Environmental Analysis of Occidental Oil Shale Inc.'s Proof-of-Concept Oil Shale Project

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ABSTRACT

In March 1990 Occidental Oil Shale Inc. requested that the National Research Center for Coal and Energy undertake an external review of the environmental health and safety aspects of its proposed proof-of-concept project. The project was to be a mid-scale (1,200 bbl/day) field test of the company's modified in situ (MIS) extraction technology. The environmental analysis project focused on air quality, water quality, solid waste, toxic substances, mine safety, transportation, subsidence, revegetation, wildlife, socioeconomics, and electrical transmission. A team of national experts was assembled to evaluate the available knowledge on each topic and the implications for development of the MIS program.

The report will assist in planning the proof-of-concept project so as to minimize hazards while focusing attention toward monitoring those critical areas where additional knowledge is needed.

This paper summarizes the organization of the environmental analysis project, lists its conclusions, and identifies key areas for further study.

TASK OVERVIEW

Objective

The objective of this report is to identify whether any outstanding environmental, health, or safety problems are likely to emerge that require attention in the design phase of the proof-of-concept project. It also proposes areas that should be the focus for study during the project.

Summary of Work Done

The program consisted of a series of expert reviews within each of eight topic areas. Expertise is drawn from West Virginia, Colorado, and Utah and includes both academics and private consultants. Each team included leaders in their respective disciplines. Team leaders inspected OOSI's facilities, reviewed the available documentation within their topical areas, and prepared reports addressing the topics outlined below:

1. Air quality
    - Surface facility emissions
    - Nonpoint sources
    - Class I area proximity
    - Global atmospheric change
    - Visibility
2. Water
    - Ground water
    - MIS retort reclamation
    - Mine dewatering
    - Regional/local hydrology
    - Usage/augmentation
    - Surface water
    - Usage/availability
    - Process/mine water disposal/reuse
    - Runoff/impoundment
    - Spill prevention
3. Solid waste
    - CFBC waste
    - Process waste
    - Mined oil shale
4. Health and safety
    - Surface facilities—toxic substances
    - Mine safety
    - Gassy mine rules
    - Retorting in mine environment
    - Shale oil handling/transportation
5. Land
    - Subsidence
    - Reclamation
6. Biological
    - Endangered/threatened species
    - Deer herds
7. Socioeconomic analysis
8. Electrical power transmission

Conclusions

No components of the project are apparent that would preclude proceeding. The environmental, health, and worker safety issues examined by the expert teams are susceptible to treatment by either conventional technologies or technologies developed over the years by OOSI. Nevertheless, a number of significant issues remain, such as effects on air and water resources, mine safety in the MIS environment, geotechnical, and solid waste issues. It will remain for the proof-of-concept project to identify their impacts and to develop remedial technologies as needed.

SUMMARY ANALYSIS OF ENVIRONMENTAL, HEALTH AND SAFETY ISSUES

Following are summaries extracted from reports of the expert teams. The summaries indicate the extent of knowledge identified in each area and, most significantly, identify the key unresolved issues so that the proof-of-concept project may focus on environmental, health, and safety issues of highest priority.

Air Quality

Air-quality degradation from major sources is regulated by the federal Clean Air Act and Colorado Department of Health regulations. Appropriate permits must be obtained before operation. Occidental Oil Shale Inc. (OOSI) appears to have complied with regulations that existed when the 1985 revised detailed development plan (RDDP) was written. OOSI is proceeding with an updated permitting process, including emissions from the new Circulating Fluidized-Bed Combustion unit (CFBC). Ambient monitoring of regulated pollutants will be performed during operations to ensure compliance. Air-quality related values, such as visibility and dry deposition, also have been examined.

OOSI has anticipated some possible future regulations—a plan for capturing and marketing carbon dioxide should global warming provisions be adopted in the upcoming Clean Air Act amendments; and monitoring of elemental toxics from CFBC emissions and in ambient air is planned. Other revisions on the way, such as PSD increments for NO_x and PM_{10}, must be dealt with as they are promulgated.

Several issues are raised that may need further explanation or investigation—the need for simple terrain as well as complex terrain dispersion modeling for permitting; inclusion of Dinosaur and Colorado National Monuments as Class I areas; possible inclusion of arsenic and radionuclides in de minimus emission levels for PSD; and possible permitting of arsenic under Colorado air toxics regulations.

Ground Water

Field data and hydrologic analyses suggest that additional pumping for mine drainage for the proposed may not affect the flow of Piceance Creek, but uncertainties remain concerning hydraulic connections among the creek, alluvial aquifer, and bedrock aquifers. Collection of hydrologic data must continue, and these data should be analyzed for trends during the project. A local study of the hydrologic characteristics of the valley-fill alluvium also is recommended.

After the retorts are burned, they must be flushed repeatedly with water to stop combustion, cool the retorts, flush sediment, and dissolve expected organic and inorganic materials from the retorts. The flushing must continue until measurements of the quality of water used for flushing indicate that the retorts will not contaminate invading ground water.

Upon abandonment, ground water will resaturate the retorts and reestablish the natural flow system. Few problems are expected with ground-water contamination in abandoned retorts, if the retorts are thoroughly flushed prior to flooding. However, water-quality monitoring is needed within the retorts and in observation wells nearby to ensure that ground-water contamination is not occurring.

Surface Water

A preliminary water budget, relative to the proposed MIS process with associated CFBC power plant, has been prepared by OOSI. It indicates the principal water streams required by and produced by various components of the system—mine dewatering, bulkhead water collection, processing, boiler feed, boiler blowdown, and cooling systems.

The quality of water emanating from quenched retorts is of particular interest. Most likely it will be saline and alkaline. The total organic content has been shown to decline over time for similar retorts at Logan Wash (Boysen and others, 1990). Total dissolved solids in water used to flush the retorts so far has remained high. A definition of what constitutes a satisfactorily reclaimed spent retort has not been finalized. No process water will be discharged to receiving streams and, indeed, the NPDES permit prohibits any discharge other than treated mine water. All excess water is to be evaporated, either through quenching of retorts, by spraying on the boiler ash pile or in an evaporation pond. Process water streams that contain significant organic compounds will be incinerated in the CFBC.

The lease stipulations and the NPDES discharge permit call for strict control of surface discharge and the resultant protection of Piceance Creek. Based on available information, no unsolvable problems regarding surface water protection have been detected.

Solid Wastes

The project will generate two types of solid wastes—boiler ash and oil shale. Oil shale is known to be an innocuous material. Boiler ash is a new material and has only recently been generated and studied.

Boiler ash, which will be generated from the Circulating Fluidized-Bed Combustor (CFBC), consists of combusted oil shale and coal. This material will be disposed in surface dumps. The amount of ash to be generated is as yet unknown as coal/oil shale optimization trials are under way. The low inherent permeability of CFBC ash will tend to isolate it from precipitation water. A leachability study of CFBC ash is under way. Preliminary results indicate that neither RCRA metals nor organic compounds exceed regulatory limits. The indication from this work is that the ash will not present an environmental threat. Previous studies have shown that raw rock (nonretorted oil shale) does not present significant pollution threats when disposed of in landfills. Field studies regarding leaching and permeability characteristics of the boiler ash should be considered. It is anticipated that the results of such a study would confirm laboratory findings regarding the leachate characteristics of the ash.

Specific plans for dealing with disposal of the solid wastes generated from the C–b site are still being developed. Preliminary reports indicate that solid waste derived from the mining of oil shale would be disposed of in a fill located in the valley immediately adjacent to the mine shafts (where material previously mined has been placed). It is not currently expected that a surface retort will be operated during the demonstration, and no specific plans have been made for disposal of retorted shale.

Human Health and Safety

The production of oil shale encompasses a range of operations associated with potential and/or real exposure to both solid and gaseous contaminants.

Workers at this operation may therefore experience contaminants in different physical and chemical states. In addition, health risks connected with the technology of mining, construction, maintenance, operation of a refinery, transportation, distribution, and testing all may contribute to the specific issues of oil shale production/use.

None of these risks are exclusive to this industry, and none can be considered unprecedented or uncontrollable. Indeed, traditional means of safety and of industrial hygiene care are applicable to this particular setting, just as they are applicable to the mining industry in general.

General control measures as applied to other extractive industries should respond equally to the impact on the general population.

Mine Safety

Gas is present in oil shale strata of the Green River Formation. The C–b oil shale mine has been classified as a gassy mine by MSHA since January 2, 1980, based on a sample containing 0.289% methane. This can be controlled by adequate ventilation and, according to OOSI personnel at the site, no methane has ever been detected by the automatic sensors that continually monitor the mine and shafts.

Most of this methane probably comes from ground water. The problems associated with gas liberated from water inflows have been identified, but because the mining horizons are dry and most water comes from the shafts, the gas will either be highly diluted with intake air or immediately exhausted to the surface (Nieuwenhuis, 1979; Watson, 1983). Current estimates of ground-water gas are 48 CFM and diffusion gas of 5 CFM, for a total of 53 CFM. To dilute this to 0.1%, only 53,000 CFM of ventilation air is required, which poses no problems.

As in any fissile shale, oil shale is subject to spalling. The primary area where this is of concern is in the roofs of the underground tunnels, where the safety of personnel and equipment are of concern. OOSI's C–b facility has successfully used roof bolting and wire mesh to control roof fall five years after construction.

Based on a review of the documentation provided and the site visit, it is the reviewer's opinion that the OOSI MIS technique is a technically viable option from the perspective of mine worker safety.

Shale Oil Handling/Transportation

This report presents an evaluation of shale oil handling and transportation, with respect to health and safety, in reactivating Occidental Oil Shale Tract C–b operation near Meeker, Colorado. Assessment of proposed processes and technology associated with the products mentioned above was made from reports provided by Occidental Oil Shale Inc. (archives of Occidental Oil Shale in Palisade, Colorado), and from discussions with Occidental personnel at C–b and Logan Wash sites during tours, April 11, 1990. Evaluation of the proposed process and technology was made based on their compatibility with state of the art.

Two options are available for transportation of shale oil. In the first, trucks would haul the oil to Unocal's upgrader at Parachute Creek, Colorado. It is estimated that this would entail nine tanker truckloads per day and not place any significant burden on the route. The second option involves transporting shale oil by pipeline and tank train to Amoco Pipeline Company facilities at Sterling, Colorado. Both options include conventional technology, and no problems are anticipated.

Subsidence

Two mine development plans were proposed during research and development programs of the 1980s. The first mine plan involves only clusters of MIS retorts laid out in panel form. The second plan consists of two parts—a room and pillar mining section, and an MIS section. Subsidence prediction was performed to determine the size of the shaft pillar using the National Coal Board (Great Britain) method in 1975 and that proposed by Abel and Lee in 1980. The panels were designed not to subside, but the pillar design methods by two separate groups produced considerable differences in pillar strength (2,180 psi vs 670 psi).

This discrepancy must be resolved. The subsidence-prediction techniques used in this project were developed by the National Coal Board, which has been proven unsuitable for United States coal fields, for which several new techniques since have been developed. These should be investigated for application in oil shale.

Reclamation

Disturbance of land in the proof-of-concept facility will be limited to the construction of a boiler-ash dump and possibly a spent-shale dump. Reclamation of surface disturbances around injection holes, coring operations, and installation of the MIS gas-collection shaft present few problems to revegetation specialists. Revegetation of such sites can be done quickly and effectively.

Revegetation of boiler ash has not been studied. However, retorted or spent oil shale has been studied extensively. Boiler ash likely will be similar to spent shale but differs primarily in the addition of some proportion of coal ash and the amount of carbon remaining in the ash. Some spent shales have carbon residues of +4 wt %, while boiler ash carbon content will be much lower (less than 1%) and has properties like "Lurgi" spent shale. The characteristics of spent shale commonly causing problems relative to revegetation are coarse particle size, dark color, high salt content, and low nitrogen and phosphorus content.

Practices used to overcome deleterious properties of raw and spent shale include topsoiling, addition of organic matter, fertilization, mulching, irrigation, and seeding of adapted plant species.

Upon review of numerous scientific experiments conducted over the past 30 years in the area and analysis of demonstration plots constructed at the C–b site, revegetation of surface disturbances, of raw and processed shale piles, and of boiler-ash dumps created during the project will not present major challenges. The experimental and demonstration revegetation trials demonstrate that with careful planning and timely application of topsoil, amendments, and seed from adapted plant species, revegetation can successfully be accomplished and completed concurrent with project operations.

State and federal revegetation requirements concerning plant cover and productivity also can be met. Environmental concerns relative to deposition of raw and processed shale and boiler ash on the surface and their revegetation are not warranted when recommendations for their revegetation are followed.

Wildlife

Background documents that have been assembled to evaluate the influences of oil shale development on wildlife provide an accurate representation of the status of wildlife and the prospects of the effects of development of the oil resource on a wide range of wildlife species, including both game and nongame species. Most of the baseline studies related to C–b tract were conducted between 1974 and 1980. Despite the ten-year interval since the last detailed studies, there is no obvious reason to question their current validity. Given that this is the case, the analysis of wildlife presented in section 2.5 of the Revised Detailed Development Plan—1985 is considered to be an acceptable representation of the status of wildlife on the tract.

Results of the current analysis suggest that the proof-of-concept study will have few, if any, negative impacts on the populations of wildlife species. In fact, the proposed study may be the only reasonable way to collect data to evaluate the actual impacts of MIS technology on wildlife. The proposed demonstration is sufficiently small in scale that if negative impacts do occur, they will be minor. Data from this experience should allow us to scale up to the potential impacts of commercial-level shale oil production.

Socioeconomic Assessment

The proof-of-concept oil shale project, to be located on federal oil shale lease tract C–b in western Colorado, will be constructed and operated over a ten-year period. The socioeconomic effects of the project are positive.

The project will directly employ 546 construction workers in the peak year of construction activity and 285 operation workers in the peak year of operations. Total direct employment will range from 59 to 690 over the life of the project, with an average direct employment of 268 workers.

Development of the project will result in increased employment, personal income, and public tax flows. Revenues will flow to local government jurisdictions, the State of Colorado, and the federal government. Direct public revenues alone will amount to approximately $20 million for state and local governments. A total of $141 million will be paid to project workers directly in the form of payroll wages, with estimated indirect wages amounting to $169 million for the ten-year life of the project.

The project-related population represents only slightly over 1% of the population of the region and can easily be accommodated by existing towns and cities in the area. No adverse public impacts have been identified to date. The construction and operation of the project presents an opportunity to develop technical expertise in oil shale mining and processing with minimal socioeconomic impacts. It is anticipated that socioeconomic information collected during the proof-of-concept project will facilitate permit acquisition and socioeconomic impact mitigation for commercial oil shale development projects.

Electricity Transmission

The proof-of-concept operation will not require construction of new transmission capacity, only minor modifications of existing switchyards (at the C–b site and at Meeker). The existing 138-kV line will be used to sell cogenerated power. The environmental, health, and safety impacts possibly arising from this line are discussed in the February 19, 1980, Environmental Assessment, and the topic will be considered in a new Environmental Impact Statement. The 1980 report shows that the existing 138-kV line was constructed according to standards described in *Electric Transmission Specification and Drawings*, REA Form 805 (Rev 2–73) and by the sixth edition of the *National Electric Safety Code*. In addition, because the line would cross an area with a raptor population, the pole structures were designed according to REA Bulletin 61–10 (March 9, 1979), *Powerline Contacts by Eagles and Other Large Birds*, to minimize impact of the line on raptors.

In the event of full-scale commercial development, a second line would follow the existing right-of-way. In this case, the present right-of-way would be evaluated for its potential to include an additional transmission line. This additional transmission capacity would only be required by a significant expansion at the C-b site (for example, to 50,000 bbl/day capacity).

CONCLUSIONS

Among the key objectives of the proof-of-concept project is the evaluation of the impacts of MIS technology on key environmental, health, and safety issues. It represents a long-term demonstration and development stage prior to full-scale commercial operations. The scale of the proof-of-concept project is such that processes and procedures can be modified over its course so as to achieve a technology that not only is efficient but also safe for workers, the public, and the environment. This report is an attempt to identify whether any outstanding problems are likely to emerge that require attention in the design portion of the proof-of-concept project. It also proposes areas that should be the focus for study during the project. These are listed in the above section.

In short, no components of the project are apparent that would preclude proceeding. The environmental, health, and worker safety issues examined by the expert teams are susceptible to treatment by either conventional technologies or technologies developed over the years by OOSI. Nevertheless, a number of significant issues remain, such as effects on air and water resources, mine safety in the MIS environment, geotechnical, and solid waste issues. It will remain for the proof-of-concept project to identify their impacts and to develop remedial technologies as needed.

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