policies and philosophies (general conceptions) applied to the plant (e.g. ALARA, etc.).

9.4.12 Management responsibility for environmental affairs

This section of the EAP will include an organogram or similar to indicate the State management, regulatory authorities and level of top management and lines of responsibility for environmental management. It will show the interactions and interelations with parallel management structures such as those involved with radiological protection and health and safety.

9.4.1.3 Licences

This section of the EAP will list all legislation, consents, standards, etc. to which the NPP is required to conform. It will identify all relevant authorities including the materials which the NPP management is required to supply to regulatory authorities.

9.4.1.4 Inspection

This section of the EAP will list all statutory inspections relevant to environmental protection to which the NPP is subjected including future dates and the nature of inspections if known.

9.4.1.5 Objectives and targets

This section of the EAP will set objectives and targets for improvement of environmental performance. Targets will, wherever possible, be formed in a quantitative context.

9.4.1.6 Mitigation measures

This section of the EAP will list all mitigation measures identified in the EIA with an indication of responsibility and timescale to ensure that the agreed mitigation measures have been implemented.

9.4.1.7 Monitoring

This section of the EAP will list all monitoring and control requirements (radiological and non-radiological) that have been referred to in the EIA, along with any others already carried out.

9.4.1.8 Records

This section of the EAP will specify the system for recording of monitoring results and other environmental information, and for recording actions taken as a consequence of monitoring and inspection.

9.4.1.9 Environmental audit

This section of the EAP will specify the procedure for undertaking internal environmental audits and will identify the topics to be included and the frequency of audits.

9.4.1.10 Reporting

This section of the EAP will define methods and the frequency of reporting the results of monitoring and auditing to both statutory authorities and to the public.

9.4.1.11 Liaison

This section of the EAP will specify the methods for liaison with local community and interested NGOs, government departments, etc., for example via a Local Liaison Committee.

9.4.1.12 Environmental training/awareness

This section of the EAP will specify the programme of training for managers and staff, along with the content of the specified programme.

9.4.1.13 Decommissioning plans

This section of the EAP will include details of the programme to prepare full plans for decommissioning. It will expand how estimates of quantities of materials are to be derived, destination of wastes, site after-use, etc.

9.4.1.14 Emergency plan

This section of the EAP will provide the detailed emergency plans for the site along with details of all communication contacts. It will include the programme for training/exercises.

9.4.1.15 Procedures

This section of the EAP will provide the procedures required for implementation of the Environmental Action Plan.

9.4.1.16 Documentation

This section of the EAP will include the references to all relevant environmental manuals, handbooks, guidelines, etc. including those issued internally.

9.4.1.17 Verification and compliance

This section of the EAP will include the procedure for determining adherence to the Environmental Action Plan, including details of audits to be undertaken.

9.4.1.18 Special conditions

This section of the EAP will list all conditions that have been identified in the EIA and which will be attended to during the preparation of the EAP. It is anticipated that these conditions will include but not be limited to those topics included in Appendix D.

9.4.2 Implementation

The programme for developing and implementing the EAP involves the following steps, all of which will need to be completed prior to the commissioning of the project.

1) Initial environmental audit of the Khmelnitsky NPP site.
2) Discussions with NPP management and regulatory bodies to agree on the content of the EAP.
3) Provision of all necessary information by the NPP management.
4) Preparation of the final EAP and agreement on its contents with the NPP management.

It is currently intended that the above steps will be completed over the period of public consultation.

9.5 References

9.1 Report of an experts mission to review the modernisation programme of Khmelnitsky NPP unit 2. IAEA-TA-2486. TC Project RER/9/035. IAEA, July 1996.

9.2 Currie, I. ALARA progress in the EU and Russia. Nuclear Engineering International. October 1997, pages 23-25.

9.3 European Bank for Reconstruction and Development. Environmental procedures. September 1992.