SAFETY AND ENVIRONMENTAL SURVEILLANCE MEASURES IN MINING AND PROCESSING OF URANIUM ORE AT URANIUM CORPORATION OF INDIA LTD.

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The discovery of nuclear fission has brought to light the use of uranium as a source of abundant energy. As the world's energy requirement is rapidly increasing with every passing day and the conventional fossil fuels (coal, oil & gas) are depleting steadily, the requirement of nuclear energy as a dependable additional energy source is being increasingly felt by the mankind. This trend is likely to continue in the years to come and nuclear energy is slowly occupying a place as the most clean and affordable source of unconventional energy keeping the long-term sustainability in view. There are now 442 nuclear power reactors in operation in 32 countries of the world meeting about 20% of the electricity demand. Uranium is the basic fuel for the nuclear power reactors, which is available on earth in extractable mode as ore. Of all the major fuels that mankind has ever used for heat, only uranium belongs to this century. The ability of uranium atom to release a huge amount of energy through the process of nuclear fission was brought to light during early 40s and since then the mankind has been showing enough interest to locate good deposits of uranium ore and commercially extract it with innovative approaches

In India, presently the total installed capacity of nuclear power is 2770 MWe contributing about 2.7% of the total electrical energy produced. 14 nuclear power plants in six states are under operation for this purpose of which 12 reactors (PHWRs) use natural uranium as the primary fuel. The first two reactors set up at Tarapur use enriched uranium as fuel.

Uranium Corporation of India Limited (UCIL), a Public Sector Enterprise under the administrative control of Department of Atomic Energy, Government of India was established in 1967 with specific objective of mining and processing of uranium ore to produce uranium concentrate in India. At the time of formation of corporation, UCIL was operating only two units - Jaduguda Mine and Jaduguda Mill. During the last three decades of its existence, the company has expanded its activities manifold. There are now four operating underground mines at Jaduguda, Bhatin, Narwapahar & Turamdih and a uranium ore processing plant at Jaduguda. All these units are located in the Singhbhum East district, Jharkhand.

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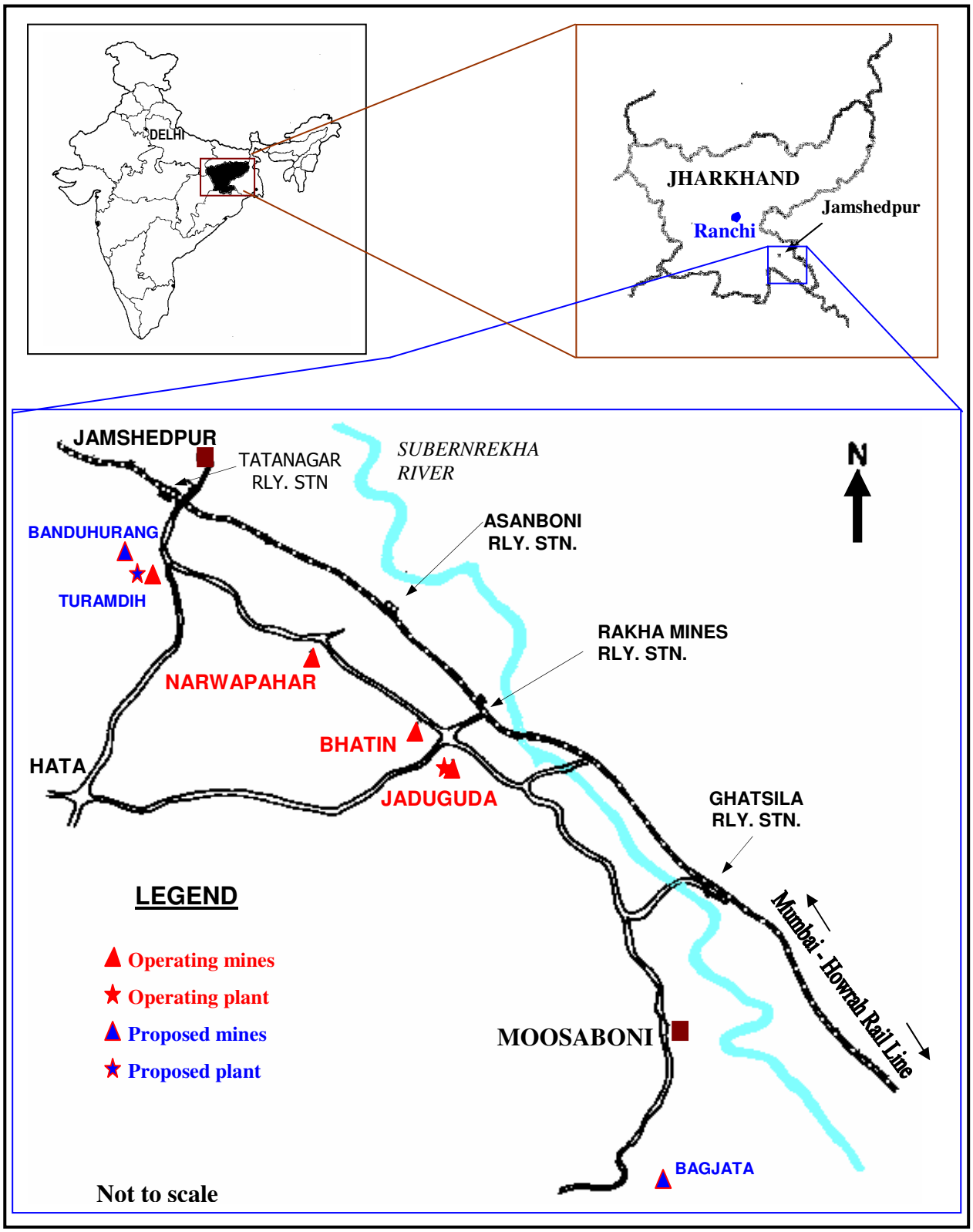
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LEGEND
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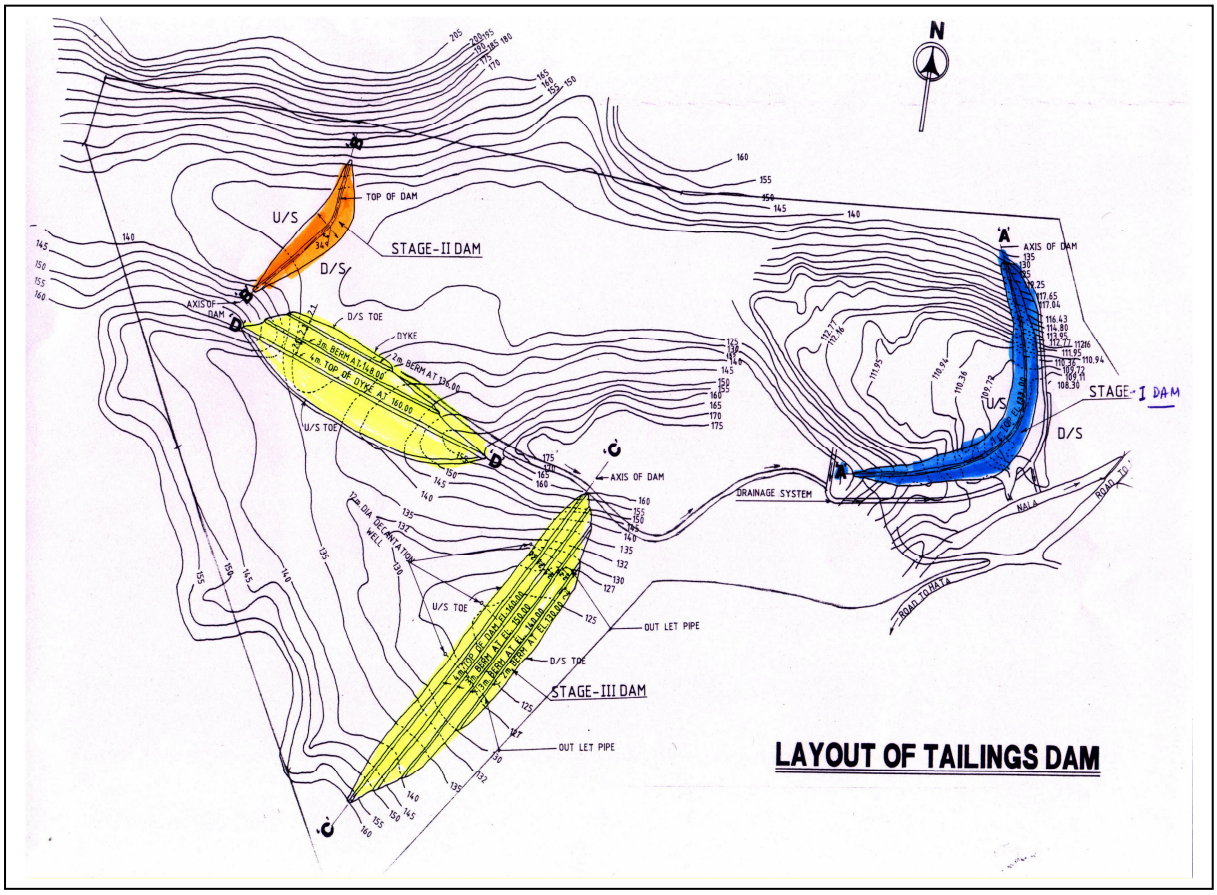
Uranium ore mining: The uranium ore being mined by UCIL from its different mines is of very low grade. The lenticular orebodies in the meta-sediments of Singhbhum sear zone persist from surface to several hundred meters below the ground. The hangwall and footwall rocks are competent and self-supporting in most of the areas. The underground mines developed by UCIL are very well designed adopting modern techniques and deploying different large trackless diesel and electro-hydraulic machinery. Most of the operations in underground are mechanized thus, eliminating the direct handling of ore. All the working areas in underground are well ventilated with adequate continuous supply of fresh air. The void created by excavation of ore is filled up with the mill tailings and the waste rock generated in the mines.

Uranium ore milling: The ore mined from four mines of UCIL are treated in a common plant following the hydro-metallurgical process. The ore of different sizes undergo crushing followed by two stages of wet grinding. The ground ore in the form of slurry is thickened and leached in leaching pachucas under controlled Ph and temperature conditions. The leached liquor is then filtered and undergo ion-exchange in which uranyl ions get absorbed in the resin. This is further eluted and treated with magnesia to get magnesium di-uranate or yellow cake which is thickened, washed, filtered, dried and packed in drums. Most of the operations in the mill are automated with on-line monitoring system.

The final product of UCIL plant is the Yellow cake (magnesium di-uranate), which is sent to Nuclear Fuel Complex, Hyderabad for further processing to nuclear grade fuel**.**

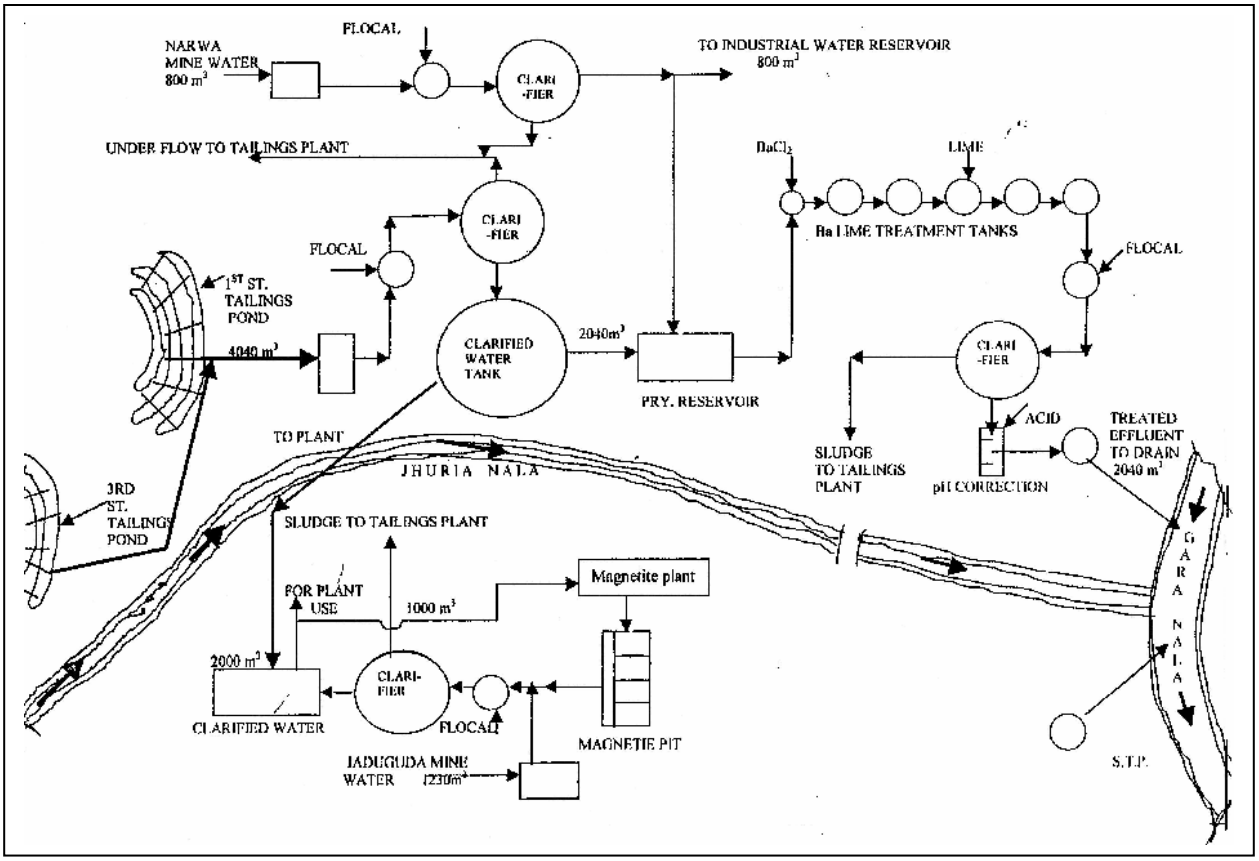
Waste management: The waste rocks generated in the mining of uranium ore are very less. These are mostly disposed in underground for filling the void created by excavation of ore. Some quantity is also used within the premises for filling low-lying areas. The mine water is reclaimed for use in ore processing plant after clarification. The mill tailings form the bulk of the waste generated. The coarse fraction of the tailings (about 50%) after neutralization, are used in underground for filling the mined out stopes. The fine fraction in the form of slime, are neutralized and disposed off in a specially engineered impoundment system called tailings pond. The tailings pond has high natural hills as barriers on three sides. The embankment has been designed in one side to accommodate the entire tailings for a very long period with no scope of its discharge into the environment. The decantation wells in the pond are planned to allow the flow of excess water only preventing any discharge of solid particles**.** The decanted effluent from the tailings pond is treated further at effluent treatment plant and is brought to

normal conditions before being used in the process. Remaining water, if any, is discharged into the local stream after strict monitoring. Access to tailings pond area is prohibited by laying of permanent fences all around. Security personnel are also posted at site as guard against any entry. The pond is located at a safe distance from the population to avoid any direct contamination. Large part of the tailings pond is covered with vegetation to prohibit re-suspension of dust into the atmosphere.



View of the tailings pond at Jaduguda

Decantation wells in Tailings pond at Jaduguda



Flowsheet of Effluent Treatment Plant at Jaduguda

Most of the occupational hazards and environmental issues associated with UCIL's underground mines and plant are by and large similar to the nature of hazards at any other underground metal mines and processing plants. But some of the activities are susceptible to low level of radiological hazards as the uranium ore is a radioactive material. During last 36 years of operation of mining and processing of low-grade uranium ore, UCIL has always maintained a very high level of safety, health and environmental standards in conformity with the international practices in the nuclear industry. The guidelines of different regulatory bodies like Directorate General of Mines Safety, Atomic Energy Regulatory Board, State Pollution Control Board and Ministry of Environment and Forest etc are strictly adhered to.

Industrial safety: Every day-to-day operation in UCIL units are planned and executed with utmost care to eliminate and minimise hazards associated with it. Statutory rules and regulations are strictly adhered to with regular monitoring.

The underground mines of UCIL are well planned with adequate measures for roof control and other mining related hazards. Mechanisation of most of the operations in underground has resulted in complete elimination of direct handling of ore by the workers. The mining personnel are provided with personal protective equipment such as respirators, ear-muffs, safety goggles, gumboots, safety helmet etc for protection against injuries and harmful exposures. Many engineering control measures have been adopted to reduce the noise levels of different heavy machinery in use in underground. Well-designed ventilation network provides adequate fresh air at all underground working places. Routine monitoring of noise level, air quality, radiation & radioactivity levels etc are carried out using sophisticated instruments.

The process plant is in operation with many in-built engineering control measures to enhance the safety standards in different work practices. Generation and dispersion of dust are controlled at source using dust extractor. Local extractors are provided at dust generation points. Exhaust stream is passed through a scrubber with water spray system. Dry fog dust control measures are also provided at suitable locations. Air activity is controlled by providing fabric dampers to outlets of pipes discharging active solutions to reaction tanks and by covering the tank openings. Final product drum filling point is covered with thick fabric chute while transferring dry material. The whole operation is carried out inside a glass chamber with remote control to minimise dispersion of active material. Sources of noise are isolated as far as possible. Natural ventilation in the plant is supplemented by providing series of fans at strategic points. Workers are provided with respirators and other personal protective equipment and personal protective equipment as and when required. Rubber aprons, gloves, helmets and gumboots are used by persons handling toxic materials and the final product.

UCIL has a well-documented safety policy, which is strictly followed. Regular on-site training, various safety related programmes, safety awareness week etc are conducted attempting to inculcate safe working habits as an in-built aspect in the operations. Safety committees are formed at different organisational levels, which periodically meet and recommend corrective measures for implementation. In order to maintain a sound industrial and radiological safety standard at UCIL, the management ensures improved house keeping conditions bringing in procedural changes and by incorporating suitable engineering modifications in the process wherever feasible. Adequate fund is made available for constantly improving the safety

measures. The corporation has won several awards at regional and national levels for achieving the highest industrial safety standards in all its working areas.

Radiological safety: The uranium ore generally contains all radio-isotopes present in its decay series which assume significance at various stages of operations. The radon-222 (a short lived, gaseous radionuclide) and its progeny may lead to internal exposure, if inhaled. This is particularly true in underground mines. In the processing plant, the long lived radionuclides like Ra-226, Th-230, Po-210 and Pb-210 assume some significance at some working areas. The tailings pond, which stores the mill tailings is also a potential source of radiation to the environment.

The standards and limits for exposure to different sources of radiation and conventional toxins are laid down by international bodies like International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA), World Health Organisation (WHO) and International Labour Organisation(ILO). These are duly approved and adopted by various national regulatory authorities in our country like Atomic Energy Regulatory Board (AERB), Pollution Control Boards and Directorate General of Mines Safety (DGMS) etc. Any revisions in the exposure limits as suggested by ICRP and IAEA and duly approved by AERB are also implemented. Health Physics Unit (a specialised division) of Bhabha Atomic Research Center stationed at different units of UCIL regularly inspects different parameters adopting various monitoring techniques and implementing innovative control measures. The principal objectives of monitoring are to evaluate occupational exposures with respect to prescribed limits and to provide information on principal sources of exposure, control measures needed and their effectiveness.

In the mines premises, monitoring of external gamma radiation, airborne radioactivity, surface contamination, radiation dosimetry, silica dust and noise level etc are carried out at all working places. Mine workers are provided with passive personal dosimeters to evaluate individual doses due to exposure to alpha and gamma radiation. The dosimeter consists of CN film and $CaSO_4$(Dy) TLD as detectors for alpha and gamma radiations.

In the processing plant, workers in sensitive areas are provided with TLD badges to evaluate their external gamma radiation dose. TLD and SSNTD based dosimeters are also placed at

various working places in the plant to evaluate the per caput and cumulative effective dose. Workers of mine and mill are periodically monitored for Rn-222 concentration in their exhaled breath to evaluate any internally deposited Ra-226 activity.

In the tailings pond area monitoring of levels of gamma radiation, Rn-222 and its progeny, gamma exposure level, migration characteristics of chemical and radio-toxins of interest are done by collecting water samples from monitoring wells. Analysis of vegetation grown in and around the tailings pond is carried out on routine basis to evaluate the migration of radio-nuclides and chemical additives from tailings pile to vegetation. Dosimeters are placed in near-by houses for detection of radiation dose above background level, if any.

Radiation monitoring of the final product in Jaduguda plant

Revegetation in tailings pond at Jaduguda and monitoring

Environmental surveillance: UCIL, during its 36 years of continuous operation in Singhbhum East district has constantly strived not only for technological and operational excellence, but also has accorded highest priority towards protecting the environment. A well-equipped Environmental Survey laboratory set-up by Bhabha Atomic Research Center at Jaduguda regularly monitors the status of the environment around the operating units. Different environmental matrices are taken into account over an area of 10 km radius. Samples of liquid effluents from mine, mill, tailings pond are regularly collected and analysed. The water from different streams and local river system, sediments from river beds are also collected in different seasons and analysed. Samples of soil, grass, vegetables, food-stuff and aquatic organisms like algae, fish etc are analysed occasionally. The samples of ground water from wells and hand pumps (tube wells) are periodically collected and analysed for the evaluation of

natural levels of radioactivity. Measurement of the levels of gamma radiation and environmental radon concentrations are carried out at the tailings pond and in nearby localities. Evaluation of natural background radiation at different locations covering a radius of five kilometers are carried out using sophisticated instruments and techniques.

The on-going radiological and environmental monitoring in and around UCIL's operating units for the last 36 years have provided a valuable database pertaining to pre and post operational conditions. This information has helped in minimizing / eliminating the effects of radiation related aspects during different stages. Eco-friendly re-vegetation on saturated tailings pond has also been successfully accomplished which has resulted in minimizing the re-suspension of tailings sand and confining the mobility of radio-toxins. It has been possible to maintain a comparatively low activity levels in public stream by keeping the discharges free from suspended solids and minimizing the concentration of dissolved radio-nuclides through proper neutralization of slimes at tailings treatment plant and re-treatment of the out-going effluent at effluent treatment plant. The large database on radiological / environmental parameters generated at UCIL is a source for various studies by many scientists, researchers and regulatory bodies. It has been concluded that UCIL's operations in Singhbhum area have in no way altered the pre-existing radiological status of the environment.

The excellent radiological status and environmental surveillance at UCIL's operations is largely attributed to the fact that Department of Atomic Energy has a well-structured safety organization of its own for exercising supervision and regulatory control over the activities of all its units. The apex body in this regard is the Atomic Energy Regulatory Board (AERB) an independent body under whose control the unit safety committees and the Safety Review Committee for Operating Plants (SARCOP) carry out regular review of the safety status of all the operating units related to radiological and environmental safety. Special inspections are carried out by the AERB which includes experts from institutions other than DAE units also.

As part of UCIL's commitment to strive for continual improvement, the company adopted a new environment policy and implemented a formal environmental management system (EMS) in 1998 with commitment to manage air, water, noise pollution in all its operating units. This has been done in accordance with the company's vision of achieving excellence in operations, in protecting the environment, and caring the health and safety of employees and the public.

Though many components of the EMS were in place for some time, the new system is providing greater consistency across the company and a better framework to stimulate the ongoing improvement. In addition, all applicable environmental laws are complied ensuring preventive and betterment measures. Recently, the corporation has received the coveted certification of ISO-14001 from TUV, Germany for excellent environmental control measures.

In accordance with the general guidelines of Ministry of Environment & Forest, environmental impact assessment and environmental management plans with special emphasis on radiological parameters are prepared by UCIL before undertaking construction activities in any new units. Baseline environmental and radiological data are collected which help in adopting appropriate control measures during the operational stage in order to retain the pre-mining conditions. Opinion of reputed consultants, research organizations, eminent personalities, scientific bodies and general public are sought and suggestions are incorporated while preparing EIA / EMP reports. After complying all related environmental laws and obtaining the clearance from statutory bodies, the new activities are taken up.

The Department of Atomic Energy has now set an ambitious target of producing about 20,000 MWe nuclear power by 2020 AD. In order to meet the requirement of uranium, UCIL is all set to construct one underground and one opencast mines and a processing plant in the Singhbhum East district, Jharkhand. Plans are underway to establish two underground mines, two opencast mines and a processing plant in the district of Nalgonda in Andhra Pradesh. In the district of West Khasi Hills, Meghalaya two opencast mines and a processing plant are also being proposed. As a part of pre-project activities, baseline environmental data collection, preparation of environmental and radiological impact assessment reports and management plans are being carried out. These will form the basis for obtaining statutory clearances are being sought from different regulatory bodies. A few more areas in different parts of the country are also under active exploration for deposits of uranium ore where mining and processing of ore will be taken up in due course. The work on all these projects will start in X five year plan for which required fund has been made available. Most of these projects are expected to be commissioned in X five year plan.

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