DISMANTLING AND CLOSURE PLAN OF AN INACTIVE URANIUM MILL FACILITY IN SPAIN

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ABSTRACT

The Uranium Mill Factory of Andujar located in the province of Jaen, was in operation from 1959 to 1981. All the tailings generated (some 1.200 millions of Kg.) are contained in the tailings pile, which covers an area of 95.000m^2, and has a total activity of 5.400 Ci. In 1986, this facility was transferred to the Spanish National Company of Radioactive Wastes (ENRESA) for the long-term conditioning of tailings and later closure of the facility. In 1988, ENRESA presented to the Ministry of Industry and Energy the Dismantling and Closure Plan, together with the Environmental Impact Study. ENRESA was assisted by INITEC, as engineering contractor in the preparation of these documents. The safety assessment has been carried out by the Nuclear Safety Council (CSN) with the participation of the General Secretary of the Environment in the non-radiological aspects. This paper summarizes the history of the facility, the licensing process, as well as the radiological protection objectives and criteria established by the CSN, the remedial action design and the construction plan.

INTRODUCTION

The Uranium Mill Factory of Andujar is located in the province of Jaen (Andalucia), on the southern floodplain of the Guadalquivir River, at 1,5 km. south from the urban center of Andujar. The site is a flat area of aproximately 175.000 m^2, has a trapezoidal shape and is enclosed within a peripheral wall, which is about 150 m. from the course of the river.

The site is on alluvial clays and gravel terraces, underlaid by a very low permeability shale.Most groundwater flow is in the gravels towards the river.

The present configuration of the Andujar mill site is shown in Fig. 1 and includes five areas: the tailings pile, the processing plant, the waste-water treatment area, the auxiliary and administrative buildings and the housing area.

History of the Mill Facility

The Andujar facility was designed for processing low grade uranium ore (0,15 % of U_3O_8) and produced 80% concentrate of U_3O_8 in the form of sodium and amonium uranate at a rate of 60-80 thousand kg. per year. The Plant was in operation from November 1959 until July 1981, as a property of the Junta de Energía Nuclear (JEN). During this period 1.200 millions Kg. of uranium ore were processed to produce 1,35 millions Kg. of uranium concentrate with a fineness of 80-85%. The uranium recovery operations involved sulphuric acid leaching followed by ion exchange and, since 1972, by tertiary amine/kerosene extraction. Solid waste were stored in tailings piles and liquid wastes were treated before its discharge to the Guadalquivir River.

All the solid wastes generated during the plant's operation (1.200 millions Kg. aproximately) are contained in the tailings pile; which covers 94.000 m^2 and has a volume of 980.000 m^3, with a total activity of 5.400 Ci. The pile has an U-shape and rise to a height of about 20 m. in the central and eastern parts and to a height of 10 m. in the western part.

In 1986, the facility was transferred to the Spanish National Company of Radiactive Wastes (ENRESA), by an Order of the Ministry of Industry and Energy, for the long-term conditioning of tailings and the later closure. In 1988, ENRESA, submitted to Ministry and Nuclear Safety Council (CSN) the license aplication, together with a Disposal Site Alternatives Report, the Dismantling and Closure Plan, as well as the Environmental Impact Study. In the preparation of this documentation ENRESA was assisted by the architect engineer contractor INITEC. The Dismantling and Closure Plan includes the remedial action design, the Quality Assurance Program, the Environmental Monitoring Program to be performed during the construction activities, the Radiological Health Physics Manual, the Contingency Plan and the Project Management Plan.

The remedial action proposed by ENRESA, takes into account the technical approaches used in the Uranium Mill Tailings Remedial Action Project (UMTRA) of the U.S.

Radiological Conditions of the Area

Since the shutdown of the factory in 1981 until the present, activities of maintenance and surveillance have been carried out, (first by JEN and after by ENRESA) under the control of CSN. Additionally, monitoring programs for the determination of radon emission and soils, buildings and equipments contamination were made. The average flux of radon over the tailings ranges between 150 and 250 $pCi/m^2.s$. aproximately. The average concentration of radon in air inside the site is about 335 Bq/m^3.

The results of the radiological monitoring program indicates that in the urban center of Andujar the average level of gamma radiation is 1,2 mSv/year and the maximum radon daugthers concentration was about 6 mWL.

The analysis of ground water samples from fourteen wells (three of them near the facility) show that the concentration of radium is, in all cases, lower than 0,1 Bq/l, (2,7 pCi/l). The maximum average yearly concentration of uranium, found in two wells next to the facility is about 7 Bq/l. (189 pCi/l.) None of the wells is used for the regular supply of water.

REGULATORY FRAMEWORK AND LICENSING PROCESS

The legal basis for the regulation of the peaceful uses of nuclear energy in Spain were established by Act 25/1964. The licensing process is governed by the Regulation on Nuclear and Radiactive Installations, approved by Decree in 1972. This Regulation is fairly specific for site construction and operation permits of nuclear and radioactive facilities, but it does not explicitly mention decommissioning. Act 15/1980 creating the Nuclear Safety Council (CSN) modified considerably the responsabilities of the licensing process, that is conducted by the Ministry of Industry and Energy and the CSN. According to the provisions of this Act, CSN must issue a safety report prior to the granting of each permit,including decommissioning. The authorizations are granted by the Ministry and incorporate the preceptive and legally binding report of the CSN in matters related to the radiological protection and safety objectives, criteria, limits and conditions. (1).

The licensing process for the closure of the Andujar plant has been established by the CSN, taking into account the history of the facility, the radiological conditions of the site, and the process followed in U.S. for the UMTRA program. This process will be developed in three phases:

- The first phase consist of the authorization to ENRESA for the performing the dismantling and site restoration activities.
- The second phase is the compliance period (minimum 10 years) that is extended until the desmostration by ENRESA to the CSN that the radiological criteria, and specifically the ground water quality criteria, are achieved for a period of five consecutive years.
- The third phase is the certification of closure and licensing of the Long-Term Surveillance Plan.

Recently, the Ministry of Industry and Energy has granted the permit for the performance of dismantling activities and restoration of the site (2). It contains two parts: the Radiological and Safety Objectives, Criteria, Limits and Conditions elaborated by the CSN and the Environmental Declaration on Non-Radiological Impacts elaborated by the General Secretary of the Environment and the CSN, according with Spanish Environmental Impact Regulations. (3) (4)

RADIOLOGICAL PROTECTION OBJECTIVES AND DESIGN CRITERIA.

The radiological protection objective and design criteria that govern the dismantling and site restoration activities have been established by the CSN taking into account the recommendations of international organizations (ICRP, IAEA and OCDE/NEA), the standards promulgated by the U.S. Environmental Protection Agency (EPA) for the remediation of uranium mill tailings and the Spanish regulations, specifically those related to the protection against radiations (5), the ground water quality protection (6) and the CSN long-term radiation protection requirement for disposal radioactive wastes (1). These objectives and criteria are briefly stated here:

- Dispersion Control: Prevent inadvertent human intrusion and dispersion of contaminated materials by wind and water erosion.
- Long-term Radiation Protection: Achieve an effective equivalent dose to the individual in the critical group below 0.1 mSv/year.
- Design Life: Remain stable for 1000 years to the extent reasonably achievable and in any case for at least 200 years.
- Soil Clean-up: Reduce the residual concentration of radium-226 in land, averaged over an area of 100 m^2, so that the background level is not exceeded by more than 5 pCi/g (averaged over the first 15 cm. soil) and is less than 15 pCi/g (averaged over 15 cm.

thick layers of soil more than 15 cm. below the surface).

- Radon control: Reduce radon flux over the surface of the final pile to an average release rate of less than 20 pCi/m^2 s.
- Groundwater quality protection: Control groundwater contamination so that background water quality or maximum concentration levels (in accordance with Spanish regulations and CSN guidelines for radioactive constituents) are achieved in the long-term. These levels are: Combined radium-226 and radium-228 0,18 Bq/l(4,86 pCi/l), combined uranium-234 and uranium-238 1,2 Bq/l (32,4 pCi/l) and gross alpha activity, excluding radon and uranium, 0,5 Bq/l (13,5 pCi/l).
- Long-term maintenance: Minimize the need for long-term maintenance.
- Construction works: Minimize hazards to the workers and the environment. Specific requirements are included in the next paragraph on environmental protection during the construction.
- Regulations: Comply with other applicable and relevant Spanish regulations governing air and water quality in non radiological aspects.

Groundwater quality protection, for short-term conditions requires that the remedial work be designed to limit infiltration to ensure that, at the end of the compliance period, the combined uranium-234 and uranium-238 concentration in groundwater complies with the two following conditions:

- Be less than 6.15 Bq/l (166 pCi/l) at the point of compliance, located at the downgradient boundary of the disposal site.
- Be less than 3,5 Bq/l (94,5 pCi/l) at the wells located in the vicinity of the site.

Monitoring during the compliance period (minimum 10 years) to confirm the adequacy of the closure works and verify design performance is also required.

In order to meet the above criteria, the following design elements are incorporated into the development of the remedial action plan:

- Stabilization control for up to 1000 years: Use only natural materials with long-term durability and integrity. Design for extreme events such as the probable maximum precipitation, probable maximum flood and maximun credible earthquake. Provide multiple redundant cover systems.
- Dispersion and intrusion control: Provide erosion protection features. Provide biointrusion barriers.
- Soil clean-up : Remove contaminated soils and incorporate them within the tailings pile.
- Radon control: Provide a radon barrier of natural soils.
- Protection of groundwater quality: Limit infiltration. Provide multiple redundant cover systems; provide for evapotranspiration (soil/vegetation layers): shed water that falls on the pile (drain layers); incorporate low-permeability soils as infiltration barrier (silts, clays, and bentonite mixes).
- Long-term maintenance: Provide for the establishment of climax vegetation.

REMEDIAL ACTION DESIGN

The remedial action plan proposed by ENRESA for Andujar processing site, will consist of stabilizing and consolidating the uranium mill tailings and contaminated materials in place. The actual tailings pile will be reshaped by flattening the sideslopes to improve stability. Mill equipment, buildings and process facilities will be dismantled and demolished and will be placed in a pile adjacent to the main tailings pile (Fig. 1). Off-pile contaminated soils will be excavated and placed on top of tailings pile in order to reduce the radon flux.

The final pile configuration (Fig. 2) has been designed to minimize the movement of tailings and the size of the restricted disposal area.The pile will be constructed with four percent topslopes and 20 percent sideslopes which provide sufficient static and dynamic slope stabitity without requiring excessively large rock to resist erosion. Protection against upland watershed runoff will be provided by channeling such runoff around and away from the pile via drainage diversion swales along the perimeter of the pile. Protection against floods associated with the Guadalquivir River will be provided by a rock apron around the perimeter of the pile and riprap layers on the sideslopes.

The pile will be covered with a multilayer system to meet the three simultaneous demands of erosion control, infiltration and radon control. *Figure* 3 shows the cover components for top and side slopes of the final disposal cell. The top slope consist of, from top down:

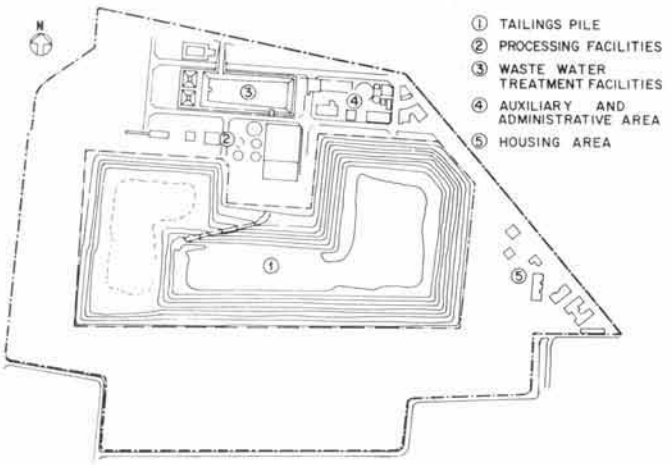

Fig. 1. Present configuration Andujar Mill site.

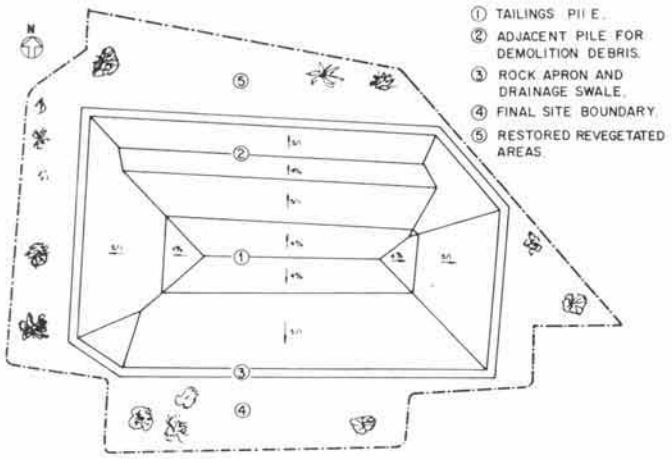

Fig. 2. Andujar Site after remediation.

- 50 mm erosion barrier of mixed gravel and soil
- 500 mm vegetation growth and desiccation protection zone of random soil
- 250 mm filter of clean sand
- 300 mm biointrusion barrier of coarse rock
- 250 mm drain of clean sand
- 600 mm radon and infiltration barrier of silty clay

The topslope is essentially the same as the conservative full component cover adopted at selected UMTRA Project in U.S. sites.The most significant benefits of this cover are its ability to deal effectively with vegetation and to reduce infiltration to the cell because of effective evapotranspiration.

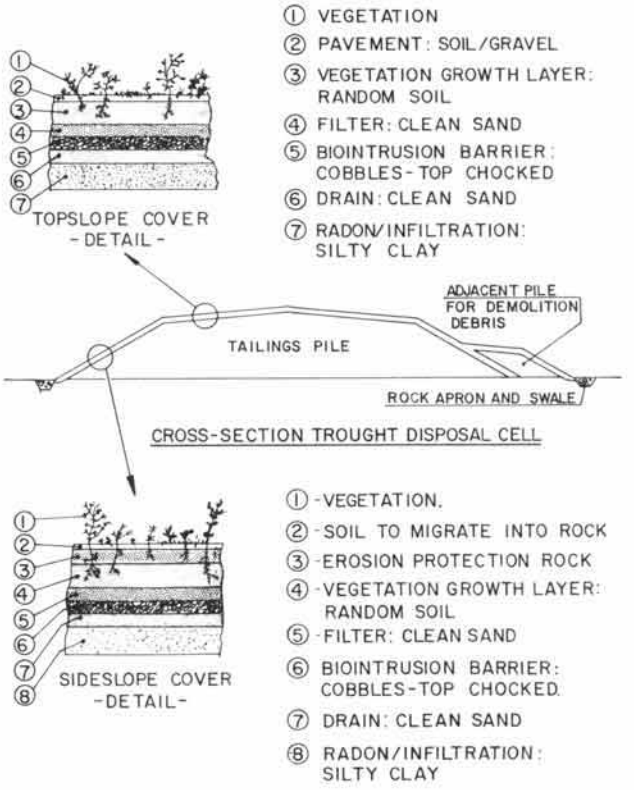

Fig. 3. Disposal cell and cover design for Andujar tailings pile.

The sideslopes incorporate details that differ from most UMTRA Project disposal cells. From the top down, sideslope cover consists of:

- 30 mm of soil to migrate into the rock and help support vegetation
- 300 mm erosion barrier of coarse rock
- 500 mm vegetation growth and desiccation protection zone of random soil
- 250 mm filter of clean sand
- 300 mm biointrusion barrier of large rocks
- 250 mm drain of clean sand
- 600 mm radon and infiltration barrier of silty clay

Advantages of this cover include protection of the radon infiltration barrier from dessication and the existence of a controlled zone-the random soil-for vegetation that might establish through the riprap and help reduce the visual impact of the remediated pile.

CONSTRUCTION PLAN AND SCHEDULE

The major construction activities for the remedial action are listed below:

- Preparation of the site including construction of a new waste-water retention basin to protect against release of contaminants, a decontamination pad to wash down equipment, field offices, and shower/change facilities.
- Construction of drainage control measures to direct generated waste-water and contaminated storm-water runoff to the retention basin during construction activities.
- Dismantling of processing facilities and burial of contaminated materials in the tailings pile.
- Demolition of mill building and structures on the processing site and burial of debris in a pile adjacent to the tailings pile.
- Reshaping the existing tailings pile and excavating, transporting, and placing off-pile contaminated materials on the tailings pile.
- Construction of the final cover system over the tailings to inhibit water infiltration, radon emanation, and wind and water erosion.
- Restoration of the excavated areas on the processing site, to ensure proper drainage.
- Revegetation of the excavated areas on and adjacent to the processing site.
- Construction of the final fencing.

The following general criteria will be followed for the remedial action construction:

- The maximum percentage of organics contained within the reshaped disposal cell will not exceed five percent by volume, and the material will be distributed in a manner that will avoid pockets or layers of organic matter.
- Contaminated demolition debris will be reduced to manageable pieces and carefully placed in the pile to ensure that no voids or nesting exists around the debris and that the adjacent contaminated materials are compacted to at least 90 percent of the Standard Proctor density.
- The relocated tailings and contaminated materials will be compacted to a minimum of 90 percent of the Standard Proctor density and should be moisture conditioned or dried to a moisture content to achieve especified density.
- The radon barrier cover will be placed at a minimum of 95 percent of the Standard Proctor density at the moisture content ranging from optimun to three percent above optimun, and compacted by a kneading method.
- Rock erosion barriers will be placed and graded in such a manner as to form a uniformly distributed, dense, compact mass. Vegetated covers soils will be of proper texture and sufficient thickness and placed at an optimum density to serve as a rooting medium for climax vegetation.

The construction sequence for the remedial action is shown in Fig. 4. It is estimated that construction activities will require approximately 28 months.

The first major activity would be the construction of a waste-water retention pond and the ditches for collection or diversion of surface runoff. The pond will be a partially below-grade structure with the excavated materials being used to build a low berm around the excavation. The pond and temporary ditches will be fully lined with an impermeable membrane. Once the site preparation activities are

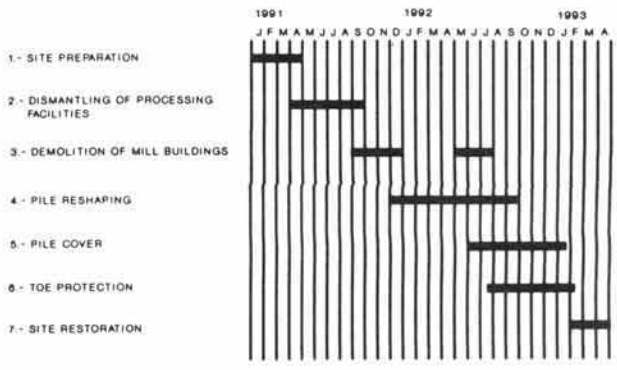

Fig. 4. Construction schedule.

complete, mill facilities and buildings will be demolished and contaminated debris will be stockpiled for placement in the pile. Concurrently, grading of the tailings pile will begin. Hauling on-site contaminated materials and cover materials will follow in areas where tailings regrading is complete.

Hauling these materials to the site and placing them on the pile can begin as preceding operations are continuing across the pile. In this manner, the tailings are graded, contaminated materials are placed, the radon cover is placed, and the pile is stabilized with erosion protection in a continuous process across the pile. This method of construction will minimize the tailings and radon cover that are subject to wind and water erosion. Restoration of the disturbed areas around the stabilized pile will consist of final grading to ensure proper drainage and revegetation as required. Other restoration activities will consist of the removal of the waste-water retention basin descotamination pad and temporary drainage ditches.

ENVIRONMENTAL PROTECTION DURING THE CONSTRUCTION

According to the requirements of CSN, ENRESA will maintain qualified radiation health staffing to ensure protection of the workers and the enviroment.

Training sessions on potential radiological hazard will be conducted for all employes prior to the start of the work. An air sampling program will be carried out in work areas. Radon concentration will be limited to 0,4 WL. Any work area wich exceeds 0,4 WL averaged over the work period must be evacuated until engineering controls can be effected or respiratory protection can be provided. Respirators will be also used in work areas where monthly average air particulate concentrations are expected to exceeds 25 percent of the applicable regulatory limits.

An environmental monitoring program will be conducted in a area around the installation of 10 Km. radius. Continuous air particulate, radon and radon daugther samples will be collected, as well as surface and ground water, sediments and vegetables samples. Operational procedures have been established to include actions levels which will be applied to construction activities to control any higher particulate or radon emissions detected by monitoring program. Administrative control will be used to limit site boundary radon levels to a maximum weekly concentration of 4,5 Bq/l, or 0,9 Bq/l average during a 3 months period and 0,45 Bq/l average during a 52-week period. Particulate levels and radon daugther levels on the site boundary have also been limited. Operating response plans will be prepared by ENRESA relative to severe weather events.

SUMMARY AND CONCLUSIONS

This paper has reviewed the spanish approaches to uranium mill tailings remediation. Standards and design criteria applicable in Spain are similar to those used in the U.S. for the UMTRA program, with some modifications to reflect the relevant Spanish regulations particularly those concerning ground water protection. Conservative design and construction approaches have been adopted for the closure of the Andujar mill to achieve the objetives of long-term stabilization and adequate protection of human health and the environment.

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